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FINAL TIER II SAMPLING AND ANALYSIS PLAN FOR AREA OF CONCERN 6 TNT GRAINING HOUSE SUMP AND TNT CATCH BOX RUINS SUB AREAS REMEDIAL INVESTIGATION CHEATHAM ANNEX FISC WILLIAMSBURG VA

9/1/2013

CH2M HILL

Title and Approval Page

Final
Tier II Sampling and Analysis Plan

AOC 6 TNT Graining House Sump and TNT Catch Box Ruins Subareas – Remedial Investigation

Naval Weapons Station Yorktown Cheatham Annex
Williamsburg, Virginia

Contract Task Order 056

September 2013

Prepared for:

Department of the Navy
Naval Facilities Engineering Command
Mid-Atlantic

Under the

NAVFAC CLEAN 1000 Program
Contract N62470-08-D-1000

Prepared by:

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*Pre-draft digitally signed by Kenneth Bowers, September 19, 2012
**Redline Draft Final digitally signed by Kenneth Bowers, September 9, 2013

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Executive Summary

This Remedial Investigation (RI) Sampling and Analysis Plan (SAP) was prepared to conduct an RI at the Area of Concern (AOC) 6 Trinitrotoluene (TNT) Graining House Sump and TNT Catch Box Ruins subareas located at Naval Weapons Station Yorktown Cheatham Annex (CAX) in Williamsburg, Virginia (Figure 1). It was prepared by the United States (US) Department of the Navy (Navy), Naval Facilities Engineering Command (NAVFAC) Mid-Atlantic Division under the Comprehensive Long-term Environmental Action Navy (CLEAN) 1000 Contract, Contract Task Order (CTO) 056 for submittal to NAVFAC Atlantic, the United States Environmental Protection Agency (USEPA) Region 3, and the Virginia Department of Environmental Quality (VDEQ). The Navy, USEPA, and VDEQ work jointly as the CAX Partnering Team. This SAP was written in accordance with the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) guidance document (USEPA, 2005) using the modified Tier II format.

CAX encompasses 2,300 acres east of Williamsburg, between Interstate 64 and the York River on the York-James Peninsula (**Figure 1**). The majority of CAX is undeveloped and heavily wooded. Major surface water features at CAX consist of Cheatham Pond, Jones Mill Pond, and Penniman Lake, and the base is adjacent to the York River. AOC 6 consists of five subareas, two of which are the subject of this RI. The TNT Graining House Sump subarea is a wooded area located near the banks of Penniman Lake, as shown on **Figure 2**, and consists of a concrete-lined, open top pit believed to be the sump pit for the TNT graining house in the former shell loading area. The TNT Catch Box Ruins is a wooded area also located near the banks of Penniman Lake and consists of an earthen, brick-lined depression located immediately adjacent to the TNT graining house in the former shell loading area. For this RI, these two subareas will be referred to together as the AOC 6 TNT subareas, based on their geographical proximity.

This SAP details various aspects of the environmental investigation process that will serve as guidelines for the field sampling event to gather the required soil and groundwater sample data to conduct the RI, which will incorporate the newly collected data and existing historical data. This document will ensure that the collected environmental data are scientifically sound, of known and documented quality, and suitable for intended uses. The laboratory information cited in **Appendix A** of this SAP is specific to the laboratories that were selected, based on a competitive selection process. These laboratories possess the necessary Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) certification for the analytical methods required by this project. In the event of changes, revisions will be submitted to the CAX Partnering Team prior to commencement of fieldwork.

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1 Project Organization Chart

Acronyms and Abbreviations

AM	Activity Manager
AOC	Area of Concern
AQM	Activity Quality Manager
ASTM	American Society for Standards and Materials
AUF	Area Use Factor
bgs	below ground surface
BTAG	Biological Technical Assistance Group
CA	Corrective Action
CAX	Cheatham Annex
CLEAN	Comprehensive Long-term Environmental Action Navy
CoC	Chain of Custody
COC	Constituent of Concern
COPC	Chemicals of Potential Concern
CSM	Conceptual Site Model
CTO	Contract Task Order
DL	Detection Limit
DNT	2,4-dinitrotoluene
DO	Dissolved Oxygen
DoD	Department of Defense
DPT	Direct Push Technology
DQI	Data Quality Indicator
DV	Data Validator
ELAP	Environmental Laboratory Accreditation Program
ERA	Ecological Risk Assessment
ESV	Ecological Screening Value
FTL	Field Team Leader
GPS	Global Positioning System
GW	groundwater
H&S	Health and Safety
HSP	Health and Safety Plan
HHRA	Human Health Risk Assessment
HQ	Hazard Quotient
HSM	Health and Safety Manager
ID	Inside Diameter
IDW	Investigation Derived Waste
LOAEL	lowest observed adverse effect level
LOD	Limit of Detection
LOQ	Limit of Quantitation
MATC	Maximum Acceptable Toxicant Concentration
MCL	Maximum Contaminant Level
MPC	Measurement Performance Criteria
MS/MSD	Matrix Spike/Matrix Spike Duplicate

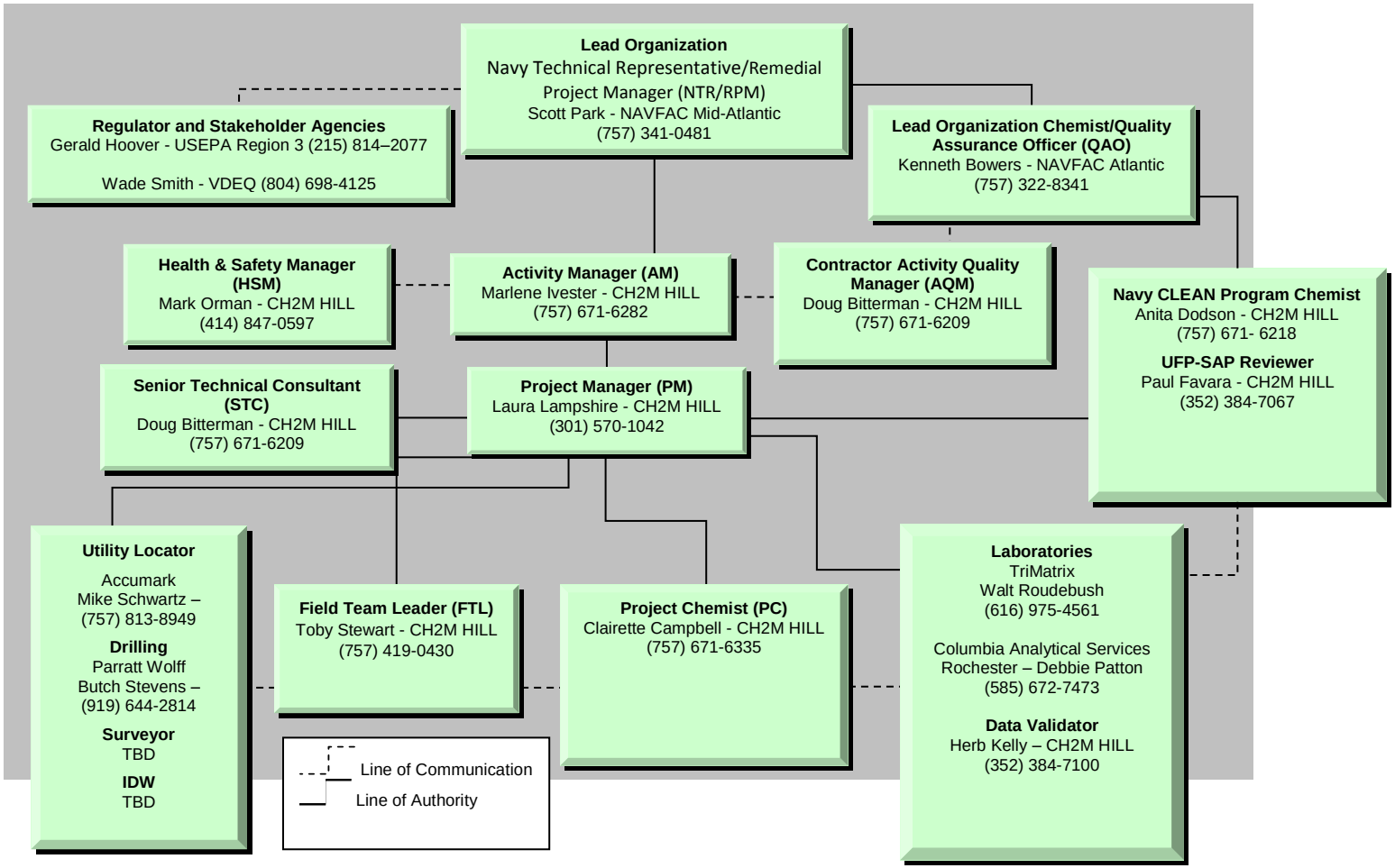
NAIP	Natural Attenuation Indicator Parameter
NAVFAC	Naval Facilities Engineering Command
Navy	Department of the Navy
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no observed adverse effect level
NTR	Navy Technical Representative
ORP	Oxidation-Reduction Potential
PAL	Project Action Limit
PC	Project Chemist
PCB	Polychlorinated Biphenyl
PDM	Project Delivery Manager
PID	Photoionization Detector
PM	Project Manager
POC	Point of Contact
PPE	Personal Protective Equipment
PSLP	Penniman Shell Loading Plant
PVC	Polyvinyl Chloride
QA	Quality Assurance
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	Quality Control
QL	Quantitation Limit
QSM	Quality Systems Manual
RPD	Relative Percent Difference
RI	Remedial Investigation
RPM	Remedial Project Manager
RSL	Risk Screening Levels
SAP	Sampling and Analysis Plan
SI	Site Investigation
SOP	Standard Operating Procedure
STC	Senior Technical Consultant
SVOC	Semivolatile Organic Compound
SW	Surface Water
TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TNT	Trinitrotoluene
TOC	Total Organic Carbon
TRV	toxicity reference value
UCL	Upper Confidence Limit
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plans
US	United States
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
UTL	Upper Tolerance Limit
VDEQ	Virginia Department of Environmental Quality

1 Project Organization

1.1 Project Organization Chart

The project organization chart (**Chart 1**) includes lines of authority and lines of communication.

CHART 1
Project Organization Chart



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1.2 Communication Pathways

The communication pathways for the Sampling and Analysis Plan (SAP) are shown in **Table 1**.

TABLE 1
Communication Pathways

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or E-mail	Procedure, Pathway, etc.
Communication with Navy (lead agency)	Naval Facilities Engineering Command (NAVFAC) Remedial Project Manager (RPM)	Scott Park	(757) 341-0481 scott.park@navy.mil	Primary point of contact (POC) for Navy; can delegate communication to other internal or external POCs. Any issues that may impact project work are to be reported to Scott immediately. RPM will notify the United States Environmental Protection Agency (USEPA) and Virginia Department of Environmental Quality (VDEQ) via email or telephone within 24 hours of field changes affecting the scope or implementation of the work.
Communication with USEPA Region 3	USEPA RPM	Gerald Hoover	(215) 814-2077 hoover.gerald@epa.gov	Primary POC for USEPA; can delegate communication to other internal or external POCs. Upon notification of field changes, USEPA will have 24 hours to approve or comment on the field changes. Responses will be communicated via email or phone.
Communication with VDEQ	VDEQ RPM	Wade Smith	(804) 698-4125 wade.smith@deq.virginia.gov	Primary POC for VDEQ; can delegate communication to other internal or external POCs. Upon notification of field changes, VDEQ will have 24 hours to approve or comment on the field changes. Responses will be communicated via email or phone.
Communication regarding overall project status and implementation and primary POC with Navy RPM, USEPA, and VDEQ	CH2M HILL Activity Manager (AM)	Marlene Ivester	(757) 671-6282 marlene.ivester@ch2m.com	Primary POC for stakeholder and agency managers; can delegate agency communication to other contract staff as appropriate. Oversees project and will be informed of project status by the Project Manager (PM). If field changes occur, the AM will work with the Navy RPM to communicate field changes to the USEPA and VDEQ via email within 24 hours.
Communications regarding project management and implementation	CH2M HILL Project Manager (PM)	Laura Lampshire	(301) 570-1042 laura.lampshire@ch2m.com	Primary modes of communication are phone, email, letter, document submittal; timing dependent on nature of communication and predefined schedule as applicable and as requested by stakeholder agencies. The PM will have 24 hours to respond to the request for field corrective actions (CAs). Responses will be communicated to the Field Team Leader (FTL) via phone. All information and materials about the project will be forwarded to the AM on a daily basis.

TABLE 1
Communication Pathways

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or E-mail	Procedure, Pathway, etc.
Technical communications for project implementation, and data interpretation	CH2M HILL Senior Technical Consultant (STC) and Activity Quality Manager (AQM)	Doug Bitterman	(757) 671-6209 doug.bitterman@ch2m.com	Team members will contact the STC regarding questions/issues encountered in the field, input on data interpretation, etc., as needed. The STC will have 24 hours to respond to technical field questions as necessary. Responses will be communicated to the PM via email or phone. In addition, the STC/AQM will review data and deliverables as necessary prior to Cheatham Annex (CAX) Partnering Team discussion or distribution.
SAP/Work Plan Changes prior to Field/Laboratory work	PM	Laura Lampshire	(301) 570-1042 laura.lampshire@ch2m.com	Notify the CAX Partnering Team by phone or email of changes to the SAP made prior to beginning field work and the reasons within 24-hours.
Field Progress Reports	Field Team Leader (FTL)	Toby Stewart	(757) 419-0430 toby.stewart@ch2m.com	Email or fax daily field progress reports to contractor PMs on a weekly basis; telephone communication with PMs on an as-needed basis.
Stop Work due to Safety Issues	Site Safety Coordinator (SSC)	Toby Stewart	(757) 419-0430 toby.stewart@ch2m.com	Notify field personnel that work is to stop immediately if a safety issue is observed. Report all health and safety (H&S) incidents and near misses to PM and Health and Safety Manager (HSM) via email or phone immediately if an incident occurred or within 24 hours if a near miss occurred.
SAP/Work Plan Changes in the Field	FTL	Toby Stewart	(757) 419-0430 toby.stewart@ch2m.com	Notify the PM by phone and email of changes to the SAP made in the field and the reasons within 24-hours. Documentation of deviations from the SAP will be kept in the field logbook; deviations made only with the approval of the PM. Approvals will be made via email or phone.
Field Corrective Actions (CAs)	FTL	Toby Stewart	(757) 419-0430 toby.stewart@ch2m.com	The need for CA for field or analytical issues will be determined by the FTL and/or senior risk assessors and STC. Senior support will ensure SAP requirements are met by the field staff. The FTL will notify the PM via phone of any need for CA within 4 hours.
Reporting Laboratory Data Quality Issues	Laboratory PM	Walt Roudebush, TriMatrix Debbie Patton, CAS-Rochester	(616) 975-4561 (585) 672-7473	All quality assurance (QA)/quality control (QC) issues with project field samples will be reported within 1 day to the Project Chemist (PC) by the laboratory.
Reporting Data Validation Issues	Data Validator (DV)	Herb Kelly	(352) 384-7100 herb.kelly@ch2m.com	All DV issues regarding resubmissions from the laboratory will copy the CH2M HILL Chemist on communications. The DV report will be due within 14 calendar days of data receipt.

TABLE 1
Communication Pathways

Communication Drivers	Responsible Affiliation	Name	Phone Number and/or E-mail	Procedure, Pathway, etc.
Data Validation CAs	PC	Clairette Campbell	(757) 671-6335 clairette.campbell@ch2m.com	All issues discovered during data validation will be reported to the PC. CAs (revisions and additional information, if necessary) will be requested from the laboratory. The PC will review the data validation narrative and request CA from the validator if necessary. Should analytical laboratory issues affect data usability by rendering a significant amount of data rejectable or unusable, such that the project completeness goal cannot be obtained, the PC will notify the project team and AM, who will in turn notify the Navy RPM. The Navy RPM will contact the Navy Chemist as needed.
Data tracking from field collection to database upload	PC	Clairette Campbell	(757) 671-6335 clairette.campbell@ch2m.com	Tracking data from sample collection through database upload.

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2 Project Approach

The purpose of this Remedial Investigation (RI) is to collect additional soil and groundwater data to supplement the current Site Investigation (SI) dataset to adequately characterize the Area of Concern (AOC) 6 Trinitrotoluene (TNT) Graining House Sump and TNT Catch Box Ruins subareas (the AOC 6 TNT subareas) located at Naval Weapons Station Yorktown Cheatham Annex (CAX) in Williamsburg, Virginia. All soil data evaluated in the SI Report (CH2M HILL, 2012), as well as soil and groundwater data collected as part of this RI, will be used to characterize the site and support a Human Health Risk Assessment (HHRA) and an Ecological Risk Assessment (ERA), through Step 3a. Previous surface water and sediment SI data (from Penniman Lake) will not be evaluated since these media will be evaluated as part of the Penniman Lake RI and groundwater data collected during the 2008 SI will not be evaluated in the RI because these samples were collected from temporary monitoring wells using direct push technology (DPT) and may not be representative of current groundwater conditions. In addition, the remaining three subareas of AOC 6 will not be investigated in this RI, as they are being evaluated under separate covers.

2.1 Project Planning Session Participants Sheet

Four project scoping sessions were conducted with the CAX Partnering Team, as described in the following sections.

2.1.1 November 2011 Scoping Session

TABLE 2
November 2011 Scoping Session

Project Name: AOC 6 TNT subareas RI			**Site Name:** AOC 6 TNT subareas	
Projected Date(s) of Sampling: Fall 2012			**Site Location:** CAX	
Project Manager: Laura Lampshire				
Date of Session: 11/16/11				
Scoping Session Purpose: AOC 6 Scoping Session				
Name	**Title**	**Affiliation**	**Phone #**	**E-mail Address**
John Burchette	RPM	USEPA Region 3	(215) 814-3378	burchette.john@epa.gov
Wade Smith	RPM	VDEQ	(804) 698-4125	wade.smith@deq.virginia.gov
Krista Parra	RPM	NAVFAC Mid-Atlantic	(757)-341-0395	krista.parra@navy.mil
Marlene Ivester	AM	CH2M HILL	(757) 671-1634	marlene.ivester@ch2m.com
Stephanie Sawyer	Deputy AM	CH2M HILL	(757) 671-6273	stephanie.sawyer@ch2m.com
Laura Lampshire	PM	CH2M HILL	(301) 570-1042	laura.lampshire@ch2m.com

Comments/Decisions:

Laura led the discussion and began by summarizing the results of Step 2 in the SI, the SI report recommendations, and the objectives of the remedial investigation.

The following questions were then discussed in order to frame the issues to be addressed by the SAP:

1. ***What is the nature and extent of contamination in soil at the AOC 6 TNT subareas?***

   Proposal: 13 surface and subsurface soil samples will be collected from the AOC 6 TNT subareas and analyzed for semivolatile organic compounds (SVOCs), explosives, and metals. Six of the soil samples will be co-located with groundwater samples during monitoring well installation (see #2 below). These and the other seven surface and seven subsurface soil samples collected during the SI will also be used to determine the nature and extent of soil contamination at the site. The Team reviewed the proposed surface and subsurface soil locations and John asked if a sample could be placed further north than CAA06-SO01. Krista replied any sample placed further north than CAA06-SO01 would be in Penniman Lake. The Team agreed to the proposed sampling locations as depicted in the scoping session presentation (Slides 6 & 7). In addition, the Team agreed to analyze the soil samples for SVOCs, explosives, and metals.

2. ***What is the nature and extent of contamination in groundwater and the groundwater flow direction and velocity?***

   Proposal: Six permanent monitoring wells will be installed and groundwater samples will be collected and analyzed for total and dissolved metals. The six monitoring wells will be gauged and slug tests will be conducted in order to determine the groundwater flow direction and velocity. Laura mentioned that although groundwater samples were collected during the SI, the plan is that the SI groundwater samples will not be used in this evaluation since the groundwater samples were not collected from permanent monitoring wells and may not be representative of current groundwater conditions and asked if the Team agreed. Wade asked if the contaminant concentrations in the DPT groundwater samples were used in placing the proposed monitoring well locations and Marlene said that they were. Wade agreed to this proposal. John, however, said that he needs to discuss this proposal and the proposed sampling locations with his technical support and will report back to the Team if USEPA agrees. The Team reviewed the proposed groundwater monitoring well sample locations and agreed to the number of samples and to analyze samples for total and dissolved metals.

3. ***Do site media pose a potentially unacceptable risk to human health?***

   Proposal: Existing and proposed soil (surface and subsurface) and proposed groundwater data will be evaluated in a baseline Human Health Risk Assessment (HHRA). The Team agreed, with the exception of John needing to check with his technical support about eliminating the SI DPT groundwater data from evaluation in the RI.

4. ***Is there any additional data that can be collected to refine the HHRA?***

   Proposal: At least five surface soil, subsurface soil, and groundwater samples will be collected and analyzed for total chromium and hexavalent chromium. The Team agreed.

5. ***Do soil and groundwater pose a potentially unacceptable risk to ecological receptors?***

   Proposal: Existing and proposed soil (surface and subsurface) data will be evaluated in an Ecological Risk Assessment (ERA) (through Step 3a). In addition, all surface soil samples (0-6 inches below ground surface [bgs]) will be analyzed for sieve grain size, and all surface and subsurface soil samples collected within 24 inches bgs will be analyzed for pH and total organic carbon (TOC). The Team agreed. *In addition, it was proposed that groundwater data collected during the RI will not be used in the ERA, because Penniman Lake will not be evaluated as part of the AOC 6 RI, but as part of a separate Penniman Lake RI. Therefore, there is no ecological receptor exposure to groundwater at AOC 6.* The Team agreed to not to include the groundwater data in the ERA in this RI.

6. ***Is further action (i.e., further investigation, removal, or remediation) warranted at this site based on the results of this study?***

   Proposal: Further action will be recommended based on the determination of the nature and extent of contamination, findings of the human health and ecological risk assessments, exceedances of groundwater maximum contaminant levels (MCLs), and the expected future use of the site. The Team agreed.

   Laura went over the summary of the samples and sample locations proposed. The Team agreed.

Action Items:

- John to discuss not including the temporary monitoring well groundwater results collected as part of the SI with his technical support. *On December 22, 2011, the USEPA agreed to not use the 2008 SI DPT groundwater results in the RI.*
- John to discuss proposed RI monitoring well locations with his hydrologist. *Upon consultation with USEPA's hydrogeologist, the proposed monitoring well locations at the AOC 6 TNT subareas were approved by the USEPA via email on December 22, 2011.*
- Navy and USEPA to discuss with their human health specialists if hexavalent chromium not detected in soil, would it be expected in the groundwater or can infer it would not be OR should analyze for it separately because of the different media? *Based on the outcome of discussions with their human health specialists, the USEPA and Navy conducted a separate scoping session in January 2012 to discuss hexavalent chromium speciation. The results of this scoping session are included in* ***Section 2.1.2****, as follows.*

2.1.2 January 2012 Scoping Session

TABLE 3
January 2012 Scoping Session

Project Name: AOC 6 TNT subareas RI			**Site Name:** AOC 6 TNT subareas	
Projected Date(s) of Sampling: Fall 2012			**Site Location:** CAX	
Project Manager: Laura Lampshire				
Date of Session: 1/18/12				
Scoping Session Purpose: Chromium Speciation Sampling				
Name	**Title**	**Affiliation**	**Phone #**	**E-mail Address**
John Burchette	RPM	USEPA Region 3	(215) 814-3378	burchette.john@epa.gov
Wade Smith	RPM	VDEQ	(804) 698-4125	wade.smith@deq.virginia.gov
Krista Parra	RPM	NAVFAC Mid-Atlantic	(757)-341-0395	krista.parra@navy.mil
Marlene Ivester	AM	CH2M HILL	(757) 671-1634	marlene.ivester@ch2m.com
Stephanie Sawyer	Deputy AM	CH2M HILL	(757) 671-6273	stephanie.sawyer@ch2m.com
Anita Dodson	Navy CLEAN Program Chemist	CH2M HILL	(757) 671-6218	anita.dodson@ch2m.com

Comments/Decisions:

Krista led the discussion to review the appropriate number of soil samples to collect for hexavalent chromium analysis for CAX Site 4, AOC 6, and AOC 8.

Krista informed the Team that her human health tech support said collecting two, instead of five, samples for hexavalent chromium speciation in soil is sufficient for each site; however, John preferred three samples for stats. Krista mentioned the hexavalent chromium results from each site would be used to create a base-wide number. John and Wade were fine with this approach. Stephanie added that the two samples collected for hexavalent chromium analysis at each site will be collected from the areas of the highest chromium concentrations in the SI samples. Krista proposed no sampling for hexavalent chromium in groundwater, unless there is a known site source. John agreed and added that his human health tech support said most of the time hexavalent chromium, not trivalent, is what you see in groundwater. John suggested doing one surface and one subsurface soil sample at each site for the hexavalent chromium analysis so we can get a number for both intervals. However, this was not agreed to by the Team.

Based on this discussion, the Team agreed at AOC 6 to collect one surface soil sample, instead of five, near SI location SO03, and two, instead of five, subsurface soil samples near SI locations SO03 and SO01 for total and hexavalent chromium analysis. Groundwater samples will not be analyzed for hexavalent chromium.

2.1.3 March 2012 Scoping Session

TABLE 4
March 2012 Scoping Session

Project Name: AOC 6 TNT subareas RI		**Site Name:** AOC 6 TNT subareas		
Projected Date(s) of Sampling: Fall 2012		**Site Location:** CAX		
Project Manager: Laura Lampshire				
Date of Session: 3/21/12				
Scoping Session Purpose: AOC 6 Scoping Session (email correspondence)				
Name	**Title**	**Affiliation**	**Phone #**	**E-mail Address**
John Burchette	RPM	USEPA Region 3	(215) 814-3378	burchette.john@epa.gov
Wade Smith	RPM	VDEQ	(804) 698-4125	wade.smith@deq.virginia.gov
Scott Park	RPM	NAVFAC Mid-Atlantic	(757)-341-0481	scott.park@navy.mil
Marlene Ivester	AM	CH2M HILL	(757) 671-1634	marlene.ivester@ch2m.com
Stephanie Sawyer	Deputy AM	CH2M HILL	(757) 671-6273	stephanie.sawyer@ch2m.com
Laura Lampshire	PM	CH2M HILL	(301) 570-1042	laura.lampshire@ch2m.com

Comments/Decisions:

On March 21, 2012, Krista e-mailed the Team on behalf of the Navy requesting that the semivolatile organic compound (SVOC) analysis for the surface and subsurface soil samples be removed from the AOC TNT subareas RI UFP-SAP since: (1) 2,4-dinitrotoluene (DNT) is the only SVOC constituent that exceeded risk screening criteria in the soil samples, (2) the exceedances occurred at only one sample location, and (3) 2,4-DNT is included as a constituent in the explosives analysis proposed for the RI. The VDEQ and USEPA responded back via email with their approval of this proposal on March 29, 2012 and April 9, 2012, respectively.

2.1.4 June 2013 Scoping Session

TABLE 5
June 2013 Scoping Session

Project Name: AOC 6 TNT subareas RI	**Site Name:** AOC 6 TNT subareas
Projected Date(s) of Sampling: Fall 2013	**Site Location:** CAX
Project Manager: Laura Lampshire	
Date of Session: 6/4/2013	
Scoping Session Purpose: CAX Partnering Team conference call to review the additional comments provided by the EPA on April 29, 2013, on the Draft SAP and to reach consensus on the responses	

Name	Title	Affiliation	Phone #	E-mail Address
Susanne Haug	RPM	USEPA Region 3	(215) 814-3394	haug.susanne@epa.mail.epa.gov
John McCloskey	Ecological Risk Assessor	US Fish and Wildlife Service (USEPA Region 3 Biological Technical Assistance Group [BTAG])	(804) 693-6694 x116	john.mccloskey@fws.gov
Peter Knight	Ecological Risk Assessor	National Oceanic Atmospheric Administration (NOAA) (USEPA BTAG)	(215) 814-3321	peter.knight@noaa.gov
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The CAX Partnering Team, including technical support personnel, conducted a conference call June 4, 2013 to discuss the additional comments provided by the USEPA on April 29, 2013, following their review of the Navy's responses to their comments on the Draft SAP. Based on the discussion, the Team agreed to: (1) add food web modeling to the ecological risk assessment; (2) collect 3-point composite surface and subsurface soil samples within the Catch Box Ruins, starting at the lowest point at the surface and continuing until groundwater is reached; and (3) field check the former TNT Graining House Sump for residual material (from former ordnance plant processes and not organic material), and if present, collect a composite sample.

2.2 Conceptual Site Model

The conceptual site model (CSM) for the AOC 6 TNT Graining House Sump and TNT Catch Box Ruins subareas is based on data evaluated in the SI. Due to the geographical proximity of the AOC 6 TNT Graining House Sump and the TNT Catch Box Ruins, these two subareas were included together during the SI and are herein referred to as the AOC 6 TNT subareas (**Figure 2**). This CSM incorporates the site background and history, physical setting, distribution of contamination, release history, potential migration pathways, and the potential exposure pathways and receptors. The CSM figure for the AOC 6 TNT subareas is provided as **Figure 3**.

2.2.1 Site Background and History

CAX encompasses 2,300 acres east of Williamsburg, between Interstate 64 and the York River on the York-James Peninsula (**Figure 1**). CAX is located on the site of the former DuPont Company Penniman facility and is currently

used to supply Atlantic Fleet ships and provide recreational opportunities to military and civilian personnel. AOC 6 is comprised of five non-contiguous subareas, each less than 1 acre, related to the former Penniman Shell Loading Plant (PSLP). The PSLP was an explosives manufacturing facility operated by the DuPont de Nemours Company on what is now CAX and adjacent properties. This facility operated as a TNT manufacturing plant beginning in approximately 1916, and subsequently began loading artillery shells for the war effort in 1918. Between 1918 and 1925, following the end of World War I, this facility was demolished and reverted to farmland. The Navy established CAX on a portion of this property in 1942 (Weston, 1999).

In August 2000, the USEPA and Navy agreed to investigate five non-contiguous subareas of the PSLP. These five subareas (1918 Drum Storage Area, Ammonia Settling Pits, TNT Graining House Sump, TNT Catch Box Ruins, and Waste Slag Material) comprise AOC 6 (Penniman AOC), and are located within the vicinity of the former shell loading area, south of Sanda Avenue (formerly DuPont's "G" plant) on Navy property (Weston, 1999) (**Figure 2**). The AOC 6 TNT subareas, comprised of the former TNT Graining House Sump and TNT Catch Box Ruins and located along the southwest bank of Penniman Lake (**Figure 2**), are the only subareas being investigated as part of this RI; the other three AOC 6 subareas will be evaluated separately.

The history of the AOC 6 TNT subareas is unknown. The subareas were originally identified as potential waste sources by Weston through a review of historical aerial photographs, engineering drawings, and site reconnaissance visits (Weston, 1999). In 1999, waste samples were collected from each of the TNT subareas and analyzed for Target Compound List (TCL) Organics (volatile organic compounds [VOCs], semivolatile organic compounds [SVOCs], pesticides, and polychlorinated biphenyls [PCBs]), Target Analyte List (TAL) metals, cyanide, and explosives. The results indicated that detections of one explosive and several metals exceeded the 1999 USEPA Region 3 risk-based concentrations, were summarized in the Final Site Inspection Narrative Report for the Penniman Shell Loading Plant (Weston, 1999), and were reviewed as part of the SI Work Plan (CH2M HILL, 2008).

In 2008, SI field activities were conducted and included surface and subsurface soil sampling, groundwater sample collection via DPT, and surface water and sediment (surface and subsurface) sampling from nearby Penniman Lake. The soil and sediment samples were analyzed for SVOCs, explosives, metals, and cyanide; the groundwater and surface water samples were analyzed for SVOCs, explosives, metals (total and dissolved), cyanide (total and dissolved), and hardness (surface water only). Since VOCs, SVOCs, pesticides, and PCBs were not found to be potential constituents of concern during the 1999 SI, these analyses were not carried forward in the recent SI, except for SVOCs, which were added at the request of the USEPA. The sample results were evaluated as part of the 2012 SI Report and indicated that potentially unacceptable human health and/or ecological risks were associated with exposure to explosives and metals in soil and metals in groundwater; therefore an RI was recommended. Because no potential human health or ecological risks were identified for the sediment and surface water data and an RI for Penniman Lake is planned, no further action with respect to AOC 6 was recommended for these media as part of AOC 6 (CH2M HILL, 2012).

A geophysical survey was conducted in April 2010 around the AOC 6 Ammonia Settling Pits, TNT Graining House Sump, and TNT Catch Box Ruins subareas to address USEPA's concerns as to whether the buildings in these areas had underground piping connecting them to each other or to other PSLP buildings for the transfer of explosives materials. The results of the geophysical survey indicated there is no evidence of underground piping at any of the three subareas (CH2M HILL, 2012).

2.2.2 Physical Setting

The AOC 6 TNT subareas are wooded and moderately vegetated with shrubs. In general, the topography of the AOC 6 TNT subareas is gently undulating with a somewhat abrupt topographic descent along the shoreline of Penniman Lake. Surficial runoff from the AOC 6 TNT subareas flows primarily east toward Penniman Lake and southeast toward King Creek. The presumed directions of groundwater and surface water flow are illustrated in the CSM (**Figure 3**).

The area encompassing the AOC 6 TNT subareas is approximately 0.5 acre in size. In general, soil in the vicinity of the subareas consists of brown silt and olive brown clay, underlain by yellow sand (CH2M HILL, 2012). Based on

the limited stratigraphy observed during the DPT temporary monitoring well installations in 2008, the shallow aquifer underlying the AOC 6 TNT subareas is interpreted to be the Yorktown-Eastover aquifer, and during the SI field activities, groundwater was encountered between approximately 8 and 10 feet bgs. Groundwater is expected to flow east to the adjacent Penniman Lake and southeast toward King Creek.

The AOC 6 TNT subareas are located within the confines of CAX and access is restricted to the general public. Navy and DoD personnel do have access to the AOC 6 TNT subareas and they are currently used by Navy and DoD personnel for recreational activities such as jogging, hunting, and fishing. Future land use at the AOC 6 TNT subareas is not expected to change and will likely continue as recreational in the foreseeable future.

2.2.3 Distribution of Contamination

Based on the results of the 2008 SI, 1 SVOC (2,4-dinitrotoluene [DNT]), six explosives (1,3-dinitrobenzene; 2,4,6-TNT; 2-amino-4,6-dinitrotoluene; 2-nitrotoluene; 3,5-dinitroaniline; and 4-amino-2,6-dinitrotoluene), and 10 metals (aluminum, arsenic, chromium, iron, lead, mercury, selenium, thallium, vanadium, and zinc) were detected in surface and/or subsurface soil at concentrations exceeding the base background 95 percent upper tolerance levels (95% UTLs), adjusted residential and industrial risk screening levels (RSLs) and/or site specific ecological screening values (ESVs) (CH2M HILL, 2012). Specifically, exposure to surface soil may result in unacceptable human health risks associated with 2,4-dinitrotoluene, 2,4,6-TNT, 2-nitrotoluene, arsenic, and chromium and exposure to subsurface soil may result in unacceptable human health risks associated with 2,4-DNT, 2,4,6-TNT, arsenic, and chromium. Potential unacceptable ecological risks were identified with exposure to surface soil attributable to 2-nitrotoluene, 2,4,6-TNT, and selenium, and to subsurface soil attributable to 2,4,6-TNT and selenium. The spatial distribution of the SI soil locations did not encompass the western and northeastern portions of the site. Therefore, additional soil data are required to close these data gaps and supplement the existing dataset in order to adequately characterize the potential impacts from the known source areas to soil. Since the one SVOC (2,4-DNT) will be included under the explosives analysis, the RI soil samples will be analyzed for explosives and metals, as described in **Section 2.3.3.**

In groundwater, 13 total metals (aluminum, arsenic, beryllium, chromium, cobalt, copper, iron, lead, manganese, nickel, silver, vanadium, and zinc) and 10 dissolved metals (aluminum, arsenic, chromium, cobalt, copper, iron, lead, manganese, silver, and thallium) exceeded the base background 95% UTLs, adjusted Tap Water RSLs, and/or MCLs (CH2M HILL, 2012). Specifically, exposure to groundwater may result in unacceptable human health risks associated with aluminum, arsenic, beryllium, chromium, cobalt, iron, lead, manganese, and vanadium. Potential unacceptable ecological risks were identified with exposure to groundwater attributable to aluminum and iron (**Appendix B**). Additional data are required to adequately characterize the potential impacts from the known source areas to groundwater, as described in **Section 2.3.3.**

The 2008 SI data indicate that exposure to surface water and sediment in Penniman Lake adjacent to the AOC 6 TNT subareas would not be expected to result in any unacceptable human health or ecological risks. However, based on the limited surface water and sediment data from the AOC 6 TNT subareas and per Team agreement (November 2011 scoping session), any future investigation of Penniman Lake surface water and sediment will be evaluated as part of a separate Penniman Lake RI and these media will not be sampled during this RI.

2.2.4 Release History

Potential historical leakage or discharge from the former TNT Graining House sump and/or TNT Catch Boxes are the primary known and suspected sources of contamination at the AOC 6 TNT subareas (**Figure 3**).

2.2.5 Potential Migration Pathways

The principle contaminant release and transport mechanisms from source areas include potential leaks from the former TNT Graining House sump and/or TNT Catch Boxes and leaching from soil to groundwater as a result of rainwater infiltration. Where contaminants are exposed at the ground surface, transport could also occur through surface water runoff.

2.2.6 Potential Exposure and Receptor Pathways

Potential human receptors exposed to soil and groundwater at the AOC 6 TNT subareas include:

- Surface Soil – Current Base Workers and Adult and Child Recreational Users
- Surface and Subsurface Soil – Potential Future Base Workers, Adult and Child Recreational Users, Construction Workers, and Adult and Child Residents
- Groundwater – Future Base Workers, Construction Workers, and Adult and Child Residents
- Residual Sump Material (if present within the Graining House Sump) – Current and Future Base Workers and Adult and Child Recreational Users

The potential human health receptors may be exposed to site related contaminants in soil through ingestion of soil, inhalation of particulate emissions from soil, and dermal contact with soil; in groundwater through ingestion of and dermal contact with groundwater; and in residual material within the Graining House Sump (if present) through ingestion and dermal contact.

Potential human receptors may also be exposed to site-related constituents in the surface water and sediment in Penniman Lake. However, surface water and sediment sampling are not included in this RI, as exposure to Penniman Lake surface water and sediment will be evaluated in the Penniman Lake RI.

Potential ecological receptors exposed to surface soil at the AOC 6 TNT subareas include lower trophic level terrestrial receptors (i.e., soil invertebrates, terrestrial plants, and reptiles). Due to the small size of the potentially impacted area, potential exposures for upper trophic level receptors (i.e., birds and mammals) are not likely to be significant but will also be evaluated (see **Section 2.3.2.2**). Ecological receptors may also be exposed to residual material within the Graining House Sump (if present). Although the nature of this material is not known, it is assumed that this material (if present) will be the equivalent of freshwater sediment with the potential for exposure to aquatic/benthic invertebrates and amphibians.

Potential ecological receptors exposed to site-related constituents in the surface water and/or sediment in adjacent Penniman Lake (possible transport via surface runoff and groundwater) at the AOC 6 TNT subareas include lower trophic level aquatic receptors (i.e., aquatic/wetland plants, benthic and aquatic invertebrates, fish, reptiles, and amphibians) and upper trophic level receptors (i.e., birds and mammals). However, as previously stated, these potential exposures will be evaluated as part of the Penniman Lake RI.

2.3 Data Quality Objectives/Systematic Planning Process Statements

2.3.1 Project Statement and Objectives

The objective of the RI is to collect additional data to supplement the current SI dataset required to adequately characterize the AOC 6 TNT subareas and evaluate the potential risk to human health and ecological receptors. Field activities will include collecting additional soil, groundwater samples from permanent monitoring wells, and residual sump material (if present) to characterize the two AOC 6 TNT subareas. All soil data evaluated in the 2008 SI (CH2M HILL, 2012) and soil, groundwater, and residual sump material (if present) data collected as part of this RI, will be used to characterize the site and support a HHRA and an ERA.

2.3.2 Data Quality Objectives

Quantifiable analytical results will be the primary basis for project decisions. The limit of quantitation (LOQ), which is defined as the minimum concentration or quantity of a target analyte that can be reported with accurate quantitation, will be the metric to define whether an analytical result is quantifiable.

If the analysis of samples determines that analytes are undetected or if any detected analytes are below the Project Action Limits (PALs), then it will be assumed that the nature and concentrations of these constituents do not pose an unacceptable risk and no further action for them will be necessary.

If the analysis of samples determines that the analytes are detected above the project specific PALs then a quantitative HHRA and ERA will be conducted to identify Chemicals of Potential Concern (COPCs) as follows:

2.3.2.1. Human Health Risk Decision Logic (Figure 4)

Results of the soil sampling will be combined with the soil sample data evaluated in the SI and results of the residual sump material sampling (if present) will be evaluated to determine if there may be unacceptable risks to potential human receptors:

- Soil concentrations will be compared to the adjusted residential soil RSLs (adjusted meaning that RSLs based on non-noncarcinogenic effects are divided by 10 to account for exposure to more than one constituent that effects the same target organ, RSLs based on carcinogenic endpoints are not adjusted). If the maximum detected concentration of a constituent exceeds the applicable RSL, the constituent will be identified as a COPC.
- Residual sump material (if present) concentrations will be compared to 10 times the adjusted residential soil RLs (adjusted meaning that RSLs based on non-noncarcinogenic effects are divided by 10 to account for exposure to more than one constituent that effects the same target organ, RSLs based on carcinogenic endpoints are not adjusted). If the maximum detected concentration of a constituent exceeds the applicable screening level, the constituent will be identified as a COPC.
- If COPCs are identified, human health risks will be evaluated for exposure to the COPCs identified in soil and/or residual sump material for all potential human receptors (e.g., current/future recreational users, current/future industrial workers, and future construction workers [soil only], and residents [soil only]). The 95 percent upper confidence limit (95% UCL) of the mean soil concentration and the concentration in the residual sump material composite soil sample will be used as the exposure concentration for the risk calculations. If all risks are within acceptable USEPA risk levels, no further action/assessment based on human health will be required for soil or residual sump material.
- If potentially unacceptable risks are identified associated with metals, the maximum detected metals concentrations data will be compared to the base background 95 percent upper tolerance limits (95% UTLs) (CH2M HILL, 2011) to determine if the risks are associated with the site or background conditions. If risks are associated with background conditions, no further action or assessment based on human health will be required for metals in soil or residual sump material. If risks are not associated with base background conditions, the constituent will be identified as a constituent of concern (COC).
- If the COPC concentrations exceed the background 95% UTLs, further evaluation will be conducted to consider whether the COPC concentrations may be attributable to a release or may be associated with background conditions (such as comparing site data to the maximum base background concentrations). If the results of this evaluation potentially indicate that site concentrations are not consistent with background conditions, then recommendations for additional investigation and action will be made in the RI report.

Results of the RI groundwater sampling will be evaluated to determine if there may be unacceptable risks to potential human receptors:

- Groundwater concentrations from monitoring wells sample data will be compared to the adjusted tap water RSLs (adjusted meaning that RSLs based on non-noncarcinogenic effects are divided by 10 to account for exposure to more than one constituent that effects the same target organ, RSLs based on carcinogenic endpoints are not adjusted). If the maximum detected concentration of a constituent exceeds the applicable RSL, the constituent will be identified as a COPC.
- If COPCs are identified, human health risks will be evaluated for exposure to the COPCs identified in groundwater for future industrial workers, residents, and construction workers. The 95% UCL of the mean for wells from the most contaminated portion of the groundwater plume (if a plume is identified) will be used as

the exposure concentration for the risk calculations. If all risks are within acceptable USEPA risk levels, no further action/assessment based on human health will be required for groundwater.

- If potentially unacceptable risks are identified associated with metals, the maximum detected metals concentrations will be compared to the base background 95% UTLs to determine if the risks are associated with the site or background conditions. If all risks are associated with background conditions, no further action or assessment based on human health will be required for metals in groundwater. If risks are not associated with base background conditions, the constituent will be identified as a COC.
- If the COC concentrations exceed the background 95% UTLs, further evaluation will be conducted to consider whether the COC concentrations are consistent with background conditions or if they represent a release such that further action is warranted.

Surface water and sediment will not be evaluated as part of the HHRA for this RI. Surface water and sediment will be evaluated as part of a separate Penniman Lake RI.

2.3.2.2. Ecological Risk Decision Logic

Results of the soil and residual sump material (if present) analytical sampling will be evaluated as follows to determine if potential risks to terrestrial receptors may be occurring (**Figure 4**):

- Soil concentrations from each site sample (with a sample depth of less than 2 feet) will be compared to literature-based soil ESVs for plants and/or soil invertebrates. Both the mean and 95% UCL of the mean soil concentrations will be calculated and compared with soil ESVs (samples may be partitioned by spatial area when calculating means), with the 95% UCL used as the primary decision EPC in Step 3A of the ERA (with consideration of the mean and maximum concentrations, as appropriate). If the mean concentration exceeds soil ESVs, then the chemical will be considered a COPC. If it is below the soil ESVs, the chemical will not be considered a COPC, although the magnitude of the maximum hazard quotient (HQ) will also be considered when making this determination.
- If the results of the quantitative ERA (through Step 3a) determine that there is unacceptable potential risk, the COPCs will be compared to the base surface soil background 95% UTLs to determine if the detected concentrations are consistent with the base background concentrations. If the COPCs do not exceed the background 95% UTL, then no further action for the COPCs will be necessary.
- If the COPC concentrations exceed the background 95% UTLs, further evaluation will be conducted to consider whether the COPC concentrations are consistent with background conditions or if they represent a release such that further action is warranted.
- It is assumed that chemical concentrations from the residual material within the Graining House Sump (if present) will be compared to freshwater sediment values, since the sump compartments tend to hold rain water. However, the actual ESVs used will depend upon the environmental conditions encountered and the nature of the collected material. If the detected chemical concentration exceeds the ESV, then the chemical will be considered a COPC. If it is below the ESV, the chemical will not be considered a COPC.
- Food web exposures (for detected bioaccumulative constituents in surface soil) for upper trophic level receptors will also be modeled for terrestrial habitats at the AOC 6 TNT Subareas. Terrestrial receptors may include: (1) meadow vole; (2) short-tailed shrew; (3) white-footed mouse; (4) red fox; (5) American robin; and (6) red-tailed hawk. If maximum exposure doses (calculated using maximum surface soil concentrations) exceed no observed adverse effect level (NOAEL)-based ingestion toxicity reference values (TRVs), the chemical will be identified as an initial COPC. Mean and 95% UCL-based exposure doses (for bioaccumulative chemicals) will also be calculated and compared with NOAEL, lowest observed adverse effect level (LOAEL), and Maximum Acceptable Toxicant Concentration (MATC)-based TRVs. If the MATC-based HQ equals or exceeds one based upon the mean and/or 95% UCL soil concentration, the chemical will be identified as a refined COPC. Appropriate Area Use Factors [AUFs] may be applied when selecting refined COPCs.

Groundwater and Penniman Lake surface water and sediment data will not be evaluated as part of the ERA for this RI and will be evaluated as part of a separate Penniman Lake RI.

2.3.3 What are the environmental questions being answered?

The following environmental questions will be answered in the RI.

- **What is the nature and extent of contamination in soil?** There are seven existing surface soil samples and seven existing subsurface soil samples that were collected and evaluated in the 2008 SI (CH2M HILL, 2012). These data will be used to aid in determining the nature and extent of contamination at the site. However, additional soil data are necessary for expanded spatial coverage to adequately characterize this medium.

  The following work is proposed to answer this environmental question: To supplement the existing soil data, 13 co-located surface (0 to 6 inches) and subsurface (6 to 24 inches) soil samples will be collected from the AOC 6 TNT subareas at soil sample locations CAA06-SO28 through CAA06-SO34 and from the soil borings for monitoring well locations CAA06-MW01 through CAA06-MW06 (**Figure 5**) and analyzed for explosives and metals. The surface samples also will be analyzed for pH, TOC and sieve grain size, and the subsurface samples also will be analyzed for pH and TOC to assist in completing the ERA. At soil sample location CAA06-SO27, a surface (0 to 6 inches) and a subsurface (6 to 24 inches) soil sample will be collected and analyzed for total and hexavalent chromium to assist with the HHRA.

  To account for the potential variability of contaminant concentrations within the Catch Box Ruins and to address the potential for contamination at depths below 24 inches, 3-point composite soil samples will be collected from the surface of the depression (0 to 6 inch-interval) and from the subsurface at two-foot intervals (except for the first interval at 6 to 24 inches bgs) until groundwater is reached (anticipated to be around 10 feet bgs). The 3-point composite samples will be collected from the lowest portion and center of the Catch Box Ruins, with the vicinity of SI location CAA06-SO01 as the center point and a location to the north and south of it as the other two points (location CAA06-SO01 is where the highest detections of explosives and metals were observed in surface and subsurface soil during the SI). All of the composite samples will be field composited and analyzed for explosives and metals. The surface composite sample also will be analyzed for pH, TOC and sieve grain size, and the subsurface composite sample from the 6 to 24-inch interval also will be analyzed for pH and TOC to assist with the ERA. In addition, at the center point (vicinity of SI location CAA06-SO01), a discrete surface (0 to 6 inches) and a discrete subsurface (6 to 24 inches) soil sample will be collected and analyzed for total and hexavalent chromium to assist with the HHRA.

- **What is the nature and extent of contamination in groundwater and the groundwater flow direction and velocity?** There are four existing DPT groundwater samples that were collected and evaluated in the 2008 SI (CH2M HILL, 2012). These data were used to site the six proposed RI monitoring well locations. However, because the SI groundwater samples were collected from temporary monitoring wells using DPT rather than permanent monitoring wells, the 2008 SI groundwater data may not be representative of current groundwater concentrations. Therefore, these data will not be evaluated in the RI to aid in determining the nature and extent of contamination at the site. Additional groundwater data are necessary to adequately characterize this medium.

  The following work is proposed to answer this environmental question: Six permanent monitoring wells, CAA06-MW01 through CAA06-MW06 (**Figure 5**), will be installed in the AOC 6 TNT subareas and six groundwater samples will be collected and analyzed for metals (total and dissolved). The six groundwater samples will also be analyzed for natural attenuation parameters (wet chemistry parameters – alkalinity, chloride, nitrate, nitrite, sulfate, sulfide, methane, TOC, and pH) to support a natural attenuation evaluation, if necessary.

  Although the RI soil samples will be analyzed for SVOCs and explosives, the groundwater samples will not be analyzed for these parameters because none of these constituents were detected in groundwater at similar locations during the recent SI. In addition, the release occurred nearly 100 years ago, such that if soil

contaminants were present at concentrations sufficient to allow significant migration from soil to groundwater, the SI results would have provided evidence of that result given that groundwater is only approximately 8 to 10 feet bgs and the matrix is sandy. Furthermore, the water solubility of 2,4,6-TNT, the explosive constituent with the highest concentrations in soil in October 2008, is relatively low and "in the case of impact areas, the majority of the TNT may be degraded in the surface soil, but small quantities can reach shallow ground water" (USEPA, 2012).

In addition, the monitoring wells will be gauged and slug tests will be conducted in order to determine the groundwater flow direction and velocity.

- **Do site media pose a potentially unacceptable risk to human health?** Soil (surface and subsurface) and groundwater data from the 2008 SI were evaluated to determine if detected constituents could potentially pose a risk to human health (CH2M HILL, 2012). This evaluation was conducted to allow for a "look-ahead" to identify what the likely risk drivers would be at the AOC 6 TNT subareas. Based on the results of this evaluation, explosives and metals were identified as constituents that could potentially pose a risk to human health in soil (surface and subsurface) and metals were identified as constituents that could potentially pose a risk to human health in groundwater. Based on spatial coverage of the existing and proposed data set, no additional soil and groundwater sampling is necessary to adequately assess the potential risk to human health.

  The following work is proposed to answer this environmental question: A baseline HHRA will be completed to determine if site contaminants in soil and groundwater potentially pose an unacceptable risk to human health. The 2008 SI soil data and soil and groundwater data collected as part of this RI will be evaluated in the baseline HHRA.

- **Is there any additional data that can be collected to refine the HHRA?** Results of the human health risk evaluation in the 2008 SI (CH2M HILL, 2012) indicated that exposure to chromium in soil (surface and subsurface) and groundwater may pose potential risk to human health. However, in performing the risk evaluation, it was assumed that all of the chromium detected in these media is in the hexavalent form, which is unlikely since chromium is generally found in natural soil in the trivalent form, unless activities at the site have resulted in the release or formation of hexavalent chromium. Therefore, chromium speciation data are needed to assess the potential risk to human health due to exposure to soil. As agreed during the January 2012 Partnering Meeting (**Section 2.1.2)**, no sampling for hexavalent chromium in groundwater is proposed at AOC 6 since a known source for this constituent has not been identified at the AOC 6 TNT subareas.

  The following work is proposed to answer this environmental question: Discrete surface (0 to 6 inches) and subsurface (6 to 24 inches) soil samples will be collected from RI sample locations CAA06-SO026 and CAA06-SO027 (**Figure 5**) and analyzed for total and hexavalent chromium. These two sampling locations are in the vicinity of the SI sample locations that had the highest chromium detections (i.e., CAA06-SO01 and CAA06-SO03).

- **Do soil and groundwater pose a potentially unacceptable risk to ecological receptors?** Soil (surface and subsurface) and groundwater data from the 2008 SI (CH2M HILL, 2012) were evaluated to determine if detected constituents could potentially pose a risk to ecological receptors. This evaluation was conducted to allow for a "look-ahead" to identify what the likely risk drivers would be at the AOC 6 TNT subareas. Based on the results of this evaluation, explosives and metals were identified as constituents that could potentially pose a risk to ecological receptors in surface and subsurface soil. In addition, select metals were identified as constituents that could potentially pose a risk to ecological receptors in groundwater (transport to Penniman Lake). As agreed upon by the CAX Partnering Team, groundwater analytical data will not be evaluated as part of the ERA because Penniman Lake will not be evaluated as part of the AOC 6 TNT subareas RI, but as part of a separate Penniman Lake RI. Therefore, there is no ecological receptor exposure to groundwater at the AOC 6 TNT subareas. However, additional soil data are necessary to complete an ERA and adequately assess the potential risk to ecological receptors.

The following work is proposed to answer this environmental question: An ERA (through Step 3A) will be completed to determine if site contaminants in soil could potentially pose an unacceptable risk to ecological receptors. All existing site soil data and soil data collected as part of this RI will be evaluated in the ERA; however, the ERA will only consider soil data collected within 2 feet of the ground surface. In addition, groundwater data collected during the 2008 SI and as part of this RI will not be evaluated in the ERA, because ecological receptors do not have direct exposure to groundwater. Penniman Lake is located adjacent to the site; however, any potential ecological risk associated with exposure to surface water and sediment within Penniman Lake will be evaluated as part of a separate Penniman Lake RI.

- **Is there residual material from site operations remaining in the Graining House Sump, and if so, does it pose a potentially unacceptable risk to human health and/or ecological receptors?** During draft SAP comment resolution, the EPA speculated whether or not there was residual material from the former ordnance plant processes (and not organic material) remaining within the Graining House Sump compartments. Given that the plant was in operation nearly 100 years ago, was dismantled in the 1920s, and the compartments are exposed to the elements, it is doubtful there is any residual material present. However, the CAX Partnering Team agreed to field verify this.

  The following work is proposed to answer this environmental question: The field crew will check the Graining House Sump compartments for residual material potentially related to site operations. If present, a composite sample will be collected and analyzed for the same parameters as for surface soil (except grain size). The results will be evaluated in the HHRA and ERA.

- **Is further action (i.e., further investigation, removal or remediation) warranted at this site based on the results of this study?** Further action will be recommended based on the determination of the nature and extent of contamination, findings of the human health and ecological risk assessments, exceedances of groundwater maximum contaminant levels (MCLs), and the expected future use of the site.

  The following work is proposed to answer this environmental question: Soil and groundwater data will be collected during the RI, and along with soil analytical data from the 2008 SI, will be used to determine the nature and extent of contamination at the AOC 6 TNT subareas and to complete a baseline HHRA and ERA (through Step 3A). As previously stated, groundwater data will not be evaluated during the ERA. The results of the RI, to include the risk assessments and proposed recommendations, will be documented in an RI Report.

2.3.4 What are the Project Action Limits?

The detected soil, groundwater, and residual sump material (if present) data will be compared to the following PALs to identify COPCs:

1. Surface Soil: USEPA adjusted Residential Soil RSLs and literature-based ecological soil screening values for plants and soil invertebrates
2. Subsurface Soil: USEPA adjusted Residential Soil RSLs and literature-based ecological soil screening values for plants and soil invertebrates (if less than 2 feet).
3. Residual Sump Material: Ten times the USEPA adjusted Residential Soil RSLs and literature-based ecological soil screening values for plants and invertebrates (freshwater sediment values may be used for residual sump material, if present, depending upon the environmental conditions encountered and the nature of the material).
4. Groundwater: USEPA adjusted Tap-water RSLs and Federal Maximum Contaminant Levels (MCLs).

Identified COPCs will be used in a quantitative HHRA (in accordance with USEPA guidance) and an ERA (through Step 3A) to calculate potential risks to human and ecological receptors, and to identify baseline COPCs for each medium.

The COPC concentrations will also be compared to the background 95% UTLs (CH2M HILL, 2011), where available and applicable, to determine if the detected concentrations are consistent with the base background concentrations. If the COPC concentrations exceed the background 95% UTL, further evaluation will be conducted to consider whether the COPC concentrations may be attributed to a release or may be associated with background conditions (such as comparing site data to the maximum base background concentrations). If the results of this evaluation potentially indicate that site concentrations are not consistent with background conditions, then the COPC concentrations may be attributed to a release and the COPC should be considered a site-related COC.

Specific PAL values and laboratory detection and quantitation limits (QLs) are included in the Reference Limits and Evaluation Tables (**Appendix A, Tables A-1 through A-7**). Additionally, the specific reference for each ESV is included in **Attachment 1** of **Appendix A**.

2.3.5 How will the data be used?

Groundwater data (i.e., water level data, hydraulic slug tests) will be used to determine the general groundwater conditions, including depth to water, rate of groundwater flow and direction of groundwater flow. In addition, the lithologic data collected in the field during monitoring well installation will be used to verify the depth of the Yorktown-Eastover aquifer underneath the site and support conclusions regarding fate and transport of contaminants in groundwater. This information will be incorporated into the CSM for the site and utilized in the discussion of contaminant fate and transport.

The existing and proposed soil and groundwater data, and the residual sump material data (if present), will be used to determine the nature and extent of contamination at the AOC 6 TNT subareas and will be used to appropriately assess potential human health (soil, residual sump material, and groundwater) and ecological (soil and residual sump material) risks at the site. The HHRA will estimate the likelihood of adverse impacts to current and potential future users of the site based on the current and potential future use of the site. The ERA will estimate the likelihood of adverse impacts to ecological receptors that may use the site.

Wet chemistry soil data (TOC, pH, and grain size) will be collected to further characterize the soil medium. Wet chemistry groundwater data (chloride, nitrate, nitrite, sulfate, sulfide, alkalinity, methane, TOC, and pH, as well as dissolved oxygen and ferrous iron) will be collected to characterize aquifer conditions regarding natural attenuation indicators.

One Toxicity Characteristic Leaching Procedure (TCLP) soil and one TCLP groundwater sample will be collected to characterize investigation-derived waste (IDW) media for disposal purposes.

2.3.6 What types of data are needed?

Section 2.5 contains detailed information on the types of data needed for this project, including sample locations and sample depth intervals. In general, additional analytical soil and groundwater data are required for this project to determine the nature and extent of contamination and to complete the HHRA and ERA. All analytical samples will be submitted to an offsite subcontracted laboratory for analysis. Refer to **Section 2.5** and **Section 3** for sample locations, numbers, rationale, and methodology. Sample locations are provided on **Figure 5**.

2.3.7 Are there any special data quality needs, field or laboratory, in order to support environmental decisions?

The data will be used in the HHRA and ERA to make further investigation/action decisions; therefore, the validator will qualify the data according to the Measurement Performance Criteria (MPC) outlined in **Section 2.4** for field QC samples and the Laboratory QC Samples Table in **Appendix A** for laboratory QC samples. These MPC are consistent with the DoD Quality Systems Manual (QSM) as applicable and laboratory in-house limits where the QSM does not apply.

The data collected from the AOC 6 TNT subareas will be validated internally by CH2M HILL. This process is outlined in **Section 2.3.9**.

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

Detailed information on where, when, and how the data will be collected is provided in **Section 3**. Data generated at the subcontract laboratory(s) will be reported in a data package equivalent to an USEPA Contract Laboratory Program (CLP) level IV deliverable, as is required for these data. This data package includes a case narrative, all field sample results, QC forms, and raw data. An electronic data deliverable (EDD) will also be required.

2.3.9 How will the data be evaluated?

Data will undergo an evaluation for quality and completeness at the laboratory and will be validated by CH2M HILL data validators. Specific verification and validation steps are detailed in **Table 6**, *Data Verification and Validation (Steps I and IIa/IIb) Process Table* (**Section 2.3.11**). In general:

- Deviations from the SAP will be reviewed to assess whether CA is warranted and to assess impacts to the achievement of project objectives.
- To assess whether a sufficient quantity of acceptable data are available for decision-making, the data will be reconciled with MPC following validation and review of Data Quality Indicators (DQIs).
- For duplicate sample results, the most conservative detected value will be used for project decisions.
- Field and laboratory precision will be compared as Relative Percent Difference (RPD) between the two results.
- For statistical comparisons non-detect values will be represented by a concentration equal to one-half the sample reporting limit.

2.3.10 How will the data usability be documented?

The PM, PC, and other team members will be responsible for compiling the data. The data will then be presented to the CAX Partnering Team who, as a whole, will evaluate the data usability according to project objectives. Any qualifications made to the data during data validation will be included for consideration; possible qualifications that may be applied to the data during validation are as follows:

- When major QC deficiencies are encountered, data will be qualified with an R and in most cases is not considered usable for project decisions. If R-qualified data are used in evaluations and, ultimately, project decisions, the rationale for their use will be included in the RI Report. The R-qualifier is defined as follows:
  - R = Rejected result. Result not reliable.
- For minor QC deficiencies that will not affect the usability of the data, data may be qualified as estimated with the following qualifiers: J, UJ, K, L, or UL. These qualifiers are defined as follows:
  - J = Analyte present. Reported value may or may not be accurate or precise.
  - UJ = Analyte not detected. Quantitation limit (QL) may be inaccurate or imprecise.
  - K = Analyte present. Reported value may be biased high. Actual value is expected to be lower.
  - L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.
  - UL = Analyte not detected. QL is probably higher.
- Additional qualifiers that may be applied to data by the validator are:
  - B = Not detected substantially above the level reported in laboratory or field blanks. This detection is attributed to blank contamination and is to be treated as a non-detect.
  - N = Tentative identification. The analyte is considered present, though special methods may be needed to confirm its presence or absence in future sampling efforts.
  - NJ = Qualitative identification is questionable due to poor resolution. Presumptively present at approximate quantity.
  - U = Not detected.

Data usability will be documented in data tables and discussed in the data quality evaluation, both of which will be provided as part of the RI report. Data tables will reflect the reported concentration of analytes, whether the analyte was detected, and what, if any, data qualifiers accompany the result. The data quality evaluation will discuss the use of specific data qualifiers and their impact on decision-making, the overall quality of the data set, and any data usability limitations determined by the CAX Partnering Team.

2.3.11 Data Verification and Validation (Steps I and IIa/IIb) Process Table

Data will be collected as detailed in Section 3, and will be reviewed for quality and completeness as detailed in the *Data Verification and Validation (Steps I and IIa/IIb) Process Table* (**Table 6**). More information about data validation and usability is provided in **Section 2.3.10**.

TABLE 6
Data Verification and Validation (Steps I and IIa/IIb) Process Table

Data Review Input	Description	Responsible for Verification	Internal/ External [1]
Field Notebooks	Field notebooks will be reviewed internally and placed into the project file for archival at project closeout.	Field Team Leader/CH2M HILL	Internal
Chains of Custody and Shipping Forms	Chain-of-custody forms and shipping documentation will be reviewed internally upon their completion and verified against the packed sample coolers they represent. The shipper's signature on the chain-of-custody will be initialed by the reviewer, a copy of the chains-of-custody retained in the site file, and the original and remaining copies taped inside the cooler for shipment. Chains-of-custody will also be reviewed for adherence to the SAP by the project chemist.	Field Team Leader/CH2M HILL Project Chemist/CH2M HILL	Internal & External
Sample Condition upon Receipt	Any discrepancies, missing, or broken containers will be communicated to the Project Delivery Manager (PDM) in the form of laboratory logins.	Project Chemist / CH2M HILL	External
Documentation of Laboratory Method Deviations	Laboratory Method Deviations will be discussed and approved by the project chemist. Documentation will be incorporated into the case narrative which becomes part of the final hardcopy data package.	Project Chemist/CH2M HILL	External
Electronic Data Deliverables	Electronic Data Deliverables will be compared against hardcopy laboratory results (10% check).	Project Chemist / CH2M HILL	External
Case Narrative	Case narratives will be reviewed by the data validator during the data validation process. This is verification that they were generated and applicable to the data packages.	Data Validator/CH2M HILL	External
Laboratory Data	All laboratory data packages will be verified internally by the laboratory performing the work for completeness and technical accuracy prior to submittal.	Respective Laboratory Quality Assurance Officer	Internal
Laboratory Data	The data will be verified for completeness by the PDM.	Project Chemist / CH2M HILL	External
Audit Reports	Upon report completion, a copy of all audit reports will be placed in the site file. If corrective actions are required, a copy of the documented corrective action taken will be attached to the appropriate audit report in the QA site file. Periodically, and at the completion of site work, site file audit reports and corrective action forms will be reviewed internally to ensure that all appropriate corrective actions have been taken and that corrective action reports are attached. If corrective actions have not been taken, the site manager will be notified to ensure action is taken.	Project Manager/CH2M HILL Project Chemist/CH2M HILL	Internal
Corrective Action Reports	Corrective action reports will be reviewed by the project chemist or project manager and placed into the project file for archival at project closeout.	Project Manager/CH2M HILL Project Chemist/CH2M HILL	External
Laboratory Methods	Ensure the laboratory analyzed samples using the correct methods.	Project Chemist/CH2M HILL	External
Target Compound List and Target Analyte List	Ensure the laboratory reported all analytes from each analysis group.	Project Chemist/CH2M HILL	External
Reporting Limits	Ensure the laboratory met the project-designated quantitation limits. If quantitation limits were not met, the reason will be determined and documented.	Project Chemist/CH2M HILL	External
Field Standard Operating Procedures (SOPs)	Ensure that all field SOPs were followed.	Field Team Leader/CH2M HILL	Internal
Laboratory SOPs	Ensure that approved analytical laboratory SOPs were followed.	Respective Laboratory Quality Assurance Officer	Internal

TABLE 6
Data Verification and Validation (Steps I and IIa/IIb) Process Table

Data Review Input	Description	Responsible for Verification	Internal/ External [1]
Raw Data	10 percent review of raw data to confirm laboratory calculations.	Data Validator/CH2M HILL	External
Onsite Screening	All non-analytical field data will be reviewed against SAP requirements for completeness and accuracy based on the field calibration records.	Field Team Leader/CH2M HILL	Internal
Documentation of Method QC Results	Establish that all required QC samples were run.	Data Validator/CH2M HILL	External
Documentation of Field QC Sample Results	Establish that all required QC samples were run.	Project Chemist/CH2M HILL	Internal
DoD ELAP Evaluation	Ensure that each laboratory is DoD ELAP Certified for the analyses they are to perform. Ensure evaluation timeframe does not expire.	Project Chemist/CH2M HILL	External
Analytical data for Explosives, Metals (total and dissolved), Mercury (total and dissolved), Cyanide, and Hexavalent Chromium in all matrixes analyzed, e.g. groundwater, surface soil, Residual Sump Material sample (if present), and/or subsurface soil.	Analytical methods and laboratory SOPs as presented in this SAP will be used to evaluate compliance against QA/QC criteria. Should adherence to QA/QC criteria yield deficiencies, data may be qualified. The data qualifiers used are those presented in *Region III Modifications to the National Functional Guidelines for Organic Data Review* (USEPA, September 1994) and in *Region III Modifications to the Laboratory Data Validation Guidelines for Inorganic Data Review* (USEPA, April 1993). National Functional Guidelines will not be used for data validation; however, the specific qualifiers listed therein may be applied to data should non-conformances against the QA/QC criteria as presented in this SAP be identified.	Data Validator/CH2M HILL	External
Analytical data for wet chemistry or grain-size in all matrixes analyzed, e.g. groundwater, surface soil, Residual Sump Material sample (if present), and/or subsurface soil.	Wet chemistry [Natural Attenuation Indicator Parameter (NAIPs)] and grain-size analytical data will not undergo third-party data validation, but are subject to all other data review protocols detailed above.	NA	NA

[1] Internal/External is with respect to the entity that generated the data.

2.4 Field Quality Control Samples

Field QC samples will be collected to assist in evaluating whether the results reported from the field effort meet the precision, accuracy, and representativeness requirements for this project. Presented in **Tables 7A through 7F** are details about the frequency at which each QC sample will be collected, what constitutes acceptable field QC results, and what aspect of data quality is indicated by the outcome of each QC sample.

TABLE 7A
Measurement Performance Criteria Table for Field QC Samples

Matrix: Surface Soil, Subsurface Soil, Residual Sump Material, if present[1]
Analytical Group: Explosives, Metals including Mercury, Cyanide, and Hexavalent Chromium[2]
Concentration Level: Medium / Low

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria
Field Duplicate	Metals including Mercury, Cyanide, and Hexavalent Chromium	1 per 10 field samples	Precision	Relative Percent Difference (RPD) ≤ 20%
Equipment Blank		1 per day of sampling, per type of equipment	Bias/ Contamination	Target analytes ≤ 1/2 LOQ
Cooler Temperature Indicator		1 per cooler to the laboratory	Representativeness	Temperature ≤ 6 degrees Celsius (°C)

[1] Field QA/QC will be collected separately for each matrix listed.
[2] Field QA/QC as described in this table will be collected and analyzed for each of the analytical groups listed.

TABLE 7B
Measurement Performance Criteria Table for Field QC Samples

Matrix: Surface Soil, Subsurface Soil, Residual Sump Material, if present[1]
Analytical Group: Wet Chemistry (TOC, pH)[2]
Concentration Level: Medium

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria
Cooler Temperature Indicator	Wet Chemistry	1 per cooler to the laboratory	Representativeness	Temperature ≤ 6 degrees Celsius (°C)

[1] Field QA/QC will be collected separately for each matrix listed.
[2] Field QA/QC as described in this table will be collected and analyzed for each of the analytical groups listed.

TABLE 7C
Measurement Performance Criteria Table for Field QC Samples

Matrix: Surface Soil
Analytical Group: Grain-size

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria
None	Grain-size	NA	NA	NA

TABLE 7D
Measurement Performance Criteria Table for Field QC Samples

Matrix: Groundwater
Analytical Group: Total Metals including Mercury and Cyanide; Dissolved Metals including Mercury[1]
Concentration Level: Medium / Low

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria
Field Duplicate	Total Metals including Mercury and Cyanide; Dissolved Metals including Mercury	1 per 10 field samples	Precision	Relative Percent Difference (RPD) ≤ 20%
Equipment Blank		1 per day of sampling, per type of equipment	Bias/ Contamination	Target analytes ≤ 1/2 LOQ
Cooler Temperature Indicator		1 per cooler to the laboratory	Representativeness	Temperature ≤ 6 degrees Celsius (°C)

[1] Field QA/QC as described in this table will be collected and analyzed for each of the analytical groups listed.

TABLE 7E
Measurement Performance Criteria Table for Field QC Samples

Matrix: Groundwater
Analytical Group: Wet Chemistry (NAIPs listed in Table A1-8)[1]
Concentration Level: Medium

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria
Cooler Temperature Indicator	Wet Chemistry	1 per cooler to the laboratory	Representativeness	Temperature ≤ 6 degrees Celsius (°C)

[1] Field QA/QC as described in this table will be collected and analyzed for each of the analytical groups listed.

2.5 Sampling Design and Rationale

The CAX Partnering Team met to scope this investigation, as presented in **Section 2.1**. During these meetings, the Team discussed and agreed to the proposed sampling rationale for the AOC 6 TNT subareas. **Figure 5** presents the proposed sample locations for each medium to be evaluated, including the proposed new monitoring well locations. Exact sample locations will ultimately be field-determined, but will be in proximity to the proposed sample locations.

The proposed sampling scheme and associated rationale for the AOC 6 TNT subareas are included in **Table 8**.

QC samples will be collected as described in **Section 2.4**.

Samples from each medium will be analyzed as outlined in **Section 3.2** and will include:

Discrete soil (surface [0 to 6 inches bgs] and subsurface [6 to 24 inches bgs]): explosives, metals, and wet chemistry (for surface soil: TOC, pH, grain size and for subsurface soil: pH and TOC)

Discrete soil (surface [0 to 6 inches bgs] and subsurface [6 to24 inches bgs]): total and hexavalent chromium only

Composite soil (surface [0 to 6 inches bgs] and subsurface [6 inches bgs to groundwater (~10 feet bgs)]): explosives, metals, and wet chemistry (for surface soil: TOC, pH, grain size and for subsurface soil [6 to 24 inches bgs only]: pH and TOC)

Groundwater: total metals, dissolved metals, and wet chemistry (chloride, nitrate, nitrite, sulfate, sulfide, alkalinity, methane, TOC, pH).

Residual sump material from surface of concrete TNT Graining House Sump compartments (if present): explosives, metals, pH, and TOC

Analytical methods to be employed by the laboratory for each analyte and their respective PALs are listed in **Appendix A**.

Section 3.1 provides a detailed outline of the field methods to be performed.

TABLE 8
AOC 6 TNT Subareas Proposed Sampling Scheme and Associated Rationale

Media	Sample Count	Analysis	Rationale
Surface Soil (discrete) (0-6”)	13	Explosives, metals	Collected to provide adequate spatial coverage, determine the nature and extent of contamination, and support an HHRA and ERA
	2	Total and hexavalent chromium	Collected to refine the HHRA
	13	pH, TOC, sieve grain size	Collected to refine the ERA
Subsurface Soil (discrete) (6-24 inches)	13	Explosives, metals	Collected to provide adequate spatial coverage, determine the nature and extent of contamination, and support an HHRA and ERA
	2	Total and hexavalent chromium	Collected to refine the HHRA
	13	pH and TOC	Collected to refine the ERA
Surface Soil (composite) (0-6”)	1	Explosives, metals	Collected to account for the potential variability of contaminant concentrations within the Catch Box Ruins, address the potential for contamination at depths below 24 inches, and support an HHRA and ERA
	1	pH, TOC, sieve grain size	Collected to refine the ERA
Groundwater	6	Total and dissolved metals, nitrate, nitrite, sulfate, sulfide, alkalinity, methane, TOC, pH	Collected to characterize the nature and extent of contamination in groundwater; to assist in determining the degradation and mobility of metals; and support an HHRA and ERA
Residual Material (if present) (from surface of concrete TNT Graining House Sump compartments)	1	Explosives, metals	Collected to characterize any residual material remaining from former plant processes and to support an HHRA and ERA
	1	pH and TOC	Collected to refine ERA

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3 Field Project Implementation

The following sections provide a summary of field activities.

3.1 Project Logistics

In general, work will be performed in Level D personal protective equipment (PPE), which includes hard hat, safety glasses, safety-toed boots, hearing protection, and impermeable gloves. Upgrades to higher levels of PPE will be presented in the Health and Safety Plan (HSP), which will be prepared as a part of mobilization efforts and available to all field personnel during field activities. In addition, a photoionization detector (PID) will be used for monitoring sampling locations for organic vapors in the breathing zone as a health and safety precaution which will be discussed in the HSP.

All field activities will be conducted during normal working hours, unless requested otherwise by the Navy. Following field activities, the site will be restored to original site conditions.

3.2 Field Project Tasks

Details regarding sample nomenclature, sampling and analysis are provided in **Table 9.** Applicable Standard Operating Procedures (SOPs) for project tasks outlined in this section are listed in **Table 10**.

3.2.1 Utility Clearance

Utility clearances at the AOC 6 TNT subareas will be performed prior to the start of subsurface investigation activities. The CH2M HILL field staff will coordinate subsurface utility clearance with Miss Utility of Virginia (800-552-7001 or 811) and obtain available utility maps from CAX (Mr. James Michener at 757-636-4084). In addition, a third party utility clearance subcontractor will be procured by CH2M HILL to clearly mark all proposed sample locations. Proposed monitoring wells located within 5 feet of a marked utility will be relocated. If a monitoring well location needs to be adjusted to avoid a utility, the field team will use their best judgment in relocating the well and notify the PM of its new location.

3.2.2 Mobilization

Following approval of the SAP, CH2M HILL will begin mobilization activities. Before mobilization, all field team members will review this SAP and the project-specific HSP. A field team kickoff meeting will be held to ensure that personnel are familiar with the scope of field activities and discuss any safety issues. Mobilization activities include coordination with base personnel and preparation of field equipment.

3.2.3 Vegetation Clearance

The AOC 6 TNT subareas are located in a moderately wooded area and may require vegetation clearing to gain access. If required, prior to sampling activities, vegetation will be cleared to minimally impact the site. Trees less than three inches in diameter will be cut and/or low-hanging tree limbs will be removed. All cut vegetation debris will remain on site. Cutting will be accomplished through either manual or mechanical methods. Selection of the appropriate land clearing strategy will be based on the type and density of vegetation, topography, drainage patterns, terrain and soil conditions, and the level of effort required to maintain environmental and natural resource protection.

3.2.4 Soil Sampling

Thirteen discrete, co-located surface (0 to 6 inches bgs) and subsurface (6 to 24 inches bgs) soil samples (**Figure 5** locations CAA06-SO28 through CAA06-SO34 and CAA06-MW01 through CAA06-MW06) will be collected using a stainless steel hand auger and analyzed for explosives, metals, and wet chemistry parameters [for surface soil: TOC, pH, grain size and for subsurface soil: pH and TOC]). Two discrete, co-located surface (0 to 6 inches bgs) and subsurface (6 to 24 inches bgs) soil samples (**Figure 5** locations CAA06-SO26 and CAA06-SO27) will be collected

and analyzed for total and hexavalent chromium. Co-located 3-point composite surface (0 to 6 inches bgs) and subsurface (at intervals 6 to 24 inches bgs, 2 to 4 feet bgs, 4 to 6 feet bgs, 6 to 8 feet bgs, and 8 to 10 feet bgs [approximate depth of water table])(**Figure 5** location CAA06-SO26) soil samples will be collected via Macro-Core and analyzed for explosives, metals, and wet chemistry parameters [for surface soil: TOC, pH, grain size and for subsurface soil [the 6 to 24-inch bgs interval only]: pH and TOC], as outlined in **Table 9**. Any relevant information pertaining to contamination or visual observations will be recorded in the sample log book. Samples will be homogenized prior to placement in the laboratory prepared sample container. The SOPs to be used are referenced in **Table 10**.

3.2.5 Monitoring Well Installation

A total of six monitoring wells will be installed at the AOC 6 TNT subareas. Prior to monitoring well installation, soil samples will be collected for lithologic characterization at each location in accordance with unified soil classification system (USCS) standards and field screening for organic vapors will be conducted using a PID as the boreholes are advanced. Soil samples will be collected continuously from the ground surface to the final depth of the borehole using either direct push technology or split-spoon sampling.

Monitoring wells will be installed with a drilling rig using a 4.25-inch inner diameter hollow stem auger. Each monitoring well will be constructed of 2-inch inside diameter (ID) Schedule-40 polyvinyl chloride (PVC) pipe and installed at a maximum of 20 feet deep. The monitoring well screens will be machine-slotted 0.010-inch PVC.

A silica sand filter pack will be placed around the annular space of the well screen from the bottom of the boring extending to a depth of 2 feet above the top of the screen. A 2-foot bentonite layer will be placed above the top of the sand pack. After the bentonite has been hydrated, a cement –bentonite grout will be placed in the remaining annular space. The monitoring wells will be completed as a stick-up with a steel cover. A locking, watertight cap will be placed on the PVC pipe and each well will be clearly labeled with its assigned well number.

3.2.6 Well Development

Following installation, each monitoring well will be developed by the drilling subcontractor using a submersible pump and a combination of surging and pumping throughout the well screen. During monitoring well development, CH2M HILL will measure water quality parameters including pH, oxidation-reduction potential (ORP), temperature, conductivity, turbidity, and dissolved oxygen (DO) with a Horiba U-22 water quality meter or similar water quality meter. The water quality parameters will be recorded in the field notebook approximately every 5 minutes. In addition, the water quality meter will be calibrated daily (at a minimum) and the calibration documented in the field notebook. At least three well volumes of water will be removed in addition to the amount of water added during the installation process. Development will continue until the water is relatively clear and free of sediment or until 2 hours of development have passed, whichever comes first. Development parameter information, including pH, ORP, temperature, conductivity, turbidity, DO, and gallons purged will be recorded in the field logbook.

3.2.7 Water-Level Survey

Following monitoring well installation and development, and prior to the start of groundwater sampling, the depth to groundwater, to the nearest 0.01 foot, will be measured from all monitoring wells. Measurements will be made from the surveyed location on the lip of the PVC, which will be marked with an indelible marker. If during removal of the locking well cap the well demonstrates signs of being under pressure (escaping air sounds, cap being pushed off by pressure), the depth to water in that monitoring well will not be measured for a period of one hour in order to allow for the water level to equilibrate. Depth to water and time measured will be recorded in the field logbook.

3.2.8 Groundwater Sampling

Each newly-installed monitoring well will be sampled using a Monsoon pump (or similar pump) following low-flow sampling protocol and analyzed for total/dissolved inorganic constituents and the natural attenuation parameters, as outlined in **Table 9**. All groundwater samples will be collected by placing the sample tubing intake

in the middle of the screen interval. Water quality parameters including pH, ORP, temperature, conductivity, turbidity, and DO will be measured with a Horiba U-22 water quality meter or similar water quality meter. The water quality parameters will be recorded in the field notebook approximately every 5 minutes. In addition, the water quality meter will be calibrated daily (at a minimum) and the calibration documented in the field notebook.

DO will be field-verified using CHEMetrics test kits, and ferrous iron will be measured to evaluate redox potential to assist in determining the mobility of inorganic constituents in groundwater. Sampling will begin when water quality parameters have stabilized over three consecutive readings when measurements agree as follows:

- pH within 0.1 pH units
- Conductivity within 3 percent
- DO within 10 percent
- ORP within 10 millivolts (mV)
- Turbidity measurement within 10 percent or is minimized to the extent practical for the well

If the recharge rate of the well is so low that the well goes dry despite a flow rate of 0.1 liter per minute (lpm), purging will stop and the well will be allowed to recharge. This will be repeated as necessary and sampling will be conducted once at least one well volume has been removed.

3.2.9 Field Inspection of TNT Graining House Sump and Residual Material Sampling

During the RI field activities, the former TNT Graining House Sump will be field checked for residual material (from former ordnance plant processes and not organic material) within each of the sump compartments. A stainless steel spoon and/or disposable sediment corer will be used to check for residual material. If residual material is present, one composite sample will be collected, using equal volumes of material from each compartment where the residual material is found. The sample will be field composited and submitted to the laboratory for explosives, metals, pH and TOC analyses.

3.2.10 Equipment Decontamination

All non-disposable sampling equipment will be decontaminated before and immediately after each use as described in the applicable SOPs referenced in **Table 10**. Equipment will be decontaminated with Liquinox® (or equivalent solution) and allowed to dry between each use. The water-level indicator will be scrubbed with deionized water between each measurement. All decontamination liquids will be containerized and handled according to the IDW Handling section below. Disposable equipment (e.g., tubing for low-flow sampling, filters, paper towels, disposable PPE) will be disposed as ordinary trash.

Heavy equipment such as drill rig equipment (augers, rods or split spoons) will be steam-cleaned before use at each new monitoring well location. A decontamination pad will be set up onsite to prevent runoff of the decontamination water and to allow easy collection of decontamination fluids into a 55-gallon drum and treatment as IDW.

3.2.11 Investigation-derived Waste Handling

All IDW generated during this project is anticipated and assumed to be non-hazardous; however, it will be fully characterized in order to ensure it is transported and disposed of in accordance with all pertinent regulations.

The IDW generated during monitoring well installation and sampling will be soil cuttings, monitoring well development water, purge water, and solutions used to decontaminate non-disposable sampling equipment. Solid and aqueous IDW will be containerized separately in Department of Transportation-approved 55-gallon drums, which will be stored onsite. Secondary containment for IDW storage will be large enough to contain 10 percent of the volume of containers or the volume of the largest container, whichever is greater. The IDW storage area will be covered with a tarp to minimize the drums to exposure and prevent rain water from accumulating in the

secondary containment. It is anticipated that 7 drums of solid IDW and 12 drums of aqueous IDW will be generated.

Unless there is evidence of gross contamination, one composite soil sample and one composite groundwater sample will be collected for the purpose of IDW characterization, and will be analyzed for full TCLP, ignitability, corrosivity, and reactivity analyses. All drums will be removed from the site within 90 days of generation (with Navy approval).

Disposable equipment, including PPE and paper towels, will be disposed as ordinary trash.

3.2.12 Surveying

Following sample collection, soil sample locations will be marked in the field using pin flags with the sample station clearly labeled. All soil sample locations will be horizontally located, and all monitoring wells will be horizontally and vertically located by a Virginia licensed surveyor. The surveyor will provide coordinates of all points X, Y, to the nearest 0.5 feet and Z to the nearest 0.01 foot (0.1 foot for unpaved ground surface elevations).

3.2.13 Quality Control

Field QC samples will be collected as outlined in **Table 9** to assist in evaluating whether the results reported from the field effort meet the precision, accuracy, and representativeness requirements for this project. Field and laboratory activities will be implemented following the applicable SOPs as referenced in **Table 10** and **Appendix A**.

3.3 Sample Details Table

Table 9 includes details regarding sample nomenclature, sampling and analysis that will be conducted as part of this SAP.

TABLE 9

Sample Details

CTO-56
Cheatham Annex AOC 6
Remedial Investigation Sampling
Fall 2012, tentative

Main Laboratory
TriMatrix Labs
5560 Corporate Exchange Ct.SE
Grand Rapids, MI 49512
Walt Roudebush - 616-975-4561

Hexavalent Chromium Laboratory
Columbia Analytical Services, Inc.
1565 Jefferson Road, Building 300, Suite 360
Rochester, NY 14623
Deb Patton - (585)-672-7473

					Aqueous														Solid							
										Wet Chemistry (NAIPs)																
				Analysis Group	Total Metals, including mercury and cyanide			Dissolved Metals, including mercury		Methane	Alkalinity	Chloride, Nitrate, Nitrite, Sulfate	Sulfide	TOC	pH	Explosives	CrVI	Ferrous Iron and Dissolved Oxygen	Explosives	Metals, including mercury and cyanide			wet chemistry (pH and TOC)		CrVI	Grain-size
				Preparation and Analytical Method	SW-846 3010A/ 6010C and 3020A/ 6020A	SW-846 7470A	SW-846 9010C/ 9014	SW-846 3010A/ 6010C and 3020A/ 6020A	SW-846 7470A	RSK-175	SM2320B	EPA 300.0	SM 4500-S2-F	SW-846 9060A	SW-846 9040C	SW-864 8330	SW-846 7199	Field test kits	SW-864 8330	SW-846 3050B/6010C and 3050B/6020A	SW-846 7471A	SW-846 9010C/ 9014	SW-846 9045C	Lloyd Kahn	SW-846 7199	ASTM D422 (sieve only)
				Analytical Laboratory/ SOP Reference	TriMatrix / GR-01-100, GR-01-129	TriMatrix / GR-01-123	TriMatrix / GR-05-122	TriMatrix / GR-01-100, GR-01-129	TriMatrix / GR-01-123	TriMatrix / GR-03-130	TriMatrix / GR-06-101	TriMatrix / GR-02-113	TriMatrix / GR-06-110	TriMatrix / GR-05-105	TriMatrix / GR-07-100	CAS-R / HPLC-8330	CAS-R / GEN-7199	Performed in the Field	CAS-R / HPLC-8330	TriMatrix / GR-01-100, GR-01-129	TriMatrix / GR-01-123	TriMatrix / GR-05-122	TriMatrix / GR-07-113	TriMatrix / GR-05-132	CAS-R / GEN-7199	TriMatrix / GR-16-119
				Data Package Turnaround Time	28 Calendar Days																					
				Container Type/ Volume required (if different than container volume)	500ml HDPE / 150ml		500ml opaque HDPE / 50ml	500ml HDPE / 150ml		2, 40ml clear glass vials / 40ml	500ml HDPE / 100ml		500ml amber glass / 100ml	3, 40mL clear glass vials /40ml	500ml HDPE / 50ml	2L amber glass / 1L	250mL HDPE/ 10mL	NA	1-4oz. Wide-mouth/ 20g	8oz glass jar / 20g		4oz glass jar / 60g		8oz glass jar / 100g	1-4oz. Wide-mouth/ 2.5 g	32oz WM HDPE
				Preservative	pH <2 w/HNO3, Cool to <6°C		pH >10 w/NaOH, Cool to <6°C	pH <2 w/HNO3, Cool to <6°C		pH <2 w/HCl, Cool to <6 °C	Cool to <6 °C		pH >9 w/NaOH and ZnAC, Cool to <6°C	pH <2 w/H_2SO_4, cool to <6°C	Cool to <6°C	Cool to <6°C	Cool to 0-6ºC	NA	Cool to 0-6ºC							
				Holding Time (Preparation/ Analysis) [7]	180 days	28 days	14 days	180 days	28 days	14 days	14 days	48 hrs: Nitrate Nitrite; 28 days Chloride, Sulfate	7 days	28 days	7 days	7 days extraction, 40 days for analysis from date of extraction	24 hours	NA	14 days until extraction/ 40 days from extraction to analysis	180 days	28 days	14 days	7 days from sample receipt (lab-specified)	14 days	30 days to extraction; 7 days from extraction to analysis	28 days
Matrix	**Station ID**	**Sample ID[2]**	**QC Sample [8]**	**Sampling Depth**																						
Groundwater Samples																										
GW	CAA06-MW01	CAA06-GW01-MMYY	-	TBD	X	X	X	X	X	X	X	X	X	X	X			X								
		CAA06-GW01P-MMYY	duplicate	TBD	X	X	X	X	X									X								
	CAA06-MW02	CAA06-GW02-MMYY	-	TBD	X	X	X	X	X	X	X	X	X	X	X			X								
		CAA06-GW02-MMYY-MS	MS	TBD	X	X	X	X	X																	
		CAA06-GW02-MMYY-SD	MSD	TBD	X	X	X	X	X																	
	CAA06-MW03	CAA06-GW03-MMYY	-	TBD	X	X	X	X	X	X	X	X	X	X	X			X								
	CAA06-MW04	CAA06-GW04-MMYY	-	TBD	X	X	X	X	X	X	X	X	X	X	X			X								
	CAA06-MW05	CAA06-GW05-MMYY	-	TBD	X	X	X	X	X	X	X	X	X	X	X			X								
	CAA06-MW06	CAA06-GW06-MMYY	-	TBD	X	X	X	X	X	X	X	X	X	X	X			X								
Soil Samples (discrete or composite)																										
3-point composite Soil	CAA06-SO26 [3]	CAA06-SO26-TDBD-MMYY	-	0 - 0.5 ft															X	X	X	X	X	X		X
		CAA06-SO26-TDBD-MMYY	-	0.5 - 2 ft															X	X	X	X	X	X		
		CAA06-SO26-TDBD-MMYY	-	2 - 4 ft															X	X	X	X				
		CAA06-SO26-TDBD-MMYY	-	4 - 6 ft															X	X	X	X				
		CAA06-SO26-TDBD-MMYY	-	6 - 8 ft															X	X	X	X				
		CAA06-SO26-TDBD-MMYY	-	8 - 10 ft[4]															X	X	X	X				
Discrete Soil		CAA06-SS26-MMYY	-	0 - 0.5 ft																Cr only					X	
		CAA06-SS26P-MMYY	duplicate	0 - 0.5 ft																Cr only					X	
		CAA06-SB26-TDBD-MMYY	-	0.5 - 2 ft																Cr only					X	
		CAA06-SB26P-TDBD-MMYY	duplicate	0.5 - 2 ft																Cr only					X	
	CAA06-SO27 [5]	CAA06-SS27-MMYY	-	0 - 0.5 ft																Cr only					X	
		CAA06-SS27-MMYY-MS	MS	0 - 0.5 ft																Cr only					X	
		CAA06-SS27-MMYY-SD	MSD	0 - 0.5 ft																Cr only					X	
		CAA06-SB27-TBDB-MMYY	-	0.5 - 2 ft																Cr only					X	
		CAA06-SB27-TBDB-MMYY-MS	MS	0.5 - 2 ft																Cr only					X	
		CAA06-SB27-TBDB-MMYY-SD	MSD	0.5 - 2 ft																Cr only					X	
	CAA06-SO28	CAA06-SS28-MMYY	-	0 - 0.5 ft															X	X	X	X	X	X		X
		CAA06-SB28-TBDB-MMYY	-	0.5 - 2 ft															X	X	X	X	X	X		
	CAA06-SO29	CAA06-SS29-MMYY	-	0 - 0.5 ft															X	X	X	X	X	X		X
		CAA06-SB29-TBDB-MMYY	-	0.5 - 2 ft															X	X	X	X	X	X		
	CAA06-SO30	CAA06-SS30-MMYY	-	0 - 0.5 ft															X	X	X	X	X	X		X
		CAA06-SB30-TBDB-MMYY	-	0.5 - 2 ft															X	X	X	X	X	X		
	CAA06-SO31	CAA06-SS31-MMYY	-	0 - 0.5 ft															X	X	X	X	X	X		X
		CAA06-SB31-TBDB-MMYY	-	0.5 - 2 ft															X	X	X	X	X	X		
	CAA06-SO32	CAA06-SS32-MMYY	-	0 - 0.5 ft															X	X	X	X	X	X		X
		CAA06-SB32-TBDB-MMYY	-	0.5 - 2 ft															X	X	X	X	X	X		

TABLE 9 (continued)

					Aqueous														Solid							
										Wet Chemistry (NAIPs)																
				Analysis Group	Total Metals, including mercury and cyanide			Dissolved Metals, including mercury		Methane	Alkalinity	Chloride, Nitrate, Nitrite, Sulfate	Sulfide	TOC	pH	Explosives	CrVI	Ferrous Iron and Dissolve d Oxygen	Explosives	Metals, including mercury and cyanide			wet chemistry (pH and TOC)		CrVI	Grain-size
Matrix	**Station ID**	**Sample ID[2]**	**QC Sample [8]**	**Analysis Group**																						
Soil Samples (discrete or composite) CONTINUED																										
	CAA06-SO33	CAA06-SS33-MMYY	-	0 - 0.5 ft															X	X	X	X	X	X		X
		CAA06-SB33-TBDB-MMYY	-	0.5 - 2 ft															X	X	X	X	X	X		
	CAA06-SO34	CAA06-SS34-MMYY	-	0 - 0.5 ft															X	X	X	X	X	X		X
		CAA06-SB34-TBDB-MMYY	-	0.5 - 2 ft															X	X	X	X	X	X		
	CAA06-MW01	CAA06-SS35-MMYY	-	0 - 0.5 ft															X	X	X	X	X	X		X
		CAA06-SB35-TBDB-MMYY	-	0.5 - 2 ft															X	X	X	X	X	X		
	CAA06-MW02	CAA06-SS36-MMYY	-	0 - 0.5 ft															X	X	X	X	X	X		X
		CAA06-SS36P-MMYY	duplicate	0 - 0.5 ft															X	X	X	X				
		CAA06-SB36-TBDB-MMYY	-	0.5 - 2 ft															X	X	X	X	X	X		
		CAA06-SB36P-TBDB-MMYY	duplicate	0.5 - 2 ft															X	X	X	X				
	CAA06-MW03	CAA06-SS37-MMYY	-	0 - 0.5 ft															X	X	X	X	X	X		X
		CAA06-SS37-MMYY-MS	MS	0 - 0.5 ft															X	X	X	X				
		CAA06-SS37-MMYY-SD	MSD	0 - 0.5 ft															X	X	X	X				
		CAA06-SB37-TBDB-MMYY	-	0.5 - 2 ft															X	X	X	X	X	X		
		CAA06-SB37-TBDB-MMYY-MS	MS	0.5 - 2 ft															X	X	X	X				
		CAA06-SB37-TBDB-MMYY-SD	MSD	0.5 - 2 ft															X	X	X	X				
	CAA06-MW04	CAA06-SS38-MMYY	-	0 - 0.5 ft															X	X	X	X	X	X		X
		CAA06-SB38-TBDB-MMYY	-	0.5 - 2 ft															X	X	X	X	X	X		
	CAA06-MW05	CAA06-SS39-MMYY	-	0 - 0.5 ft															X	X	X	X	X	X		X
		CAA06-SB39-TBDB-MMYY	-	0.5 - 2 ft															X	X	X	X	X	X		
	CAA06-MW06	CAA06-SS40-MMYY	-	0 - 0.5 ft															X	X	X	X	X	X		X
		CAA06-SB40-TBDB-MMYY	-	0.5 - 2 ft															X	X	X	X	X	X		
Contingent Residual Sump Material Sample (if present, this sample will be treated as sediment)[6]																										
Sump Material	CAA06-SD03	CAA06-SD03-MMYY	-	TBD															X	X	X	X	X	X		
		CAA06-SD03P-MMYY	duplicate	TBD															X	X	X	X				
		CAA06-SD03-MMYY-MS	MS	TBD															X	X	X	X				
		CAA06-SD03-MMYY-SD	MSD	TBD															X	X	X	X				
Blank Samples [8]																										
Equipment Blank for GW	CAA06-QC	CAA06-EBMMDDYY-GW	EB	NA	X	X	X	X	X																	
Equipment Blank for Soil	CAA06-QC	CAA06-EBMMDDYY-SO	EB	NA	X	X	X									X	X									
Equipment Blank for Sump Material	CAA06-QC	CAA06-EBMMDDYY-SD	EB	NA	X	X	X									X										
			Total Number of Samples to the Laboratory:		12	12	12	10	10	6	6	6	6	6	6	2	1	7	42	42	42	42	29	15	10	14

Notes:

[1] For a complete reference of laboratory SOPs, see the Analytical SOP References Table.
[2] Sample IDs contain placeholders to be updated with information regarding the sample. MMYY will be replaced with the two-digit month and year in which the sample s collected. TDBD will be replaced with the two-digit top depth (TD) and bottom depth (BD) from which the sample is collected; should a sample be collected from a half-foot increment (i.e. 2.5 to 4.5 ft bgs) the sample ID will show the half-foot increment with an "H": TDBD = 2H4H.
[3] Samples collected at station CAA06-SO26 which have "SO" in the sample ID will be 3-point composite samples. Samples at this station which have "SS" or "SB" in the sample ID will be single-point samples collected from the center of the station. This station will be located in close proximity to CAA06-SO01 which was sampled in 2008.
[4] At station CAA06-SO26, the subsurface soil sample from 8-10ft may not be necessary if the water table is encountered prior to 8 ft bgs.
[5] Station CAA06-SO27 will be located in close proximity to CAA06-SO03 which was sampled in 2008.
[6] The contingency sump (sediment) sample will be a composite sample of residual material collected from the bottom of the sump compartments, IF residual material is observed.
[7] Maximum holding time is calculated from the time the sample is collected to the time the sample is prepared/analyzed.
[8] Field QC counts may change depending on the duration of field event. Frequency of QA/QC sample collection is noted on the Measurement Performance Criteria Table in Section 2.4 of the UFP-SAP and is as follows :

Field Duplicate - One per 10 field samples
MS/MSD - One pair per 20 field samples of similar matrix (including field duplicates)
Equipment Blank- For disposable equipment, one per week of sampling; for decontaminated equipment, one per type of sampling equipment, per day of sampling
Field Blank- No field blanks will be collected for this project

3.4 Field SOPs Reference Table

Applicable SOPs for project tasks are outlined in **Table 10** and included as **Appendix C**.

TABLE 10
Field Standard Operating Procedures

SOP Reference Number	Title/Author	Revision Date or Version Number	Location of SOP (if not included in the SAP)	Any planned deviation for Project Work	Comments
1_BlankPrep	*Equipment Blank and Field Blank Preparation*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Sample Preparation and Handling	N/A	N/A
2_COC	*Chain-of-Custody*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Sample Preparation and Handling	N/A	N/A
3_DataLoggers	*Use of Data Loggers and Pressure Transducers*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Hydrogeology	N/A	
4_Decon	*Decontamination of Personnel and Equipment*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Decontamination	N/A	N/A
5_DeconRig	*Decontamination of Drilling Rigs and Equipment*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Decontamination	N/A	N/A
6_DrumSample	*Sampling Contents of Tanks and Drums*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Other	N/A	N/A
7_Dispose	*Disposal of Waste Fluids and Solids*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Decontamination	N/A	N/A
8_GPS	*Global Positioning System*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Other	N/A	N/A
9_Homog	*Homogenization of Soil and Sediment Samples*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Sample Preparation and Handling	N/A	N/A
10_Log Books	*Preparing Field Log Books*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Log Books	N/A	N/A
11_LowFlow-EPA Reg I&III	*Low-Flow Groundwater Sampling from Monitoring Wells – EPA Region I and III*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Groundwater Sampling	N/A	N/A
12_MiniRAE	*Mini RAE Photoionization Detector (PID)*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Health and Safety	N/A	N/A
13_MWInstall	*General Guidance for Monitoring Well Installation*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Hydrogeology	N/A	N/A
14_MWSamp-EPA Reg I&III	*Groundwater Sampling from Monitoring Wells- EPA Region I&III*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Groundwater Sampling	N/A	N/A
15_MWShall	*Installation of Shallow Monitoring Wells*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Hydrogeology	N/A	N/A
16_SBLog	*Logging of Soil Borings*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Soil Sampling	N/A	N/A
17_ShallowSO	*Shallow Soil Sampling*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Soil Sampling	N/A	N/A
18_ShipLowConc	*Packaging and Shipping Procedures for Low-Concentration Samples*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Sample Preparation and Handling	N/A	N/A
19_SlugTest	*Aquifer Slug Testing*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Hydrogeology	N/A	N/A
20_Soils	*Soil Sampling*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Soil Sampling	N/A	N/A
21_Splitspn	*Soil Boring Sampling-Split Spoon*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Soil Sampling	N/A	
22_Utility Location_General	*Locating and Clearing Underground Utilities*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Utility Location	N/A	N/A
23_WaterLevels	*Water Level Measurements*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Hydrogeology	N/A	N/A
24_WaterQual-Horiba_YSI	*Field Measurement of pH, Specific Conductance, Turbidity, Dissolved Oxygen, ORP, and Temperature Using a Water Quality Parameter Meter with Flow-through Cell*	8/2013	\\orion\proj\CLEANII\SOPS\1 - MASTER\Field Parameters	N/A	N/A

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4 References

CH2M HILL. 2008. *Final Work Plan for Site Investigation of Various Areas of Concern, Naval Weapons Station Yorktown Cheatham Annex, Williamsburg, Virginia*. October.

CH2M HILL. 2011. *Final Background Study Report, Naval Weapons Station Yorktown, Yorktown, Virginia and Cheatham Annex, Williamsburg, Virginia*. May.

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Roy F. Weston, Inc. (Weston). 1999. *Final Site Inspection Narrative Report, Penniman Shell Loading Plant, Williamsburg, Virginia.* August 9.

United States Environmental Protection Agency (USEPA). 1993. *Region III Modifications to the Laboratory Data Validation Guidelines for Inorganic Data Review*. April.

USEPA. 1994. *Region III Modifications to the National Functional Guidelines for Organic Data Review.* September.

USEPA. 2005. *Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP).*

USEPA. 2012. *Technical Fact Sheet – 2,4,6-Trinitrotoluene (TNT), EPA 505-5-11-011.* May.

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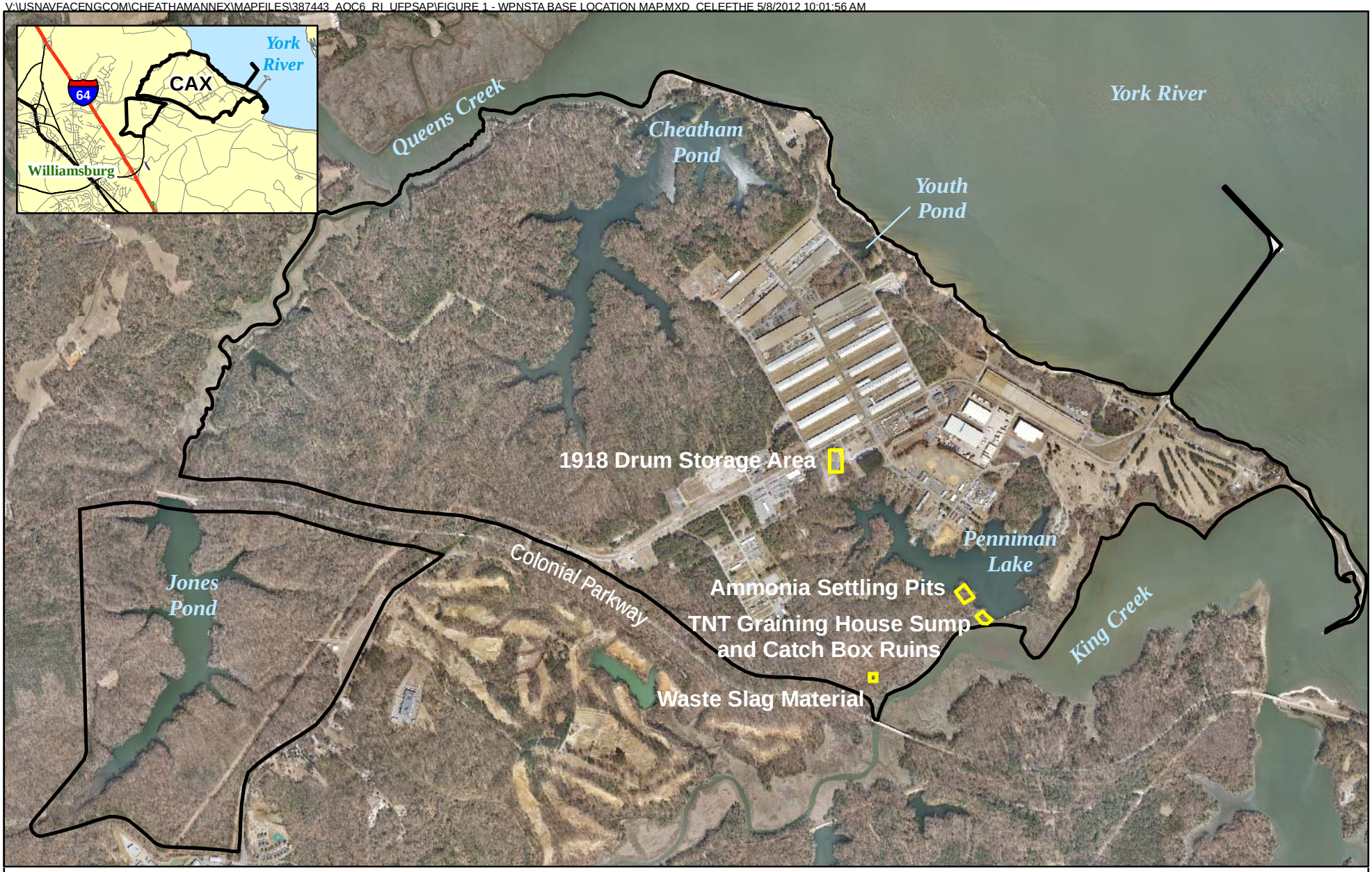
Figures

V:\USNAVFACENGCOM\CHEATHAMANNEX\MAPFILES\387443_AOC6_RI_UFPSAP\FIGURE 1 - WPNSTA BASE LOCATION MAP.MXD CELEFTHE 5/8/2012 10:01:56 AM



Legend

- AOC 6 Approximate Study Area Boundaries
- Cheatham Annex Boundary

N
W E
S

0 1,000 2,000 Feet

Figure 1
Base and AOC 6 Location Map
AOC 6 TNT Subareas Remedial Investigation UFP-SAP
Cheatham Annex
Williamsburg, Virginia

CH2MHILL

DVR \\MNUSTRICTGFS01\PROJECTS\USNAVFACENGCOM405450\CHEATHAMANNEX\MAPFILES\387443_AOC6_RI_UFPSAP\FIGURE 2 - SITE LOCATION MAP.MXD JCROCKETT 6/18/2013 12:30:16 PM

Legend

- AOC 6 Approximate Study Area Boundary
- Approximate AOC 6 TNT Subareas Study Boundary
- CAX Boundary / Fenceline

N
W E
S

0 300 600
Feet

Figure 2
Site Location
AOC 6 TNT Subareas Remedial Investigation UFP-SAP
Cheatham Annex
Williamsburg, Virginia

CH2MHILL

Lower Trophic Level Aquatic Receptors (i.e., aquatic/wetland plants, benthic/aquatic invertebrates, fish, amphibians, and reptiles): Exposure from ingestion of, and/or direct contact with, contaminants in surface water* and/or sediment*.

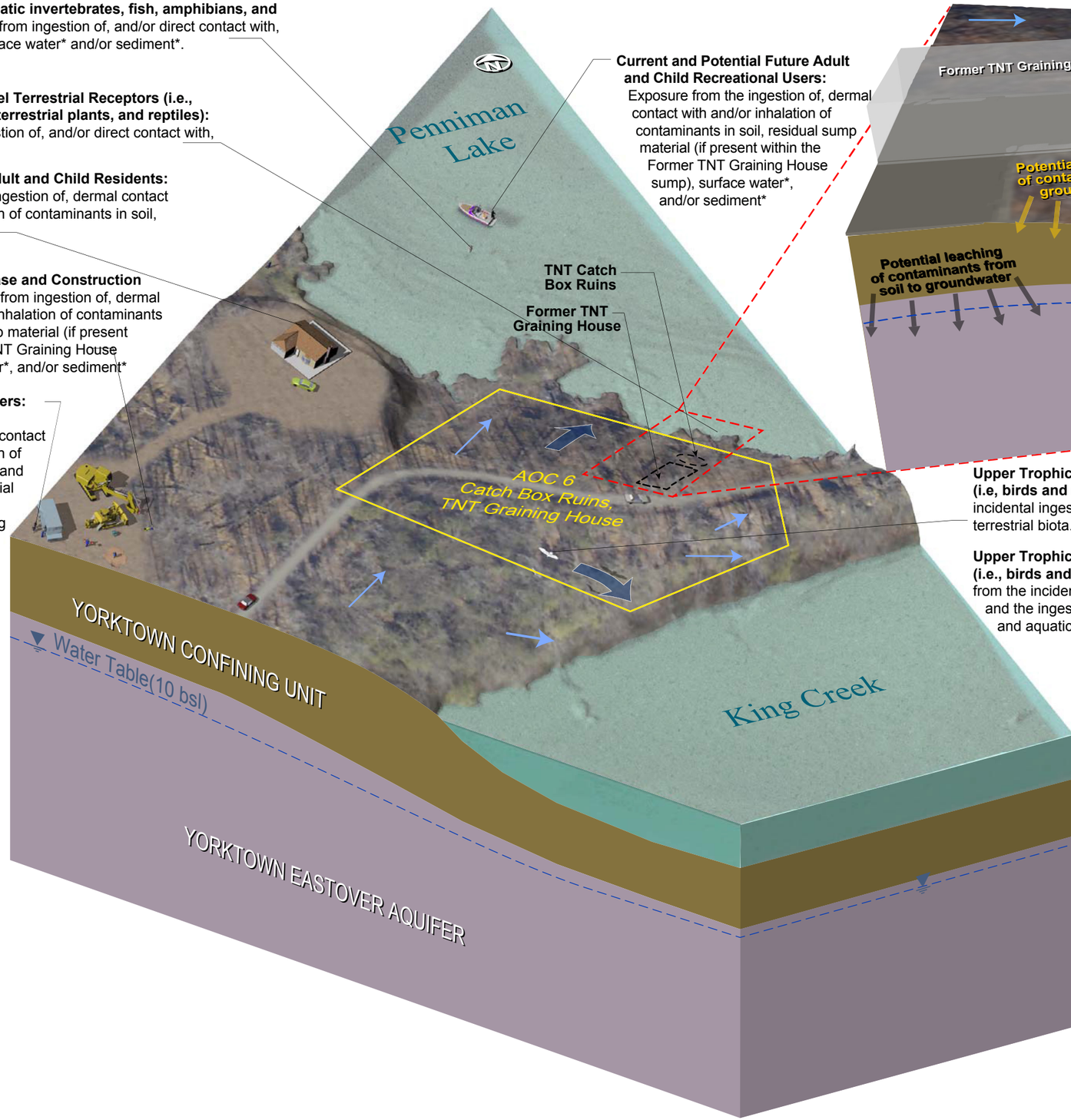
Lower Trophic Level Terrestrial Receptors (i.e., soil invertebrates, terrestrial plants, and reptiles): Exposure from ingestion of, and/or direct contact with, contaminants in soil.

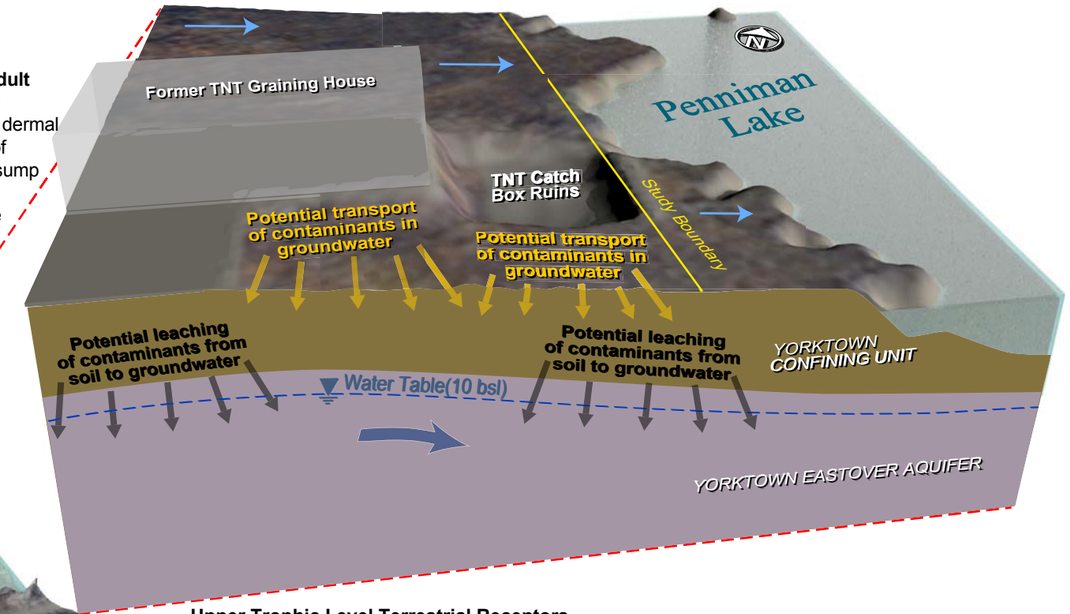
Potential Future Adult and Child Residents: Exposure from the ingestion of, dermal contact with and/or inhalation of contaminants in soil, and/or sediment*

Potential Future Base and Construction Workers: Exposure from ingestion of, dermal contact with and/or inhalation of contaminants in soil, residual sump material (if present within the Former TNT Graining House sump), surface water*, and/or sediment*

Current Base Workers: Exposure from the ingestion of, dermal contact with and/or inhalation of contaminants in soil and residual sump material (if present within the Former TNT Graining House sump)

Current and Potential Future Adult and Child Recreational Users: Exposure from the ingestion of, dermal contact with and/or inhalation of contaminants in soil, residual sump material (if present within the Former TNT Graining House sump), surface water*, and/or sediment*





Upper Trophic Level Terrestrial Receptors (i.e, birds and mammals): Exposure from the incidental ingestion of soil and the ingestion of terrestrial biota.

Upper Trophic Level Aquatic Receptors (i.e., birds and mammals): Exposure from the incidental ingestion of sediment*, and the ingestion of surface water* and aquatic biota*.

LEGEND

- Approximate Study Area
- Yorktown Confining Unit
- Yorktown Eastover Aquifer
- Anticipated Overland Surface Water Flow Direction
- Water Table
- Inferred Groundwater Flow Direction
- Contaminate Transport
- Contaminate Leaching

* Surface water, aquatic biota and sediment will be evaluated as part of the Penniman Lake Remedial Investigation.

FIGURE 3
AOC 6 TNT Subareas Conceptual Site Model
Cheatham Annex
Williamsburg, Virginia

CH2MHILL

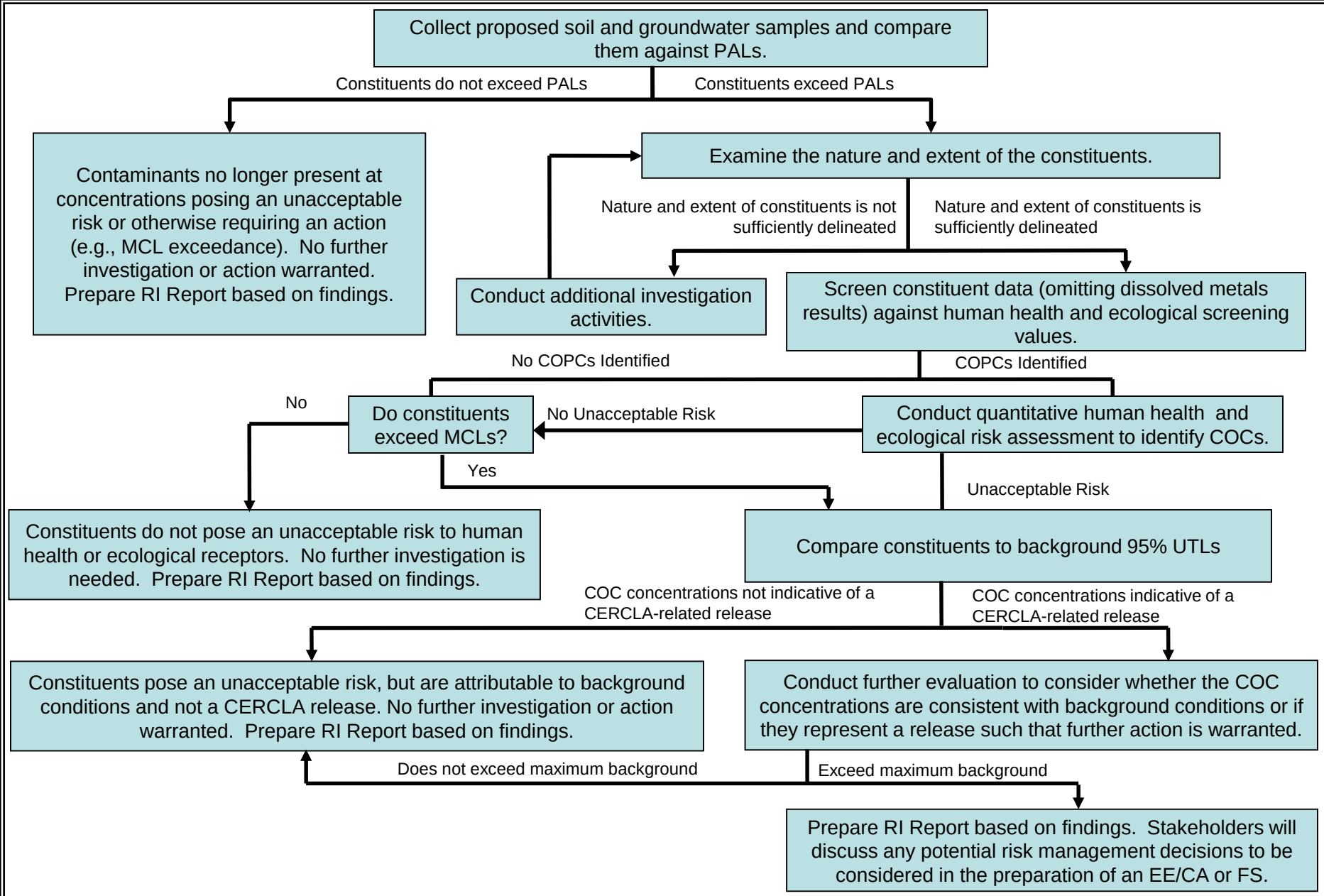


Figure 4
Soil and Groundwater Sampling Decision Tree
AOC 6 TNT Subareas Remedial Investigation UFP-SAP
Cheatham Annex
Williamsburg, Virginia

R:\USNAVFACENGCOM405450\CHEATHAMANNEX\MAPFILES\387443_AOC6_RI_UFPSAP\FIGURE 5 - PROPOSED SAMPLE LOCATIONS.MXD JCROCKETT 7/29/2013 12:23:45 PM

Legend

- Proposed Surface/Subsurface Soil Samples for Total and Hexavalent Chromium Analyses only
- Proposed 3-point composite Surface (0-6") and Subsurface [6" to groundwater table (~10')] Soil Samples from within the Catch Box Ruins. Also the location of discrete Surface/Subsurface Soil Samples from the center point for Total and Hexavalent Chromium analyses only.
- Proposed Surface/Subsurface Soil Samples
- Proposed Surface/Subsurface Soil Samples Co-Located with Groundwater Samples
- Topographic High Point (dashed where approximated)
- Approximate AOC 6 TNT Subarea Study Boundary
- Berm Boundary
- Former TNT Graining House Sump/Former Catch Boxes boundary

N W E S

0 37.5 75 Feet

Figure 5
Proposed Sample Locations
AOC 6 TNT Subareas Remedial Investigation UFP-SAP
Cheatham Annex
Williamsburg, Virginia

CH2MHILL

Appendix A
Laboratory Worksheets

Limits and Evaluation Tables

Samples will be collected and analyzed for the analytical groups and methods detailed in Section 3.3, *Sample Details Table*. The PALs and laboratory reporting limits for each analyte from these samples are provided in *Reference Limits and Evaluation Tables* (Tables A1-1 through A1-10).

TABLE A1-1
Reference Limits and Evaluation Table

Matrix: Surface Soil, Subsurface Soil

Analytical Group: Metals including Mercury, Cyanide, and Hexavalent Chromium

Analyte Name	CAS No.	Analytical Method	PALs[1,4]		CAX Background 95% UTL Values[2]		Project QL Goal[3,4] (mg/kg)	Laboratory Limits (mg/kg)			LCS and MS/MSD Recovery and RPD Limits[5] (%)		
			Adjusted Residential Soil RSL, Nov. 2011 (mg/kg)	ECO SV (mg/kg)	Surface Soil (mg/kg)	Subsurface Soil (mg/kg)		LOQ	LOD	DL	LCL	UCL	RPD
Aluminum	7429-90-5	6010C	7700	pH < 5.5	12200	13000	3850	10	5	1.36	80	120	20
Antimony	7440-36-0	6020A	3.1	78	NE	NE	1.55	0.2	0.05	0.0243			
Arsenic	7440-38-2		0.39	18	6.36	5.54	0.195	0.5	0.05	0.0163			
Barium	7440-39-3		1500	330	52.9	84.5	26.45	0.1	0.02	0.0122			
Beryllium	7440-41-7		16	40	0.587	NE	0.2935	0.1	0.05	0.0195			
Cadmium	7440-43-9		7	32	NE	NE	3.5	0.05	0.05	0.0033			
Calcium	7440-70-2	6010C	NC	NC	2290	2380	1145	50	50	20.2			
Chromium	7440-47-3	6020A	0.29	64	18.2	33.7	0.145	0.2	0.05	0.0139			
Chromium VI (Hexavalent)	18540-29-9	7199	0.29	0.4	NC	NC	0.145	0.4	0.2	0.065	**LCS 80 MS 75**	**LCS 120 MS 125**	**20**
Cobalt	7440-48-4	6020A	2.3	13	9.93	5.18	1.15	0.1	0.02	0.0064	80	120	20
Copper	7440-50-8		310	70	4.25	3.17	1.585	0.2	0.1	0.0254			
Cyanide	57-12-5	9014	160	15.8	NE	NE	7.9	0.1	0.05	0.021	80	120	
Iron	7439-89-6	6010C	5500	5 < pH > 8	19900	32000	2750	5	1	0.848	80	120	
Lead	7439-92-1	6020A	400	120	17.4	8.79	4.395	0.1	0.02	0.0066			
Magnesium	7439-95-4	6010C	NC	NC	1070	1120	535	50	25	7.1			
Manganese	7439-96-5	6020A	180	220	324	176	88	0.2	0.1	0.048			
Mercury	7439-97-6	7471A	2.3	0.1	0.111	NE	0.05	0.05	0.02	0.0061			
Nickel	7440-02-0	6020A	150	38	9.52	17.6	4.76	0.2	0.05	0.016			
Potassium	7440-09-7	6010C	NC	NC	708	901	354	50	10	7.1			
Selenium	7782-49-2	6020A	39	0.52	0.51	NE	0.255	0.5	0.1	0.0456			
Silver	7440-22-4		39	560	NE	NE	19.5	0.1	0.01	0.0039	75	120	
Sodium	7440-23-5	6010C	NC	NC	521	811	260.5	50	25	6	80	120	
Thallium	7440-28-0	6020A	0.078	1	NC	NC	0.039	0.1	0.01	0.0026			
Vanadium	7440-62-2		39	130	27.9	48.3	13.95	0.1	0.04	0.0097			
Zinc	7440-66-6		2300	120	26.5	28	13.25	2	1	0.584			

Notes:

[1] Refer to **Section 2.3.2** for a detailed discussion on the development of PALs, and refer to **Section 2.3.4** for specific identification of PALs by matrix.

[2] Background values are not PALs, but are provided for reference.

[3] Project QL goals are equal to half of the minimum applicable PAL.

[4] PALs and Project QL Goals assume dry weight basis.

[5] DoD QSM v.4.1 is the basis for LCS and MS/MSD limits. Values are bolded to indicate instances where laboratory in-house limits are used.

NC indicates that there is no criterion for a particular analyte.

NE indicates that an analyte was not evaluated in the background study.

TABLE A1-2
Reference Limits and Evaluation Table

Matrix: Surface Soil, Subsurface Soil
Analytical Group: Explosives

Analyte Name	CAS No.	PALs[1,3]		Project QL Goal[2,3] (mg/kg)	Laboratory Limits (mg/kg)			LCS and MS/MSD Recovery and RPD Limits[4] (%)		
		Adjusted Residential Soil RSL, Nov. 2011 (mg/kg)	Ecological SV (mg/kg)		LOQ	LOD	DL	LCL	UCL	RPD
1,3,5-Trinitrobenzene	99-35-4	220	NC	110	0.4	0.2	0.017			
1,3-Dinitrobenzene	99-65-0	0.61	NC	0.305	0.4	0.2	0.016			
2,4,6-Trinitrotoluene	118-96-7	3.6	10	1.8	0.4	0.2	0.022			
2,4-Dinitrotoluene	121-14-2	1.6	11	0.8	0.4	0.2	0.025			
2,6-Dinitrotoluene	606-20-2	6.1	8.5	3.05	0.4	0.2	0.056			
2-Amino-4,6-Dinitrotoluene	35572-78-2	15	80	7.5	0.4	0.2	0.033			
2-Nitrotoluene	88-72-2	2.9	NC	1.45	0.4	0.2	0.058			
3,5-Dinitroaniline	618-87-1	NC	NC	Lab LOD	0.4	0.2	0.031			
3-Nitrotoluene	99-08-1	0.61	NC	0.305	0.4	0.2	0.049	**40**	**140**	20
4-Amino-2,6-dinitrotoluene	19406-51-0	15	80	7.5	0.4	0.2	0.043			
4-Nitrotoluene	99-99-0	24	NC	12	0.4	0.2	0.126			
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	5.6	10	2.8	0.4	0.2	0.091			
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8	24	10	5	0.4	0.2	0.056			
Nitrobenzene	98-95-3	4.8	2.26	1.13	0.4	0.2	0.013			
Nitroglycerin	55-63-0	0.61	NC	0.305	0.4	0.2	0.103			
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	380	10	5	0.4	0.2	0.018			
Pentaerythritol tetranitrate (PETN)	14797-73-0	12	NC	6	0.4	0.2	0.104			

Notes:
[1] Refer to **Section 2.3.2** for a detailed discussion on the development of PALs, and refer to **Section 2.3.4** for specific identification of PALs by matrix.
[2] Project QL goals are equal to half of the minimum applicable PAL.
[3] PALs and Project QL Goals assume dry weight basis.
[4] DoD QSM v.4.1 is the basis for LCS and MS/MSD limits. Values are bolded to indicate instances where laboratory in-house limits are used.
NC indicates that there is no criterion for a particular analyte.

TABLE A1-3
Reference Limits and Evaluation Table

Matrix: Surface Soil, Subsurface Soil
Analytical Group: Wet Chemistry [1]

Analyte Name	CAS No. [2]	Analytical Method	Units	Laboratory Limits			LCS and MS/MSD Recovery and RPD Limits[3] (%)		
				LOQ	LOD	DL	LCL	UCL	RPD
pH	PH	SW-846 9045C	pH	0.1	NC	NC	NC	NC	**20**
Total Organic Carbon (TOC)	TOC	Walkley-Black	mg/kg	500	500	500	**75**	**125**	**20**

Notes:
[1] Results for pH and TOC will be used to support the ecological risk assessment.
[2] Values presented are contractor-specific chemical identifiers.
[3] DoD QSM v.4.1 is the basis for LCS and MS/MSD limits: values are bolded to indicate instances where laboratory in-house limits are used.

TABLE A1-4
Reference Limits and Evaluation Table

Matrix: Surface Soil
Analytical Group: Grain-size

Analyte Name	CAS No.	Units
GS03 Sieve 3" (75 mm)	SIEVE75.0	% Passing
GS05 Sieve 2" (50 mm)	SIEVE50.0	% Passing
GS06 Sieve 1.5" (37.5 mm)	SIEVE37.5	% Passing
GS07 Sieve 1" (25.0 mm)	SIEVE25.0	% Passing
GS08 Sieve 0.75" (19.0 mm)	SIEVE19.0	% Passing
GS10 Sieve 0.375" (9.5 mm)	SIEVE9.5	% Passing
Sieve No. 004 (4.75 mm)	SIEVE4.75	% Passing
Sieve No. 010 (2.00 mm)	SIEVE2.0	% Passing
Sieve No. 020 (850 um)	SIEVE850	% Passing
Sieve No. 040 (425 um)	SIEVE425	% Passing
Sieve No. 060 (250 um)	SIEVE250	% Passing
Sieve No. 080 (180 um)	SIEVE180	% Passing
Sieve No. 100 (150 um)	SIEVE150	% Passing
Sieve No. 200 (75um)	SIEVE75	% Passing
Gravel (%)	GRAVEL	%
Sand (%)	14808-60-7	%
Coarse Sand (%)	COARSESAND	%
Medium Sand (%)	MEDIUMSAND	%
Fine Sand (%)	FINESAND	%
Fines (%)	FINES	%

Notes:
There are no PALs or laboratory limits for grain-size analysis.

TABLE A1-5
Reference Limits and Evaluation Table

Matrix: Groundwater

Analytical Group: Total Metals including Mercury and Cyanide

Analyte Name	CAS No.	Analytical Method	PALs[1]		Project QL Goal[3] (ug/L)	Laboratory Limits (ug/L)			LCS and MS/MSD Recovery Limits[4] (%)		
			Adjusted Tapwater RSL, Nov 2011 (ug/L)	MCL (ug/L)		LOQ	LOD	DL	LCL	UCL	RPD
Aluminum	7429-90-5	6010C	1600	NC	800	100	100	24.2	80	120	20
Antimony	7440-36-0	6020A	0.6	6	0.3	2	0.5	0.148			
Arsenic	7440-38-2		0.045	10	0.0225	5	0.5	0.177			
Barium	7440-39-3		290	2000	145	2	0.5	0.136			
Beryllium	7440-41-7		1.6	4	0.8	1	0.4	0.111			
Cadmium	7440-43-9		0.69	5	0.345	0.2	0.1	0.0385			
Calcium	7440-70-2	6010C	NC	NC	Lab LOD	500	500	230			
Chromium	7440-47-3	6020A	0.031	100	0.0155	1	0.5	0.195			
Cobalt	7440-48-4		0.47	NC	0.235	1	0.2	0.05			
Copper	7440-50-8		62	1300	31	1	0.5	0.127			
Cyanide	57-12-5	9014	31	200	15.5	0.01	0.005	0.0029	**80**	**120**	20
Iron	7439-89-6	6010C	1100	NC	550	20	10	8.06	80	120	20
Lead	7439-92-1	6020A	15	15	7.5	1	0.5	0.152			
Magnesium	7439-95-4	6010C	NC	NC	Lab LOD	500	500	143			
Manganese	7439-96-5	6020A	32	NC	16	2	0.5	0.141			
Mercury	7439-97-6	7470A	0.43	2	0.215	0.2	0.1	0.055			
Nickel	7440-02-0	6020A	30	NC	15	1	0.5	0.171			
Potassium	7440-09-7	6010C	NC	NC	Lab LOD	100	100	66.6			
Selenium	7782-49-2	6020A	7.8	50	3.9	5	1	0.777			
Silver	7440-22-4		7.1	NC	3.55	0.5	0.1	0.0367			
Sodium	7440-23-5	6010C	NC	NC	Lab LOD	500	500	127			
Thallium	7440-28-0	6020A	0.016	2	0.008	0.2	0.1	0.0268			
Vanadium	7440-62-2		7.8	NC	3.9	1	0.2	0.0657			
Zinc	7440-66-6		470	NC	235	10	4	3.76			

Notes:

[1] Refer to **Section 2.3.2** for a detailed discussion on the development of PALs, and refer to **Section 2.3.4** for specific identification of PALs by matrix.

[3] Project QL goals are equal to half of the minimum applicable PAL.

[4] DoD QSM v.4.1 is the basis for LCS and MS/MSD limits: values are bolded to indicate instances where laboratory in-house limits are used.

Shading indicates instances where the PAL is lower than the LOD. Non-detects will not be treated as exceedances, though they will be reported at a value greater than the PAL.

TABLE A1-6
Reference Limits and Evaluation Table

Matrix: Groundwater

Analytical Group: Dissolved Metals including Mercury

Analyte Name	CAS No.	Analytical Method	PALs[1]		Project QL Goal[3] (ug/L)	Laboratory Limits (ug/L)			LCS and MS/MSD Recovery Limits[4] (%)		
			Adjusted Tapwater RSL, Nov 2011 (ug/L)	MCL (ug/L)		LOQ	LOD	DL	LCL	UCL	RPD
Aluminum	7429-90-5	6010C	1600	NC	800	100	100	24.2	80	120	20
Antimony	7440-36-0	6020A	0.6	6	0.3	2	0.5	0.148			
Arsenic	7440-38-2		0.045	10	0.0225	5	0.5	0.177			
Barium	7440-39-3		290	2000	145	2	0.5	0.136			
Beryllium	7440-41-7		1.6	4	0.8	1	0.4	0.111			
Cadmium	7440-43-9		0.69	5	0.345	0.2	0.1	0.0385			
Calcium	7440-70-2	6010C	NC	NC	Lab LOD	500	500	230			
Chromium	7440-47-3	6020A	0.031	100	0.0155	1	0.5	0.195			
Cobalt	7440-48-4		0.47	NC	0.235	1	0.2	0.05			
Copper	7440-50-8		62	1300	31	1	0.5	0.127			
Iron	7439-89-6	6010C	1100	NC	550	20	10	8.06			
Lead	7439-92-1	6020A	15	15	7.5	1	0.5	0.152			
Magnesium	7439-95-4	6010C	NC	NC	Lab LOD	500	500	143			
Manganese	7439-96-5	6020A	32	NC	16	2	0.5	0.141			
Mercury	7439-97-6	7470A	0.43	2	0.215	0.2	0.1	0.055			
Nickel	7440-02-0	6020A	30	NC	15	1	0.5	0.171			
Potassium	7440-09-7	6010C	NC	NC	Lab LOD	100	100	66.6			
Selenium	7782-49-2	6020A	7.8	50	3.9	5	1	0.777			
Silver	7440-22-4		7.1	NC	3.55	0.5	0.1	0.0367			
Sodium	7440-23-5	6010C	NC	NC	Lab LOD	500	500	127			
Thallium	7440-28-0	6020A	0.016	2	0.008	0.2	0.1	0.0268			
Vanadium	7440-62-2		7.8	NC	3.9	1	0.2	0.0657			
Zinc	7440-66-6		470	NC	235	10	4	3.76			

Notes:

[1] Refer to **Section 2.3.2** for a detailed discussion on the development of PALs, and refer to **Section 2.3.4** for specific identification of PALs by matrix.

[3] Project QL goals are equal to half of the minimum applicable PAL.

[4] DoD QSM v.4.1 is the basis for LCS and MS/MSD limits: values are bolded to indicate instances where laboratory in-house limits are used.

Shading indicates instances where the PAL is lower than the LOD. Non-detects will not be treated as exceedances, though they will be reported at a value greater than the PAL.

TABLE A1-7
Reference Limits and Evaluation Table

Matrix: Groundwater
Analytical Group: Wet Chemistry

Analyte Name	CAS No.	Analytical Method	Project Indicator Level[1]	Laboratory Limits (ug/L, or pH)			LCS and MS/MSD Recovery Limits[4] (%)		
				LOQ	LOD	DL	LCL	UCL	RPD
Chloride	16887-00-6	9056	NA	1000	500	56.8	**80**	**120**	15
Nitrate	14797-55-8	9056	TBD	100	50	15.4	**80**	**120**	15
Nitrite	14797-65-0	9056	TBD	100	50	26.8	**80**	**120**	15
Sulfate	14808-79-8	9056	<20000	2000	1000	223	**80**	**120**	15
Sulfide	18496-25-8	SM 4500-S2-F	>1000	1000	1000	1000	**80**	**120**	**20**
Alkalinity	471-34-1	SM 2320B	>50000	2000	2000	495	**91**	**110**	**20**
Methane	74-82-8	RSK-175	>500	1	0.84	0.277	**69**	**125**	**20**
pH	PH	9040C	5<pH<9	0.1	NC	NC	NC	NC	**20**
Total Organic Carbon	TOC	9060A	>20000	1000	500	276	**87**	**111**	**20**

Notes:

[1] Project indicator Limits (PILs) were developed to assist in determining if evidence exists for natural attenuation processes.

- Chloride is a general water quality parameter, and is produced by anaerobic dechlorination. Elevated levels of chloride may indicate that dechlorination is occurring.
- Nitrate and nitrite data will be collected in the event that a natural attenuation or enhanced biological remedy is later needed for the site.
- Sulfate and sulfate in elevated concentrations may compete with the reductive dechlorination pathway.
- Alkalinity is the measurement of the available buffering capacity against pH change, which can affect the rate of degradation of COCs.
- Ethane and ethene are the ultimate daughter products of chlorinated ethanes and ethenes. These parameters are an indicator of the extent of complete dechlorination.
- Elevated methane concentrations can be an indication of highly reducing conditions.
- Biological processes are pH-sensitive and the ideal range for dechlorinating bacteria is 5 to 9.
- TOC results will be used to determine the bioavailability of organic chemicals.

[2] DoD QSM v.4.1 is the basis for LCS and MS/MSD limits: values are bolded to indicate instances where laboratory in-house limits are used.

TABLE A1-8

Reference Limits and Evaluation Table

Matrix: Residual Sump Material sample

Analytical Group: Metals including Mercury and Cyanide

Analyte Name	CAS No.	Analytical Method	PALs[1,3] (mg/kg)		Project QL Goal[2,3] (mg/kg)	Laboratory Limits (mg/kg)			LCS and MS/MSD Recovery and RPD Limits[4] (%)		
			Adjusted Residential Soil RSL x 10 for Sediment (May2013)	Sediment ESV		LOQ	LOD	DL	LCL	UCL	RPD
Aluminum	7429-90-5	6010C	77000	25500	12750	10	5	1.36	80	120	20
Antimony	7440-36-0	6020A	31	3	1.5	0.2	0.05	0.0243			
Arsenic	7440-38-2		6.1	9.79	3.05	0.5	0.05	0.0163			
Barium	7440-39-3		15000	20	10	0.1	0.02	0.0122			
Beryllium	7440-41-7		160	NC	80	0.1	0.05	0.0195			
Cadmium	7440-43-9		70	0.99	0.495	0.05	0.05	0.0033			
Calcium	7440-70-2	6010C	NC	NC	Lab LOD	50	50	20.2			
Chromium	7440-47-3	6020A	2.9	43.4	1.45	0.2	0.05	0.0139			
Cobalt	7440-48-4		23	50	11.5	0.1	0.02	0.0064			
Copper	7440-50-8		3100	31.6	15.8	0.2	0.1	0.0254			
Cyanide	57-12-5	9014	22	NC	11	0.1	0.05	0.021			
Iron	7439-89-6	6010C	55000	20000	10000	5	1	0.848			
Lead	7439-92-1	6020A	4000	35.8	17.9	0.1	0.02	0.0066			
Magnesium	7439-95-4	6010C	NC	NC	Lab LOD	50	25	7.1			
Manganese	7439-96-5	6020A	1800	460	230	0.2	0.1	0.048			
Mercury	7439-97-6	7471A	23	0.18	0.09	0.05	0.02	0.0061			
Nickel	7440-02-0	6020A	1500	22.7	11.35	0.2	0.05	0.016			
Potassium	7440-09-7	6010C	NC	NC	Lab LOD	50	10	7.1			
Selenium	7782-49-2	6020A	390	2	1	0.5	0.1	0.0456			
Silver	7440-22-4		390	1	0.5	0.1	0.01	0.0039	75	120	
Sodium	7440-23-5	6010C	NC	NC	Lab LOD	50	25	6	80	120	
Thallium	7440-28-0	6020A	0.78	NC	0.39	0.1	0.01	0.0026			
Vanadium	7440-62-2		390	NC	195	0.1	0.04	0.0097			
Zinc	7440-66-6		23000	121	60.5	2	1	0.584			

[1] Refer to Section 2.3.2 for a detailed discussion on the development of PALs, and refer to Section 2.3.4 for specific identification of PALs by matrix.

[2] Project QL goals are equal to half of the minimum applicable PAL.

[3] PALs and Project QL Goals assume dry weight basis.

[4] DoD QSM v.4.1 is the basis for LCS and MS/MSD limits. Values are bolded to indicate instances where laboratory in-house limits are used.

NC indicates that there is no criterion for a particular analyte.

TABLE A1-9

Reference Limits and Evaluation Table

Matrix: Residual Sump Material sample
Analytical Group: Explosives

Analyte Name	CAS No.	PALs[1,3] (mg/kg)		Project QL Goal[2,3] (mg/kg)	Laboratory Limits (mg/kg)			LCS and MS/MSD Recovery and RPD Limits[4] (%)		
		Adjusted Residential Soil RSL x 10 for Sediment (May2013)	Sediment ESV		LOQ	LOD	DL	LCL	UCL	RPD
1,3,5-Trinitrobenzene	99-35-4	2200	0.0024	0.0012	0.4	0.2	0.017			
1,3-Dinitrobenzene	99-65-0	6.1	0.0067	0.00335	0.4	0.2	0.016			
2,4,6-Trinitrotoluene	118-96-7	36	0.092	0.046	0.4	0.2	0.022			
2,4-Dinitrotoluene	121-14-2	16	0.0416	0.0208	0.4	0.2	0.025			
2,6-Dinitrotoluene	606-20-2	3.3	NC	1.65	0.4	0.2	0.056			
2-Amino-4,6-Dinitrotoluene	35572-78-2	150	0.0132	0.0066	0.4	0.2	0.033			
2-Nitrotoluene	88-72-2	29	6.204	3.102	0.4	0.2	0.058			
3,5-Dinitroaniline	618-87-1	NC	NC	Lab LOD	0.4	0.2	0.031			
3-Nitrotoluene	99-08-1	6.1	1.922	0.961	0.4	0.2	0.049	**40**	**140**	20
4-Amino-2,6-dinitrotoluene	19406-51-0	150	0.0232	0.0116	0.4	0.2	0.043			
4-Nitrotoluene	99-99-0	240	4.06203	2.031015	0.4	0.2	0.126			
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	121-82-4	56	0.0127	0.00635	0.4	0.2	0.091			
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	479-45-8	240	NC	120	0.4	0.2	0.056			
Nitrobenzene	98-95-3	48	1.779	0.8895	0.4	0.2	0.013			
Nitroglycerin	55-63-0	6.1	NC	3.05	0.4	0.2	0.103			
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	2691-41-0	3800	0.00474	0.00237	0.4	0.2	0.018			
Pentaerythritol tetranitrate (PETN)	78-11-5	120	NC	60	0.4	0.2	0.104			

[1] Refer to **Section 2.3.2** for a detailed discussion on the development of PALs, and refer to **Section 2.3.4** for specific identification of PALs by matrix.

[2] Project QL goals are equal to half of the minimum applicable PAL.

[3] PALs and Project QL Goals assume dry weight basis.

[4] DoD QSM v.4.1 is the basis for LCS and MS/MSD limits. Values are bolded to indicate instances where laboratory in-house limits are used.

NC indicates that there is no criterion for a particular analyte.

Shading indicates instances where the PAL is lower than the LOD. Non-detects will not be treated as exceedances, though they will be reported at a value greater than the PAL.

TABLE A1-10

Reference Limits and Evaluation Table

Matrix: Residual Sump Material sample

Analytical Group: Wet Chemistry [1]

Analyte Name	CAS No. [2]	Analytical Method	Units	Laboratory Limits			LCS and MS/MSD Recovery and RPD Limits[3] (%)		
				LOQ	LOD	DL	LCL	UCL	RPD
pH	PH	SW-846 9045C	pH	0.1	NC	NC	NC	NC	**20**
Total Organic Carbon (TOC)	TOC	Walkley-Black	mg/kg	500	500	500	**75**	**125**	**20**

Notes:

[1] Results for pH and TOC will be used to support the ecological risk assessment.

[2] Values presented are contractor-specific chemical identifiers.

[3] DoD QSM v.4.1 is the basis for LCS and MS/MSD limits: values are bolded to indicate instances where laboratory in-house limits are used.

Analytical SOP References Table

Information regarding the laboratory SOPs and to be used for the handling and analysis of samples is provided in Analytical SOP References Tables, Tables A2-1 through A2-2.

TABLE A2-1
Analytical SOP References Table

Laboratory Name and Address: TriMatrix Laboratories, 5560 Corporate Exchange Ct. SE, Grand Rapids, MI 49512

Point of Contact: Walt Roudebush

Phone Number: (616) 975-4561

Lab SOP Number	Title, Revision Date, and Number	Date reviewed if not revised	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Variance to QSM	Modified for Project Work? (Y/N)
GR-01-100	Inductively Coupled Plasma Atomic Emission Spectroscopy-Perkin Elmer OPTIMA-3300DV/5300DV; 09/20/11, rev 5.9	NA	Definitive	Soil, Water / Metals	ICP	None	N
GR-01-123	Mercury by semi-Automated Cold Vapor Atomic Absorption, 09/25/11; rev 5.8	NA	Definitive	Soil, Water / Metals	CVAA	None	N
GR-01-129	Inductively Coupled Plasma Mass Spectrometry Perkin Elmer ELAN-6000/6100; 09/25/11, rev 4.0	NA	Definitive	Soil, Water / Metals	ICPMS	None	N
GR-01-137	Block Digestion of Solids for ICP and ICPMS; 09/20/11, rev 1.6	NA	Definitive	Soil / Metals	Block Digester	None	N
GR-01-139	Preparation Procedure for Mercury in Soils, Wastes, and Oils; 04/09/11, rev 0.2	NA	Definitive	Soil / Metals	Block Digester	None	N
GR-01-140	Preparation Procedure for Mercury in Water, Wastewater, and Liquid Waste; 04/09/10, rev 0.4	NA	Definitive	Water / Metals	Block Digester	None	N
GR-01-147	Block Digestion of Total Metals in Water for ICP; 04/09/10, rev 0.4	In review	Definitive	Water / Metals	Block Digester	None	N
GR-01-148	Block Digestion of Aqueous Samples and Extracts for Total/Dissolved Metals by ICPMS; 10/20/11, rev 0.4	NA	Definitive	Water / Metals	Block Digester	None	N
GR-02-113	Determination of Inorganic Anions by Ion Chromatography; 04/29/11, rev 300.0	NA	Definitive	Water / Wet Chemistry	IC	None	N
GR-03-130	Analysis of Dissolved Methane, Ethane, and Ethylene in Water Using a Gas Chromatography Headspace Equilibrium Technique; 09/30/11, rev 0..5	NA	Definitive	Water / GC	GC/FID	None	N
GR-05-105	Total Organic Carbon (TOC), Dissolved Organic Carbon (DOC); 02/25/11, rev 3.5	NA	Definitive	Water / Wet Chemistry	TOC Analyzer	None	N
GR-05-122	Total and Amenable Cyanide by Konelab UV Spectrophotometry; 10/06/10, rev 0.4	In review	Definitive	Soil, Water / Wet Chemistry	Spectrophometer	None	N
GR-05-132	Leco Carbon Analyzer (Organic Carbon); 10/31/10, rev 0.0 (Draft)	In review	Definitive	Soil / Wet Chemistry	TOC Analyzer	None	N

TABLE A2-1
Analytical SOP References Table

Laboratory Name and Address: TriMatrix Laboratories, 5560 Corporate Exchange Ct. SE, Grand Rapids, MI 49512

Point of Contact: Walt Roudebush

Phone Number: (616) 975-4561

Lab SOP Number	Title, Revision Date, and Number	Date reviewed if not revised	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Variance to QSM	Modified for Project Work? (Y/N)
GR-06-101	Alkalinity, Automatic Titration Method (Total, Bicarbonate, Carbonate, and Hydroxide Alkalinity); 04/19/10, rev 3.3	In review	Definitive	Water / Wet Chemistry	Autotitrator	None	N
GR-06-110	Sulfide Titrimetric; 09/25/11, rev 0.3	NA	Definitive	Water / Wet Chemistry	Manual Titrimetry	None	N
GR-07-100	pH, Potentiometric Method; 10/13/10, rev 3.4	In review	Screening	Water / Wet Chemistry	pH meter	None	N
GR-07-113	pH Potentiometric Method Soils and Wastes (Non-Aqueous Liquids); 04/19/10, rev 0.3	In review	Screening	Soil / Wet Chemistry	pH meter	None	N
GR-16-119	Particle-Size Analysis of Soils; 08/01/10, rev 0.0	In review	Definitive	Soil / Wet Chemistry	gravimetric, sieves	None	N
GR-18-106	Total and Amenable Cyanide Extraction and/or Macro-Distillation; 05/30/11, rev 3.3	NA	Definitive	Soil / Wet Chemistry	glassware / equipment for distillation	None	N
GR-18-109	Midi-Distillation for Total and Amenable Cyanide; 05/30/11, rev 3.6	NA	Definitive	Water / Wet Chemistry	glassware / equipment for distillation	None	N
GR-10-104	Internal Chain of Custody (CoC); 11/10/11, rev 2.3	NA	NA	NA	NA	None	N
GR-15-100	Sample Receiving/Sample Log-In; 04/19/10, rev 3.2	In review	NA	NA	NA	None	N

Required Laboratory Accreditation: DoD ELAP
Expiration Date: 4/30/2015
Copies of laboratory certification are included in Appendix D.

TABLE A2-2
Analytical SOP References Table

Laboratory Name and Address: ALS - Columbia, 1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14623

Point of Contact: Debbie Patton

Phone Number: (585) 672-7473

Lab SOP Number	Title, Revision Date, and Number	Date reviewed if not revised	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Variance to QSM	Modified for Project Work? (Y/N)
GEN-7199	Hexavalent Chromium by Ion Chromatography, Revision 3, 1/6/11	In Review	Definitive	water and soil	Ion Chromatography	N	N
GEN-3060A	Alkaline Digestion for Hexavalent Chromium in Soils, Revision 2, 1/6/11	In Review	Prep	soil	Prep	N	N
HPLC-8330	Nitroaromatics and Nitramines (Explosives) by High Performance Liquid Chromatography, Revision 1, 5/27/11	5/27/2011	Definitive	water and soil	HPLC-UV	N	N

Required Laboratory Accreditation: DoD ELAP
Expiration Date: 4/7/2014
Copies of laboratory certification are included in Appendix D.

Laboratory QC Samples Tables

Laboratories analyzing samples in support of this work will perform laboratory QC samples at the frequency required by the DoD QSM 4.2. Details regarding each laboratory QC sample are provided in *Laboratory QC Samples Tables*, Tables A3-1 through A3-14.

TABLE A3-1
Laboratory QC Samples Table

Matrix: Surface Soil, Subsurface Soil, Residual Sump Material sample

Analytical Group: Explosives

Analytical Method/SOP Reference: SW-846 8330B / HPLC-8330

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Surrogate	All field and QC samples - one pre sample	1,2-Dinitrobenzene 40-140% water 50-150% soil	Evaluate and reanalyze if possible. If the surrogate is outside the established limits due to well-documented matrix effects, the results must be flagged and an explanation included in the case narrative.	Analyst/Supervisor	Accuracy/Bias	Same as Method/SOP QC Acceptable Limits
Method Blank	1 per batch of 20 or fewer samples	No analytes detected > 1/2 the LOQ.	Correct problem. If required, reprep and reanalyze MB and samples with hits <10x MB contamination. If reanalysis is not possible, flag associated results.		Bias/Contamination	
LCS		QC acceptance criteria specified in DoD QSM v4.1., refer to **Table A1-3**.	Evaluate, reextract and reanalyze batch if possible. If the LCS recoveries are high but the sample results <LOQ then narrate, otherwise reprepare and reanalyze.		Accuracy/Bias	
MS		Same as LCS.	If LCS acceptable, may report with qualifier and note outliers in the case narrative		Precision / Accuracy/ Bias	
MSD		Same as MS, and refer to **Table A1-3.**	If LCS acceptable, may report with qualifier and note outliers in the case narrative unless RPD indicates prep/analytical difficulties.		Precision / Accuracy/ Bias	
Second Column Confirmation	All positive results must be confirmed	Results between primary and second column must be RPD<40%	Apply J flag if RPD >40%. Discuss in case narrative.		Identification	

TABLE A3-2
Laboratory QC Samples Table

Matrix: Surface Soil, Subsurface Soil, Groundwater, Residual Sump Material sample
Analytical Group: Select Total and Dissolved Metals (refer to Table A1-2, 6, and 7 for a specific list)
Analytical Method/SOP Reference: SW-846 6010C / GR-01-100

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparatory batch of up to 20 samples.	No analytes detected > 1/2 RL and greater than 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL.	Correct the problem. If required, reprep and reanalyze the method blank and all samples processed with the contaminated blank.	Analyst / Laboratory Area Supervisor	Contamination / Bias	Same as Method/SOP QC Acceptance Limits.
Laboratory Control Sample (LCS) containing all analytes to be reported		QC acceptance criteria specified in DoD QSM v4.1., refer to **Tables A1-**1, -5, -6, -8	Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.		Accuracy / Bias	
Matrix Spike (MS)		Same as LCS.	Examine results of LCS. If both the LCS and MS/MSD or MS/DUP are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.		Accuracy / Bias	
Matrix Spike Duplicate (MSD) or Sample Duplicate (DUP)		MSD: Same as LCS and RPD ≤ 20% (between MS and MSD or sample and sample duplicate).	Examine results of LCS. If both the LCS and MS/MSD or MS/DUP are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.		Precision / Accuracy / Bias	
Serial Dilution (aka Dilution test)	One per preparatory batch for samples with concentration > 50 x LOQ.	Five-fold dilution must agree within ± 10% of the original measurement.	Perform Post Digestion Spike (PDS) addition.		Precision / Accuracy	
Post Digestion Spike (PDS)	When serial dilution fails or analyte concentration in all samples < 50 x LOD.	Recovery within 75-125%.	Run all associated sample in the preparatory batch by method of standard additions (MSA) or qualify results.		Precision / Accuracy	
Internal Standards (IS)	NA	IS intensity within 70-125% of intensity of the IS in the ICAL.	Reanalyze sample at 5-fold dilution with addition of appropriate amounts of internal standards.		Accuracy / Bias	

TABLE A3-3
Laboratory QC Samples Table

Matrix: Surface Soil, Subsurface Soil, Groundwater, Residual Sump Material sample
Analytical Group: Select Total and Dissolved Metals (refer to Table A1-2, 6, and 7 for a specific list)
Analytical Method/SOP Reference: SW-846 6020A / GR-01-129

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparatory batch of up to 20 samples.	No analytes detected > 1/2 RL and greater than 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL.	Correct the problem. If required, reprep and reanalyze the method blank and all samples processed with the contaminated blank.	Analyst / Laboratory Area Supervisor	Contamination / Bias	Same as Method/SOP QC Acceptance Limits.
Laboratory Control Sample (LCS) containing all analytes to be reported		QC acceptance criteria specified in DoD QSM v4.1., refer to **Tables A1-** 1, -5, -6, -8	Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.		Accuracy / Bias	
Matrix Spike (MS)		Same as LCS.	Examine results of LCS. If both the LCS and MS/MSD or MS/DUP are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.		Accuracy / Bias	
Matrix Spike Duplicate (MSD) or Sample Duplicate (DUP)		MSD: Same as LCS and RPD ≤ 20% (between MS and MSD or sample and sample duplicate).	Examine results of LCS. If both the LCS and MS/MSD or MS/DUP are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.		Precision / Accuracy / Bias	
Serial Dilution (aka Dilution test)	One per preparatory batch for samples with concentration > 50 x LOQ.	Five-fold dilution must agree within ± 10% of the original measurement.	Perform Post Digestion Spike (PDS) addition.		Precision / Accuracy	
Post Digestion Spike (PDS)	When serial dilution fails or analyte concentration in all samples < 50 x LOD.	Recovery within 75-125%.	Run all associated sample in the preparatory batch by method of standard additions (MSA) or qualify results.		Precision / Accuracy	
Internal Standards (IS)	NA.	IS intensity within 30-120% of intensity of the IS in the ICAL.	Reanalyze sample at 5-fold dilution with addition of appropriate amounts of internal standards.		Accuracy / Bias	

TABLE A3-4
Laboratory QC Samples Table

Matrix: Surface Soil, Subsurface Soil, Groundwater, Residual Sump Material sample

Analytical Group: Total and Dissolved Metals (Mercury)

Analytical Method/SOP Reference: SW-846 7470A / GR-01-123

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparatory batch of up to 20 samples.	No analytes detected > 1/2 RL and greater than 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results. For common laboratory contaminants, no analytes detected > RL.	Correct the problem. If required, reprep and reanalyze the method blank and all samples processed with the contaminated blank.	Analyst / Laboratory Area Supervisor	Contamination / Bias	Same as Method / SOP QC Acceptance Limits.
Laboratory Control Sample (LCS) containing analyte to be reported		QC acceptance criteria specified in DoD QSM v4.1., refer to **Tables A1-**1, -5, 6, -8	Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes, if sufficient sample material is available.		Accuracy / Bias	
Matrix Spike (MS)		Same as LCS.	Examine results of LCS. If both the LCS and MS/MSD or MS/DUP are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.		Accuracy / Bias	
Matrix Spike Duplicate (MSD) or Sample Duplicate (DUP)		MSD: Same as LCS and RPD ≤ 20% (between MS and MSD or sample and sample duplicate).	Examine results of LCS. If both the LCS and MS/MSD or MS/DUP are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.		Precision / Accuracy / Bias	

TABLE A3-5
Laboratory QC Samples Table

Matrix: Surface Soil, Subsurface Soil, Groundwater, Residual Sump Material sample
Analytical Group: Metals (Cyanide)
Analytical Method/SOP Reference: SW-846 9014 / GR-05-122

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparatory batch of up to 20 samples.	No analytes detected > 1/2 RL and greater than 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results.	Correct the problem. If required, reprep and reanalyze the method blank and all samples processed with the contaminated blank.	Analyst / Laboratory Area Supervisor	Contamination / Bias	Same as Method/SOP QC Acceptance Limits.
Laboratory Control Sample (LCS)		QC acceptance criteria specified in DoD QSM v4.1., refer to **Tables A1-**1, -5, -8	Correct problem, then reprep and reanalyze the LCS and all samples in the associated preparatory batch for the failed analyte, if sufficient sample material is available.		Accuracy / Bias	
Matrix Spike (MS)		Use in-house limits for LCS.	Examine results of LCS. If both the LCS and MS/MSD are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.		Accuracy / Bias	
Matrix Spike Duplicate (MSD) or Sample Duplicate (DUP)		Use in-house recovery limits for LCS. RPD $\leq$ 20% (between MS and MSD or sample and sample duplicate).	Examine results of LCS. If both the LCS and MS/MSD or MS/DUP are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.		Precision / Accuracy / Bias	

TABLE A3-6
Laboratory QC Samples Table

Matrix: Surface Soil, Subsurface Soil

Analytical Group: Metals (Hexavalent Chromium)

Analytical Method/SOP Reference: SW-846 7199 / GEN-7199

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per batch of 20 or fewer samples.	No target compounds should be >1/2 LOQ.	Reclean, reanalyze and/or qualify the data.	Analyst/Supervisor	Bias/Contamination	Same as Method/SOP QC Acceptance Limits.
LCS-soluble		QC acceptance criteria specified in DoD QSM v4.1., refer to **Table A1-2.**	Redigest if possible. If samples are out of holding time, redigest and report both sets of data. If insufficient sample is available to redigest, flag. If the LCS recoveries are high and the sample results are <LOQ, narrate.		Accuracy/Bias	
LCS-insoluble	1 per batch of 20 or fewer samples (for solid matrices only).		Redigest if possible. If samples are out of holding time, redigest and report both sets of data. If insufficient sample is available to redigest, flag. If the LCS recoveries are high and the sample results are <LOQ, narrate.		Accuracy/Bias	
MS-soluble	1 per batch of 20 or fewer samples.	Refer to **Table A1-2.**	Redigest entire batch unless spike is diluted out (sample result > 4x spike concentration). If redigest fails, contact client about possible matrix investigations. If samples are out of holding time, redigest and report both sets of data. If insufficient sample is available to redigest, flag. Flag results associated with out of control matrix spike.		Accuracy/ Bias	
MS-insoluble	1 per batch of 20 or fewer samples (for solid matrices only).					
DUP(or MSD)	1 per batch of 20 or fewer samples.	If parent concentration is >4x the LOQ, RPD<20%; if the parent concentration is <4x the LOQ, duplicate is acceptable if the difference is not > +/- LOQ.	Reprep and reanalyze sample and duplicate unless obvious or historical interferences or lack of volume.		Precision	
Post Digestion Matrix Spike		85-115% of the true value.	If MS also failed, no action beyond CA for MS.		Bias	

TABLE A3-7
Laboratory QC Samples Table

Matrix: Surface Soil, Subsurface Soil, Residual Sump Material sample

Analytical Group: Wet Chemistry (TOC)

Analytical Method/SOP Reference: Lloyd Kahn / GR-05-132

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparatory batch of up to 20 samples.	Analyte not detected > 1/2 RL and greater than 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results.	Re-prepare and analyze all associated samples. Discuss with client/qualify if re-analysis not feasible.	Analyst / Laboratory Area Supervisor	Contamination / Bias	Same as Method/SOP QC Acceptance Limits.
Laboratory Control Sample (LCS)	One per preparatory batch of up to 20 samples.	QC acceptance criteria specified in DoD QSM v4.1., refer to **Table A1-4 and 10.**	Re-prepare and analyze all associated samples. Discuss with client/qualify if re-analysis not feasible.	Analyst / Laboratory Area Supervisor	Accuracy / Bias	
Matrix Spike (MS)	One per preparatory batch of up to 20 samples.	For matrix evaluation use QC acceptance criteria specified for LCS.	Examine results of LCS. If both the LCS and MS/MSD are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.	Analyst / Laboratory Area Supervisor	Accuracy / Bias	
Matrix Spike Duplicate (MSD)	One per preparatory batch of up to 20 samples.	MSD: For matrix evaluation, use QC acceptance criteria specified for LCS. MSD: RPD $\leq$ 20% (between MS and MSD).	Examine results of LCS. If both the LCS and MS/MSD are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.	Analyst / Laboratory Area Supervisor	Accuracy / Bias	

TABLE A3-8
Laboratory QC Samples Table

Matrix: Surface Soil, Subsurface Soil, Residual Sump Material sample
Analytical Group: Wet Chemistry (pH)
Analytical Method/SOP Reference: SW-846 9045C / GR-07-113

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Standard Reference Material (SRM)	Two per preparatory batch of up to 20 samples.	±0.05 pH units of certified value	Re-prepare and analyze all associated samples.	Analyst / Laboratory Area Supervisor	Accuracy	Same as Method/SOP QC Acceptance Limits.
Laboratory Duplicate (DUP)	One per preparatory batch of up to 20 samples.	RPD limit for pH is 20.	Re-prepare and analyze all associated samples.	Analyst / Laboratory Area Supervisor	Bias	

TABLE A3-9
Laboratory QC Samples Table

Matrix: Groundwater

Analytical Group: Wet Chemistry (Chloride, Nitrate, Nitrite, Sulfate)

Analytical Method/SOP Reference: EPA 300.0 / GR-02-113

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparatory batch of up to 20 samples.	No analytes detected > 1/2 RL and greater than 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results.	Re-prepare and analyze all associated samples. Discuss with client/qualify if re-analysis not feasible.	Analyst / Laboratory Area Supervisor	Contamination / Bias	Same as Method/SOP QC Acceptance Limits.
Laboratory Control Sample (LCS) containing analyte to be reported.	One per preparatory batch of up to 20 samples.	QC acceptance criteria specified in DoD QSM v4.1., refer to **Table A1-8**.	Re-prepare and analyze all associated samples. Discuss with client/qualify if re-analysis not feasible.	Analyst / Laboratory Area Supervisor	Accuracy / Bias	
Matrix Spike (MS)	One per preparatory batch of up to 20 samples.	For matrix evaluation use QC acceptance criteria specified for LCS.	Examine results of LCS. If both the LCS and MS/MSD are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.	Analyst / Laboratory Area Supervisor	Accuracy / Bias	
Matrix Spike Duplicate (MSD)	One per preparatory batch of up to 20 samples.	MSD: For matrix evaluation, use QC acceptance criteria specified for LCS. MSD: RPD $\leq$ 15% (between MS and MSD).	Examine results of LCS. If both the LCS and MS/MSD are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.	Analyst / Laboratory Area Supervisor	Accuracy / Bias	

TABLE A3-10
Laboratory QC Samples Table

Matrix: Groundwater
Analytical Group: Wet Chemistry (Sulfide)
Analytical Method/SOP Reference: SM 4500-S2-F / GR-06-110

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparatory batch of up to 20 samples.	Analyte not detected > 1/2 RL and greater than 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results.	Re-prepare and analyze all associated samples. Discuss with client/qualify if re-analysis not feasible.	Analyst / Laboratory Area Supervisor	Contamination / Bias	Same as Method/SOP QC Acceptance Limits.
Laboratory Control Sample (LCS)	One per preparatory batch of up to 20 samples.	QC acceptance criteria specified in DoD QSM v4.1., refer to **Table A1-8**.	Re-prepare and analyze all associated samples. Discuss with client/qualify if re-analysis not feasible.	Analyst / Laboratory Area Supervisor	Accuracy / Bias	
Matrix Spike (MS)	One per preparatory batch of up to 20 samples.	For matrix evaluation use QC acceptance criteria specified for LCS.	Examine results of LCS. If both the LCS and MS/MSD are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.	Analyst / Laboratory Area Supervisor	Accuracy / Bias	
Matrix Spike Duplicate (MSD)	One per preparatory batch of up to 20 samples.	MSD: For matrix evaluation, use QC acceptance criteria specified for LCS. MSD: RPD $\leq$ 20% (between MS and MSD).	Examine results of LCS. If both the LCS and MS/MSD are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.	Analyst / Laboratory Area Supervisor	Accuracy / Bias	

TABLE A3-11
Laboratory QC Samples Table

Matrix: Groundwater
Analytical Group: Wet Chemistry (Alkalinity)
Analytical Method/SOP Reference: SM2320B / GR-06-101

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparatory batch of up to 20 samples.	Analyte not detected > 1/2 RL and greater than 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results.	Re-prepare and analyze all associated samples. Discuss with client/qualify if re-analysis not feasible.	Analyst / Laboratory Area Supervisor	Contamination / Bias	Same as Method/SOP QC Acceptance Limits.
Laboratory Control Sample (LCS)	One per preparatory batch of up to 20 samples.	QC acceptance criteria specified in DoD QSM v4.1., refer to Table A1-8.	Re-prepare and analyze all associated samples. Discuss with client/qualify if re-analysis not feasible.	Analyst / Laboratory Area Supervisor	Accuracy / Bias	
Matrix Spike (MS)	One per preparatory batch of up to 20 samples.	For matrix evaluation use QC acceptance criteria specified for LCS.	Examine results of LCS. If both the LCS and MS/MSD are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.	Analyst / Laboratory Area Supervisor	Accuracy / Bias	
Matrix Spike Duplicate (MSD)	One per preparatory batch of up to 20 samples.	MSD: For matrix evaluation, use QC acceptance criteria specified for LCS. MSD: RPD < 20% (between MS and MSD).	Examine results of LCS. If both the LCS and MS/MSD are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.	Analyst / Laboratory Area Supervisor	Accuracy / Bias	

TABLE A3-12
Laboratory QC Samples Table

Matrix: Groundwater

Analytical Group: Wet Chemistry (Methane)

Analytical Method/SOP Reference: RSK-175 / GR-03-130

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparatory batch of up to 20 samples.	No analytes detected > 1/2 RL and greater than 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results.	Re-prepare and analyze all associated samples. Discuss with client/qualify if re-analysis not feasible.	Analyst / Laboratory Area Supervisor	Contamination / Bias	Same as Method/SOP QC Acceptance Limits.
Laboratory Control Sample (LCS) containing all analytes to be reported	One per preparatory batch of up to 20 samples.	QC acceptance criteria specified in DoD QSM v4.1., refer to **Table A1-8**.	Re-prepare and analyze all associated samples. Discuss with client/qualify if re-analysis not feasible.	Analyst / Laboratory Area Supervisor	Accuracy / Bias	
Matrix Spike (MS)	One per preparatory batch of up to 20 samples.	For matrix evaluation use QC acceptance criteria specified for LCS.	Examine results of LCS. If both the LCS and MS/MSD are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.	Analyst / Laboratory Area Supervisor	Accuracy / Bias	
Matrix Spike Duplicate (MSD)	One per preparatory batch of up to 20 samples.	MSD: For matrix evaluation, use QC acceptance criteria specified for LCS. MSD: RPD $\leq$ 20% (between MS and MSD).	Examine results of LCS. If both the LCS and MS/MSD are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.	Analyst / Laboratory Area Supervisor	Accuracy / Bias	

TABLE A3-13
Laboratory QC Samples Table

Matrix: Groundwater

Analytical Group: Wet Chemistry (pH)

Analytical Method/SOP Reference: SW-846 9040C / GR-07-100

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Standard Reference Material (SRM)	Two per preparatory batch of up to 20 samples.	±0.05 pH units of certified value	Re-prepare and analyze all associated samples.	Analyst / Laboratory Area Supervisor	Accuracy	Same as Method/SOP QC Acceptance Limits.
Laboratory Duplicate (DUP)	One per preparatory batch of up to 20 samples.	RPD limit for pH is 20.	Re-prepare and analyze all associated samples.	Analyst / Laboratory Area Supervisor	Bias	

TABLE A3-14
Laboratory QC Samples Table

Matrix: Groundwater
Analytical Group: Wet Chemistry (TOC)
Analytical Method/SOP Reference: SW-846 9060A / GR-05-105

QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	One per preparatory batch of up to 20 samples.	Analyte not detected > 1/2 RL and greater than 1/10 the regulatory limit (whichever is greater). Blank result must not otherwise affect sample results.	Re-prepare and analyze all associated samples. Discuss with client/qualify if re-analysis not feasible.	Analyst / Laboratory Area Supervisor	Contamination / Bias	Same as Method/SOP QC Acceptance Limits.
Laboratory Control Sample (LCS)	One per preparatory batch of up to 20 samples.	QC acceptance criteria specified in DoD QSM v4.1., refer to **Table A1-8**.	Re-prepare and analyze all associated samples. Discuss with client/qualify if re-analysis not feasible.	Analyst / Laboratory Area Supervisor	Accuracy / Bias	
Matrix Spike (MS)	One per preparatory batch of up to 20 samples.	For matrix evaluation use QC acceptance criteria specified for LCS.	Examine results of LCS. If both the LCS and MS/MSD are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.	Analyst / Laboratory Area Supervisor	Accuracy / Bias	
Matrix Spike Duplicate (MSD)	One per preparatory batch of up to 20 samples.	MSD: For matrix evaluation, use QC acceptance criteria specified for LCS. MSD: RPD $\leq$ 20% (between MS and MSD).	Examine results of LCS. If both the LCS and MS/MSD are unacceptable, re-prepare and analyze the associated samples and QC, otherwise report and narrate.	Analyst / Laboratory Area Supervisor	Accuracy / Bias	

Appendix A – Attachment 1
Ecological Screening Values for Soil

Attachment 1

Ecological Screening Values (ESVs) for Soil

Analytical Group	Chemical	ESV	Units	Reference	Comments
Explosives	1,3,5-Trinitrobenzene	NSV	--	--	
Explosives	1,3-Dinitrobenzene	NSV	--	--	
Explosives	2,4,6-Trinitrotoluene	10,000	ug/kg	Talmage et al. 1999	Plant
Explosives	2,4-Dinitrotoluene	11,000	ug/kg	NRCC 2006	Plant/Invertebrate
Explosives	2,6-Dinitrotoluene	8,500	ug/kg	NRCC 2006	Plant/Invertebrate
Explosives	2-Amino-4,6-dinitrotoluene	80,000	ug/kg	Talmage et al. 1999	Plant
Explosives	2-Nitrotoluene	NSV	--	--	
Explosives	3,5-Dinitroaniline	NSV	--	--	
Explosives	3-Nitrotoluene	NSV	--	--	
Explosives	4-Amino-2,6-dinitrotoluene	80,000	ug/kg	2-Amino-4,6-dinitrotoluene	Plant
Explosives	4-Nitrotoluene	NSV	--	--	
Explosives	HMX	10,000	ug/kg	Talmage et al. 1999	Invertebrate
Explosives	Nitrobenzene	2,260	ug/kg	Efroymson et al. 1997b	Invertebrate LC50 of 226,000; UF of 100
Explosives	Nitroglycerine	NSV	--	--	
Explosives	Nitroguanidine	NSV	--	--	
Explosives	PETN	NSV	--	--	
Explosives	RDX	10,000	ug/kg	Talmage et al. 1999	Invertebrate
Explosives	Tetryl	10,000	ug/kg	Talmage et al. 1999	Plant
Inorganics	Aluminum	pH < 5.5	--	USEPA 2003a	Eco-SSL
Inorganics	Antimony	78.0	mg/kg	USEPA 2005a	Eco-SSL - Invertebrate
Inorganics	Arsenic	18.0	mg/kg	USEPA 2005b	Eco-SSL - Plant
Inorganics	Barium	330	mg/kg	USEPA 2005c	Eco-SSL - Invertebrate
Inorganics	Beryllium	40.0	mg/kg	USEPA 2005d	Eco-SSL - Invertebrate
Inorganics	Cadmium	32.0	mg/kg	USEPA 2005e	Eco-SSL - Plant
Inorganics	Calcium	NSV	--	--	
Inorganics	Chromium	64.0	mg/kg	CCME 2007	Soil Quality Guideline
Inorganics	Cobalt	13.0	mg/kg	USEPA 2005f	Eco-SSL - Plant
Inorganics	Copper	70.0	mg/kg	USEPA 2007a	Eco-SSL - Plant
Inorganics	Cyanide	15.8	mg/kg	MHSPE 2000	Geomean of target/intervention - complex
Inorganics	Iron	5 < pH > 8	--	USEPA 2003b	Eco-SSL
Inorganics	Lead	120	mg/kg	USEPA 2005g	Eco-SSL - Plant
Inorganics	Magnesium	NSV	--	--	
Inorganics	Manganese	220	mg/kg	USEPA 2007b	Eco-SSL - Plant

Attachment 1

Ecological Screening Values (ESVs) for Soil

Analytical Group	Chemical	ESV	Units	Reference	Comments
Inorganics	Mercury	0.10	mg/kg	Efroymson et al. 1997b	Invertebrate
Inorganics	Nickel	38.0	mg/kg	USEPA 2007c	Eco-SSL - Plant
Inorganics	Potassium	NSV	--	--	
Inorganics	Selenium	0.52	mg/kg	USEPA 2007d	Eco-SSL - Plant
Inorganics	Silver	560	mg/kg	USEPA 2006a	Eco-SSL - Plant
Inorganics	Sodium	NSV	--	--	
Inorganics	Thallium	1.00	mg/kg	Efroymson et al. 1997a	Plant
Inorganics	Vanadium	130	mg/kg	CCME 2007	Soil Quality Guideline
Inorganics	Zinc	120	mg/kg	USEPA 2007e	Eco-SSL - Invertebrate

NSV - No Screening Value

Attachment 1

Ecological Screening Values (ESVs) for Freshwater Sediment

Analytical Group	Chemical	Type	ESV	Units	TOC (%)	Reference	Comment
Explosives	1,3,5-Trinitrobenzene	Freshwater	2.40	ug/kg	1	Talmage et al. 1999	
Explosives	1,3-Dinitrobenzene	Freshwater	6.70	ug/kg	1	Talmage et al. 1999	
Explosives	2,4,6-Trinitrotoluene	Freshwater	92.0	ug/kg	1	Talmage et al. 1999	
Explosives	2,4-Dinitrotoluene	Freshwater	41.6	ug/kg	1	USEPA 2006b	
Explosives	2,6-Dinitrotoluene	Freshwater	NSV	--		--	
Explosives	2-Amino-4,6-dinitrotoluene	Freshwater	13.2	ug/kg	1	NAVFAC 2007	
Explosives	2-Nitrotoluene	Freshwater	6,204	ug/kg	1	NAVFAC 2007	
Explosives	3,5-Dinitroaniline	Freshwater	NSV	--		--	
Explosives	3-Nitrotoluene	Freshwater	1,922	ug/kg	1	NAVFAC 2007	
Explosives	4-Amino-2,6-dinitrotoluene	Freshwater	23.2	ug/kg	1	NAVFAC 2007	
Explosives	4-Nitrotoluene	Freshwater	4,062	ug/kg	1	USEPA 2006b	
Explosives	HMX	Freshwater	4.74	ug/kg	1	Talmage et al. 1999	
Explosives	Nitrobenzene	Freshwater	1,779	ug/kg	1	NAVFAC 2007	
Explosives	Nitroglycerine	Freshwater	NSV	--		--	
Explosives	Nitroguanidine	Freshwater	NSV	--		--	
Explosives	PETN	Freshwater	NSV	--		--	
Explosives	RDX	Freshwater	12.7	ug/kg	1	Talmage et al. 1999	
Explosives	Tetryl	Freshwater	NSV	--		--	
Inorganics	Aluminum	Freshwater	25,500	mg/kg		Buchman 2008	ARCS TEL
Inorganics	Antimony	Freshwater	3.00	mg/kg		Buchman 2008	UET
Inorganics	Arsenic	Freshwater	9.79	mg/kg		MacDonald et al. 2000	TEC
Inorganics	Barium	Freshwater	20.0	mg/kg		MacDonald et al. 2003	TEC
Inorganics	Beryllium	Freshwater	NSV	--		--	
Inorganics	Cadmium	Freshwater	0.99	mg/kg		MacDonald et al. 2000	TEC
Inorganics	Calcium	Freshwater	NSV	--		--	
Inorganics	Chromium	Freshwater	43.4	mg/kg		MacDonald et al. 2000	TEC
Inorganics	Cobalt	Freshwater	50.0	mg/kg		Persuad et al. 1993	OWDG
Inorganics	Copper	Freshwater	31.6	mg/kg		MacDonald et al. 2000	TEC
Inorganics	Cyanide	Freshwater	NSV	--		--	
Inorganics	Iron	Freshwater	20,000	mg/kg		Persuad et al. 1993	LEL
Inorganics	Lead	Freshwater	35.8	mg/kg		MacDonald et al. 2000	TEC
Inorganics	Magnesium	Freshwater	NSV	--		--	

Attachment 1

Ecological Screening Values (ESVs) for Freshwater Sediment

Analytical Group	Chemical	Type	ESV	Units	TOC (%)	Reference	Comment
Inorganics	Manganese	Freshwater	460	mg/kg		Persuad et al. 1993	LEL
Inorganics	Mercury	Freshwater	0.18	mg/kg		MacDonald et al. 2000	TEC
Inorganics	Nickel	Freshwater	22.7	mg/kg		MacDonald et al. 2000	TEC
Inorganics	Potassium	Freshwater	NSV	--		--	
Inorganics	Selenium	Freshwater	2.00	mg/kg		USEPA 2006b	
Inorganics	Silver	Freshwater	1.00	mg/kg		MacDonald et al. 2003	TEC
Inorganics	Sodium	Freshwater	NSV	--		--	
Inorganics	Thallium	Freshwater	NSV	--		--	
Inorganics	Vanadium	Marine	57.0	mg/kg		Buchman 2008	AET
Inorganics	Zinc	Freshwater	121	mg/kg		MacDonald et al. 2000	TEC

NSV - No Screening Value

ATTACHMENT 1

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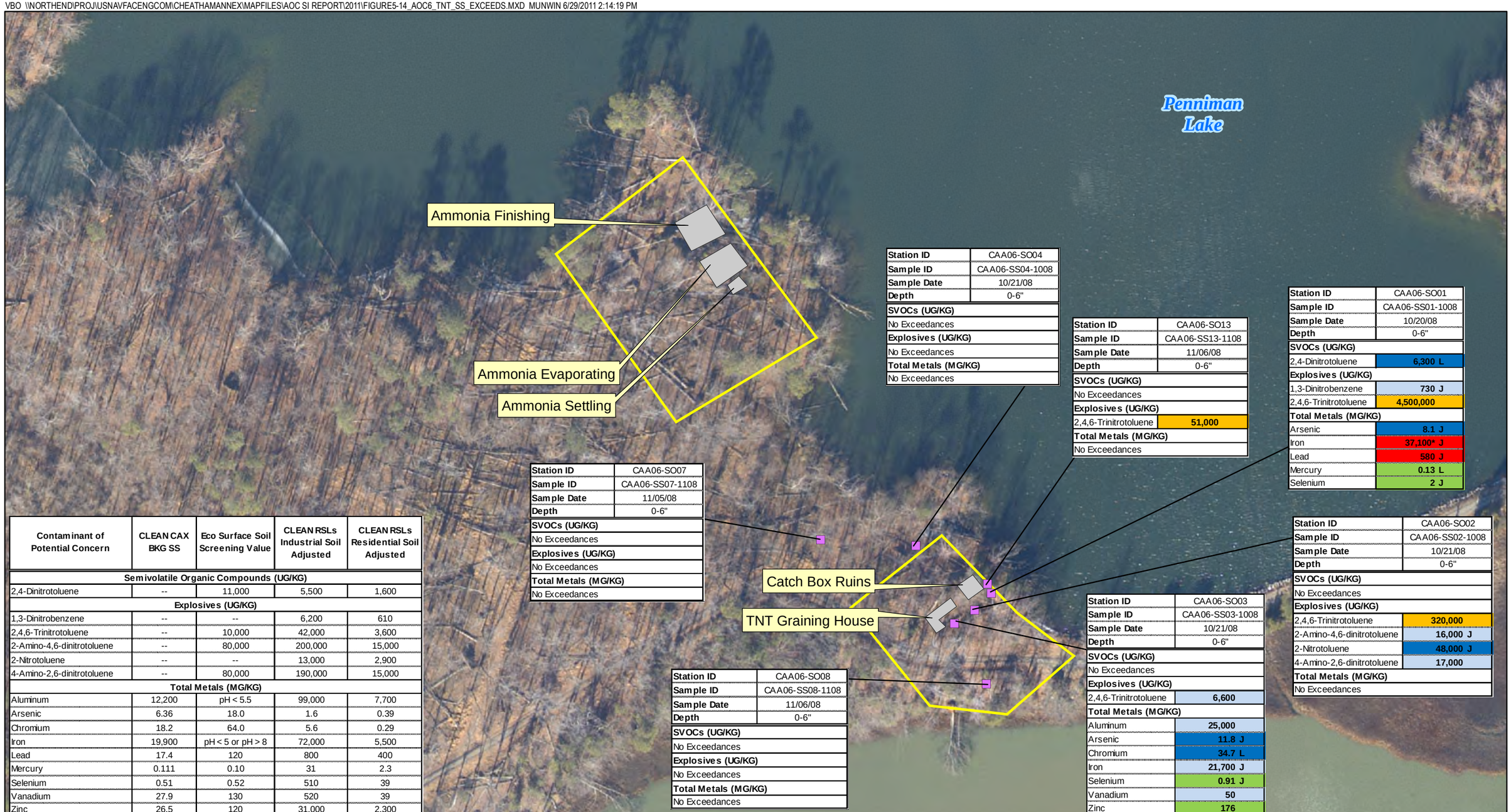
Appendix B
Site Inspection Exceedance Figures

VBO \\NORTHEND\PROJ\USNAVFACENGCOM\CHEATHAMANNEX\MAPFILES\AOC SI REPORT\2011\FIGURE5-14_AOC6_TNT_SS_EXCEEDS.MXD MUNWIN 6/29/2011 2:14:19 PM



Station ID	CAA06-SO04
Sample ID	CAA06-SS04-1008
Sample Date	10/21/08
Depth	0-6"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
No Exceedances	
Total Metals (MG/KG)	
No Exceedances	

Station ID	CAA06-SO13
Sample ID	CAA06-SS13-1108
Sample Date	11/06/08
Depth	0-6"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
2,4,6-Trinitrotoluene	51,000
Total Metals (MG/KG)	
No Exceedances	

Station ID	CAA06-SO01
Sample ID	CAA06-SS01-1008
Sample Date	10/20/08
Depth	0-6"
SVOCs (UG/KG)	
2,4-Dinitrotoluene	6,300 L
Explosives (UG/KG)	
1,3-Dinitrobenzene	730 J
2,4,6-Trinitrotoluene	4,500,000
Total Metals (MG/KG)	
Arsenic	8.1 J
Iron	37,100* J
Lead	580 J
Mercury	0.13 L
Selenium	2 J

Station ID	CAA06-SO07
Sample ID	CAA06-SS07-1108
Sample Date	11/05/08
Depth	0-6"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
No Exceedances	
Total Metals (MG/KG)	
No Exceedances	

Station ID	CAA06-SO02
Sample ID	CAA06-SS02-1008
Sample Date	10/21/08
Depth	0-6"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
2,4,6-Trinitrotoluene	320,000
2-Amino-4,6-dinitrotoluene	16,000 J
2-Nitrotoluene	48,000 J
4-Amino-2,6-dinitrotoluene	17,000
Total Metals (MG/KG)	
No Exceedances	

Station ID	CAA06-SO03
Sample ID	CAA06-SS03-1008
Sample Date	10/21/08
Depth	0-6"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
2,4,6-Trinitrotoluene	6,600
Total Metals (MG/KG)	
Aluminum	25,000
Arsenic	11.8 J
Chromium	34.7 L
Iron	21,700 J
Selenium	0.91 J
Vanadium	50
Zinc	176

Station ID	CAA06-SO08
Sample ID	CAA06-SS08-1108
Sample Date	11/06/08
Depth	0-6"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
No Exceedances	
Total Metals (MG/KG)	
No Exceedances	

Contaminant of Potential Concern	CLEAN CAX BKG SS	Eco Surface Soil Screening Value	CLEAN RSLs Industrial Soil Adjusted	CLEAN RSLs Residential Soil Adjusted
Semivolatile Organic Compounds (UG/KG)				
2,4-Dinitrotoluene	--	11,000	5,500	1,600
Explosives (UG/KG)				
1,3-Dinitrobenzene	--	--	6,200	610
2,4,6-Trinitrotoluene	--	10,000	42,000	3,600
2-Amino-4,6-dinitrotoluene	--	80,000	200,000	15,000
2-Nitrotoluene	--	--	13,000	2,900
4-Amino-2,6-dinitrotoluene	--	80,000	190,000	15,000
Total Metals (MG/KG)				
Aluminum	12,200	pH < 5.5	99,000	7,700
Arsenic	6.36	18.0	1.6	0.39
Chromium	18.2	64.0	5.6	0.29
Iron	19,900	pH < 5 or pH > 8	72,000	5,500
Lead	17.4	120	800	400
Mercury	0.111	0.10	31	2.3
Selenium	0.51	0.52	510	39
Vanadium	27.9	130	520	39
Zinc	26.5	120	31,000	2,300

Legend

- Soil Sample Location
- Approximate AOC 6 Study Area
- Buildings

Notes:

- Exceeds BKG & ECO
- Exceeds BKG & Res RSL
- Exceeds BKG, ECO & Res RSL
- Exceeds BKG, Res & Ind RSLs
- Exceeds BKG, ECO, Res & Ind RSLs

*Eco exceedance due to pH value
-- - No value available
J - Analyte present, value may or may not be accurate or precise
L - Analyte present, value may be biased low, actual value may be higher
UG/KG - Micrograms per kilogram
MG/KG - Milligrams per kilogram

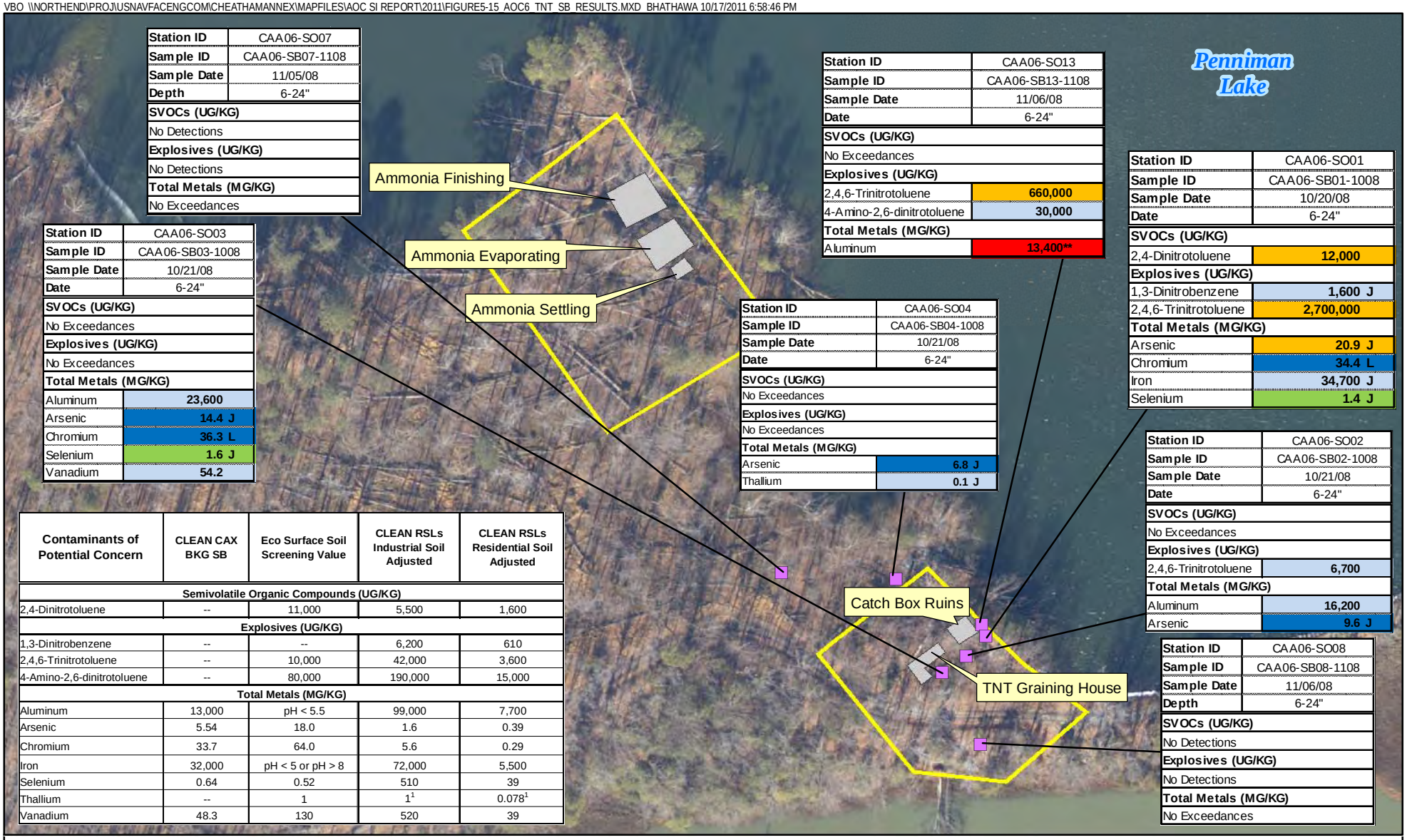
N W E S

0 100 200 Feet

Figure 5-14
AOC 6 Surface Soil Exceedance Results
TNT Graining House and Catch Box Ruins Subarea
Site Inspection Report
Areas of Concern 1, 2, 6, 7, and 8
Cheatham Annex
Williamsburg, Virginia

CH2MHILL

VBO \\NORTHEND\PROJ\USNAVFACENGCOM\CHEATHAMANNEX\MAPFILES\AOC SI REPORT\2011\FIGURE5-15_AOC6_TNT_SB_RESULTS.MXD BHATHAWA 10/17/2011 6:58:46 PM



Station ID	CAA06-SO07
Sample ID	CAA06-SB07-1108
Sample Date	11/05/08
Depth	6-24"
SVOCs (UG/KG)	
No Detections	
Explosives (UG/KG)	
No Detections	
Total Metals (MG/KG)	
No Exceedances	

Station ID	CAA06-SO03
Sample ID	CAA06-SB03-1008
Sample Date	10/21/08
Date	6-24"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
No Exceedances	
Total Metals (MG/KG)	
Aluminum	23,600
Arsenic	14.4 J
Chromium	36.3 L
Selenium	1.6 J
Vanadium	54.2

Station ID	CAA06-SO13
Sample ID	CAA06-SB13-1108
Sample Date	11/06/08
Date	6-24"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
2,4,6-Trinitrotoluene	660,000
4-Amino-2,6-dinitrotoluene	30,000
Total Metals (MG/KG)	
Aluminum	13,400**

Station ID	CAA06-SO04
Sample ID	CAA06-SB04-1008
Sample Date	10/21/08
Date	6-24"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
No Exceedances	
Total Metals (MG/KG)	
Arsenic	6.8 J
Thallium	0.1 J

Station ID	CAA06-SO01
Sample ID	CAA06-SB01-1008
Sample Date	10/20/08
Date	6-24"
SVOCs (UG/KG)	
2,4-Dinitrotoluene	12,000
Explosives (UG/KG)	
1,3-Dinitrobenzene	1,600 J
2,4,6-Trinitrotoluene	2,700,000
Total Metals (MG/KG)	
Arsenic	20.9 J
Chromium	34.4 L
Iron	34,700 J
Selenium	1.4 J

Station ID	CAA06-SO02
Sample ID	CAA06-SB02-1008
Sample Date	10/21/08
Date	6-24"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
2,4,6-Trinitrotoluene	6,700
Total Metals (MG/KG)	
Aluminum	16,200
Arsenic	9.6 J

Station ID	CAA06-SO08
Sample ID	CAA06-SB08-1108
Sample Date	11/06/08
Depth	6-24"
SVOCs (UG/KG)	
No Detections	
Explosives (UG/KG)	
No Detections	
Total Metals (MG/KG)	
No Exceedances	

Contaminants of Potential Concern	CLEAN CAX BKG SB	Eco Surface Soil Screening Value	CLEAN RSLs Industrial Soil Adjusted	CLEAN RSLs Residential Soil Adjusted
Semivolatile Organic Compounds (UG/KG)				
2,4-Dinitrotoluene	--	11,000	5,500	1,600
Explosives (UG/KG)				
1,3-Dinitrobenzene	--	--	6,200	610
2,4,6-Trinitrotoluene	--	10,000	42,000	3,600
4-Amino-2,6-dinitrotoluene	--	80,000	190,000	15,000
Total Metals (MG/KG)				
Aluminum	13,000	pH < 5.5	99,000	7,700
Arsenic	5.54	18.0	1.6	0.39
Chromium	33.7	64.0	5.6	0.29
Iron	32,000	pH < 5 or pH > 8	72,000	5,500
Selenium	0.64	0.52	510	39
Thallium	--	1	1[1]	0.078[1]
Vanadium	48.3	130	520	39

Legend

- Soil Sample Location
- Approximate AOC 6 Study Area
- Buildings

Notes:

[1]Adjusted June 2011 RSL value
* Indicates duplicate sample was collected at this location. Values presented are the higher of the two.
**Eco exceedance due to pH value
-- - No value available
J - Analyte present, value may or may not be accurate or precise
L - Analyte present, value may be biased low, actual value may be higher

UG/KG - Micrograms per kilogram
MG/KG - Milligrams per kilogram

- Exceeds BKG & ECO
- Exceeds BKG & Res RSL
- Exceeds BKG, ECO & Res RSL
- Exceeds BKG, Res & Ind RSLs
- Exceeds BKG, ECO, Res & Ind RSLs

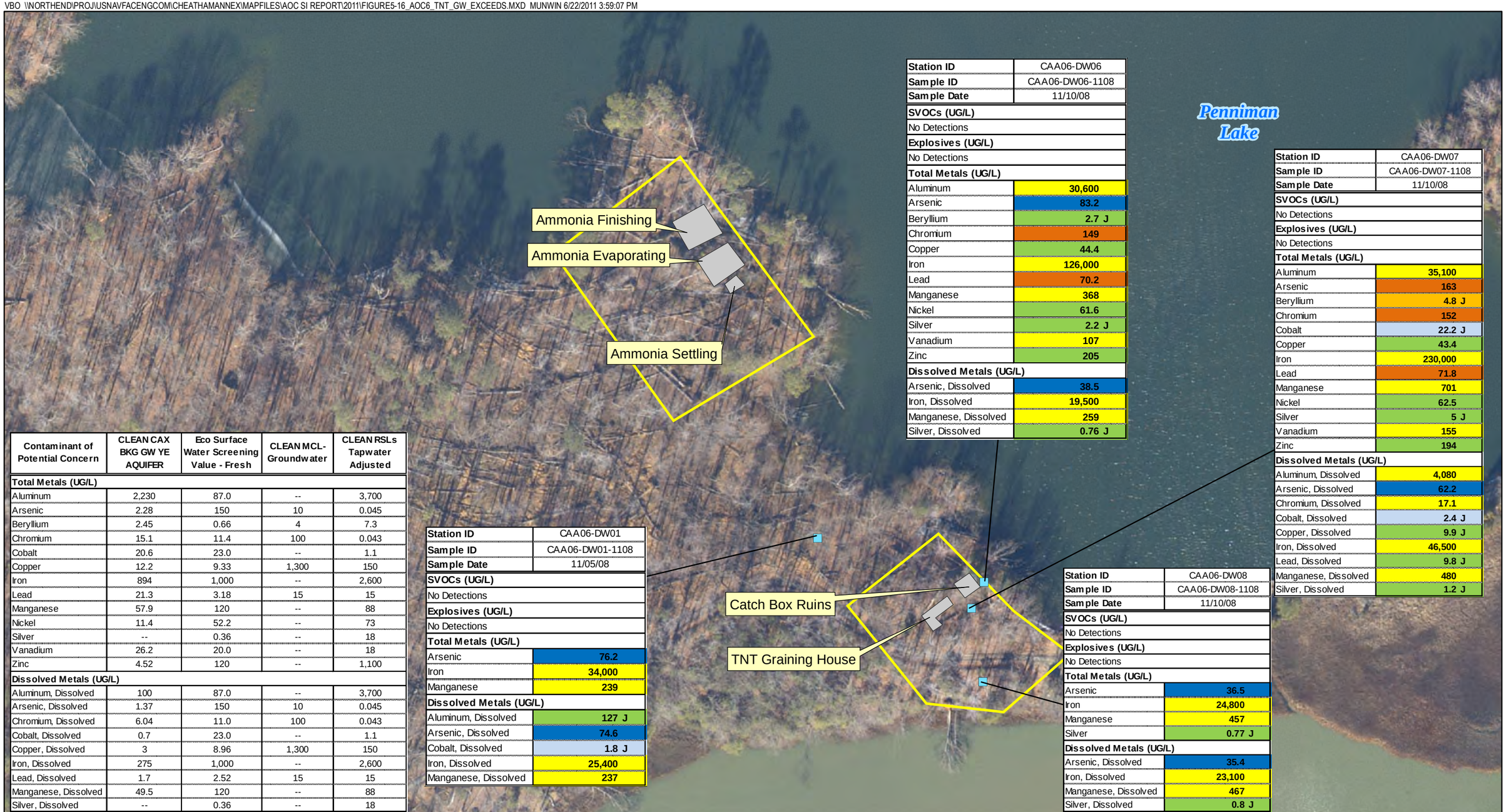
N W E S

0 60 120 Feet

Figure 5-15
AOC 6 Subsurface Soil Exceedance Results
TNT Graining House and Catch Box Ruins Subarea
Site Inspection Report
Areas of Concern 1, 2, 6, 7, and 8
Cheatham Annex
Williamsburg, Virginia

CH2MHILL

VBO \\NORTHEND\PROJ\USNAVFACENGCOM\CHEATHAMANNEX\MAPFILES\AOC SI REPORT\2011\FIGURE5-16_AOC6_TNT_GW_EXCEEDS.MXD MUNWIN 6/22/2011 3:59:07 PM



Station ID	CAA06-DW06
Sample ID	CAA06-DW06-1108
Sample Date	11/10/08
SVOCs (UG/L)	
No Detections	
Explosives (UG/L)	
No Detections	
Total Metals (UG/L)	
Aluminum	30,600
Arsenic	83.2
Beryllium	2.7 J
Chromium	149
Copper	44.4
Iron	126,000
Lead	70.2
Manganese	368
Nickel	61.6
Silver	2.2 J
Vanadium	107
Zinc	205
Dissolved Metals (UG/L)	
Arsenic, Dissolved	38.5
Iron, Dissolved	19,500
Manganese, Dissolved	259
Silver, Dissolved	0.76 J

Station ID	CAA06-DW07
Sample ID	CAA06-DW07-1108
Sample Date	11/10/08
SVOCs (UG/L)	
No Detections	
Explosives (UG/L)	
No Detections	
Total Metals (UG/L)	
Aluminum	35,100
Arsenic	163
Beryllium	4.8 J
Chromium	152
Cobalt	22.2 J
Copper	43.4
Iron	230,000
Lead	71.8
Manganese	701
Nickel	62.5
Silver	5 J
Vanadium	155
Zinc	194
Dissolved Metals (UG/L)	
Aluminum, Dissolved	4,080
Arsenic, Dissolved	62.2
Chromium, Dissolved	17.1
Cobalt, Dissolved	2.4 J
Copper, Dissolved	9.9 J
Iron, Dissolved	46,500
Lead, Dissolved	9.8 J
Manganese, Dissolved	480
Silver, Dissolved	1.2 J

Station ID	CAA06-DW01
Sample ID	CAA06-DW01-1108
Sample Date	11/05/08
SVOCs (UG/L)	
No Detections	
Explosives (UG/L)	
No Detections	
Total Metals (UG/L)	
Arsenic	76.2
Iron	34,000
Manganese	239
Dissolved Metals (UG/L)	
Aluminum, Dissolved	127 J
Arsenic, Dissolved	74.6
Cobalt, Dissolved	1.8 J
Iron, Dissolved	25,400
Manganese, Dissolved	237

Station ID	CAA06-DW08
Sample ID	CAA06-DW08-1108
Sample Date	11/10/08
SVOCs (UG/L)	
No Detections	
Explosives (UG/L)	
No Detections	
Total Metals (UG/L)	
Arsenic	36.5
Iron	24,800
Manganese	457
Silver	0.77 J
Dissolved Metals (UG/L)	
Arsenic, Dissolved	35.4
Iron, Dissolved	23,100
Manganese, Dissolved	467
Silver, Dissolved	0.8 J

Contaminant of Potential Concern	CLEAN CAX BKG GW YE AQUIFER	Eco Surface Water Screening Value - Fresh	CLEAN MCL-Groundwater	CLEAN RSLs Tapwater Adjusted
Total Metals (UG/L)				
Aluminum	2,230	87.0	--	3,700
Arsenic	2.28	150	10	0.045
Beryllium	2.45	0.66	4	7.3
Chromium	15.1	11.4	100	0.043
Cobalt	20.6	23.0	--	1.1
Copper	12.2	9.33	1,300	150
Iron	894	1,000	--	2,600
Lead	21.3	3.18	15	15
Manganese	57.9	120	--	88
Nickel	11.4	52.2	--	73
Silver	--	0.36	--	18
Vanadium	26.2	20.0	--	18
Zinc	4.52	120	--	1,100
Dissolved Metals (UG/L)				
Aluminum, Dissolved	100	87.0	--	3,700
Arsenic, Dissolved	1.37	150	10	0.045
Chromium, Dissolved	6.04	11.0	100	0.043
Cobalt, Dissolved	0.7	23.0	--	1.1
Copper, Dissolved	3	8.96	1,300	150
Iron, Dissolved	275	1,000	--	2,600
Lead, Dissolved	1.7	2.52	15	15
Manganese, Dissolved	49.5	120	--	88
Silver, Dissolved	--	0.36	--	18

Legend

- Groundwater/Soil Sample Location
- Approximate AOC 6 Study Area
- Buildings

Notes:

- Exceeds BKG & ECO
- Exceeds BKG & Tapwater RSL
- Exceeds BKG, Tapwater RSL & MCL
- Exceeds BKG, ECO & Tapwater RSL
- Exceeds BKG, ECO & MCL
- Exceeds BKG, ECO, Tapwater RSL & MCL

-- - No value available
J - Analyte present, value may or may not be accurate or precise
UG/L - Micrograms per liter

N
W E
S

0 100 200 Feet

Figure 5-16
AOC 6 Groundwater Exceedance Results
TNT Graining House and Catch Box Ruins Subarea
Site Inspection Report
Areas of Concern 1, 2, 6, 7, and 8
Cheatham Annex
Williamsburg, Virginia

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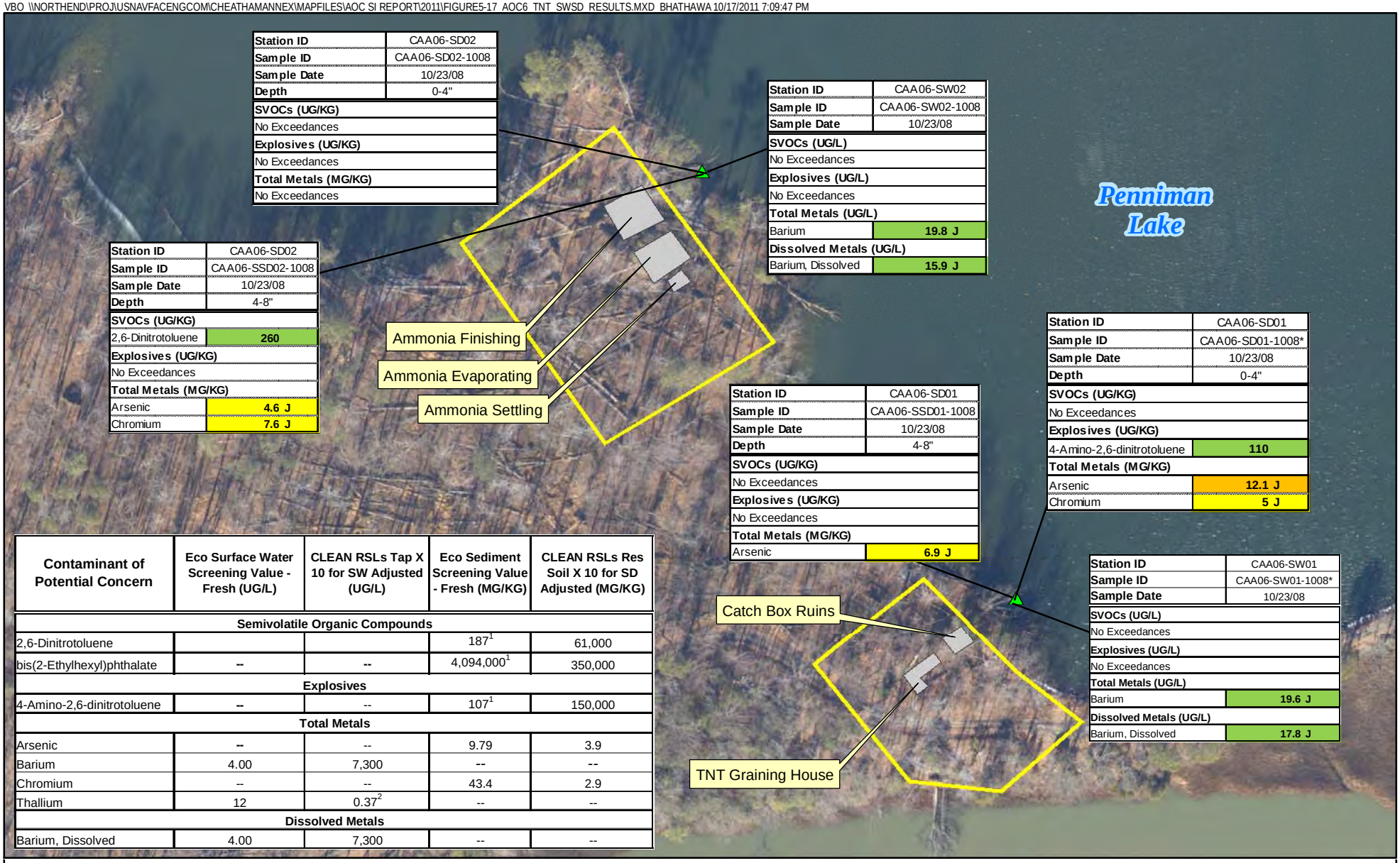
VBO \\NORTHEND\PROJ\USNAVFACENGCOM\CHEATHAMANNEX\MAPFILES\AOC SI REPORT\2011\FIGURE5-17 AOC6 TNT SWSD RESULTS.MXD BHATHAWA 10/17/2011 7:09:47 PM



Station ID	CAA06-SD02
Sample ID	CAA06-SD02-1008
Sample Date	10/23/08
Depth	0-4"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
No Exceedances	
Total Metals (MG/KG)	
No Exceedances	

Station ID	CAA06-SW02
Sample ID	CAA06-SW02-1008
Sample Date	10/23/08
SVOCs (UG/L)	
No Exceedances	
Explosives (UG/L)	
No Exceedances	
Total Metals (UG/L)	
Barium	19.8 J
Dissolved Metals (UG/L)	
Barium, Dissolved	15.9 J

Station ID	CAA06-SD02
Sample ID	CAA06-SSD02-1008
Sample Date	10/23/08
Depth	4-8"
SVOCs (UG/KG)	
2,6-Dinitrotoluene	260
Explosives (UG/KG)	
No Exceedances	
Total Metals (MG/KG)	
Arsenic	4.6 J
Chromium	7.6 J

Station ID	CAA06-SD01
Sample ID	CAA06-SD01-1008*
Sample Date	10/23/08
Depth	0-4"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
4-Amino-2,6-dinitrotoluene	110
Total Metals (MG/KG)	
Arsenic	12.1 J
Chromium	5 J

Station ID	CAA06-SD01
Sample ID	CAA06-SSD01-1008
Sample Date	10/23/08
Depth	4-8"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
No Exceedances	
Total Metals (MG/KG)	
Arsenic	6.9 J

Station ID	CAA06-SW01
Sample ID	CAA06-SW01-1008*
Sample Date	10/23/08
SVOCs (UG/L)	
No Exceedances	
Explosives (UG/L)	
No Exceedances	
Total Metals (UG/L)	
Barium	19.6 J
Dissolved Metals (UG/L)	
Barium, Dissolved	17.8 J

Contaminant of Potential Concern	Eco Surface Water Screening Value - Fresh (UG/L)	CLEAN RSLs Tap X 10 for SW Adjusted (UG/L)	Eco Sediment Screening Value - Fresh (MG/KG)	CLEAN RSLs Res Soil X 10 for SD Adjusted (MG/KG)
Semivolatile Organic Compounds				
2,6-Dinitrotoluene			187[1]	61,000
bis(2-Ethylhexyl)phthalate	--	--	4,094,000[1]	350,000
Explosives				
4-Amino-2,6-dinitrotoluene	--	--	107[1]	150,000
Total Metals				
Arsenic	--	--	9.79	3.9
Barium	4.00	7,300	--	--
Chromium	--	--	43.4	2.9
Thallium	12	0.37[2]	--	--
Dissolved Metals				
Barium, Dissolved	4.00	7,300	--	--

Legend

- Sediment/Surface Water Sample Location
- Approximate AOC 6 Study Area
- Buildings

Notes:

- Exceeds ECO
- Exceeds Res RSL
- Exceeds Eco & Res RSL

[1]Equilibrium Partitioning Value used as eco screening value. See Tables B-41 and B-43 in Appendix B.
[2]Adjusted June 2011 Tapwater RSL
* Indicates duplicate sample was collected at this location. Values presented are the higher of the two.
-- - No value available
J - Analyte present, value may or may not be accurate or precise
MG/KG - Milligrams per kilogram
UG/L - Micrograms per liter

N W E S

0 60 120 Feet

Figure 5-17
AOC 6 Surface Water and Sediment Exceedance Results
Site Inspection Report
Areas of Concern 1, 2, 6, 7, and 8
Cheatham Annex
Williamsburg, Virginia

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Appendix C
Field Standard Operating Procedures

STANDARD OPERATING PROCEDURE

Equipment Blank and Field Blank Preparation

I. Purpose

To prepare blanks to determine whether decontamination procedures are adequate and whether any cross-contamination is occurring during sampling due to contaminated air and dust.

II. Scope

The general protocols for preparing the blanks are outlined. The actual equipment to be rinsed will depend on the requirements of the specific sampling procedure.

III. Equipment and Materials

- Blank liquid (use ASTM Type II or lab grade water)
- Millipore™ deionized water
- Sample bottles as appropriate
- Gloves
- Preservatives as appropriate

IV. Procedures and Guidelines

A. Decontaminate all sampling equipment that has come in contact with sample according to SOP *Decontamination of Personnel and Equipment.*

B. To collect an equipment blank for volatile analysis from the surfaces of sampling equipment other than pumps, pour blank water over one piece of equipment and into two 40-ml vials until there is a positive meniscus, then seal the vials. Note the sample number and associated piece of equipment in the field notebook as well as the type and lot number of the water used.

For non-volatiles analyses, one aliquot is to be used for equipment. For example, if a pan and trowel are used, place trowel in pan and pour blank fluid in pan such that pan and trowel surfaces which contacted the sample are contacted by the blank fluid. Pour blank fluid from pan into appropriate sample bottles.

Do not let the blank fluid come in contact with any equipment that has not been decontaminated.

C. When collecting an equipment blank from a pump, run an extra gallon of deionized water through the pump while collecting the pump outflow into appropriate containers. Make sure the flow rate is low when sampling VOCs. If a Grundfos Redi-Flo2 pump with disposable tubing is used, remove the disposable tubing after sampling but before decon. When decon is complete, put a 3- to 5-foot segment of new tubing onto the pump to collect the equipment blank.

D. To collect a field blank, slowly pour ASTM Type II or lab grade water directly into sample containers.

E. Document and ship samples in accordance with the procedures for other samples.

F. Collect next field sample.

V. Attachments

None.

VI. Key Checks and Items

- Wear gloves.
- Do not use any non-decontaminated equipment to prepare blank.
- Use ASTM-Type II or lab grade water.

STANDARD OPERATING PROCEDURE

Chain-of-Custody

I Purpose

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

II Scope

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

III Definitions

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

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

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

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

IV. Procedures

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

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

Sample Identification

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

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

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

Measurements and observations shall be recorded using waterproof ink.

Sample Label

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

- Project - CTO Number.

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

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

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

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

Chain-of-Custody Procedures

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

Field Custody Procedures

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

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

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

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

locations in photographs, an easily read sign with the appropriate sample location number should be included.

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

Transfer of Custody and Shipment

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

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

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

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

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

V Quality Assurance Records

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

VI Attachments

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

VII References

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

Attachment A

Example Sample Label

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

Client _____
Sample No. _____
Location _____
_____
Analysis _____
_____
Preservative HCL
Date _____ By _____

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

SITE NAME	DATE
ANALYSIS	TIME
	PRESERVATIVE

SAMPLE TYPE

☐ Grab ☐ Composite ☐ Other _____

COLLECTED BY:

Attachment B

Example Chain-of-Custody Record

CH2M HILL
APPLIED SCIENCES LABORATORY

CHAIN OF CUSTODY RECORD AND AGREEMENT TO PERFORM SERVICES

CH2M Hill Project # ☐☐☐☐☐☐☐☐.☐☐.☐☐

Purchase Order #

Project Name

Company Name CH2M HILL Office

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

Report Copy to:

Requested Completion Date:

Sampling Requirements: SDWA ☐ NPDES ☐ RCRA ☐ OTHER ____

Sample Disposal: Dispose ☐ Return ☐

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

SHADED AREA– FOR LAB USE ONLY

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

Sampled By & Title (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time
Received By (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time
Received By (Please sign and print name)	Date/Time	Relinquished By (Please sign and print name)	Date/Time
Received By (Please sign and print name)	Date/Time	Shipped Via UPS BUS Fed-Ex Hand Other ____	Shipping #
Work Authorized By (Please sign and print name)	Remarks		

QC Level: 1 2 3 Other: ____

COC Rec	ICE
Ana Req	TEMP
Cust Seal	Ph

Instructions and Agreement Provisions on Reverse Side

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

REV 3/94 FORM 340

Attachment C

Example Custody Seal

CH2M HILL

CUSTODY SEAL

Date

Signature

STANDARD OPERATING PROCEDURE

Use of Data Loggers and Pressure Transducers

I. Purpose and Scope

The purpose of this procedure is to provide 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. The SOP *Water-Level Measurements* provides guidance for collecting discrete measurements of water levels.

II. Equipment and Materials

- Continuously recording data logger (e.g., Campbell® or In Situ® Hermit or In Situ® Trolls)
- Pressure transducers (e.g., Druck® or In Situ® Trolls) of adequate pressure ranges and cable lengths
- Electronic water-level meter (e.g., Solinst®) with a minimum 100-foot tape; the tape should have graduations in increments of 0.01 feet or less
- Duct tape

III. Procedures and Guidelines

The procedures for using the particular type of data logger should be obtained from the operating manuals for the equipment. 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 (e.g., slug test), the frequency of measurements, the length of the test, and the number of transducers to be monitored.

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. Therefore, if the change in water level is expected to be small (i.e., less than 10 feet), a transducer with a range from 0 to 5 psi would be best.

For downhole applications, measure the initial water level with the water-level meter. Lower the transducer into the piezometer or well until it is comfortably below the 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 (e.g., 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 traffic.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- Prior to each use, verify that the batteries 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.

STANDARD OPERATING PROCEDURE

Decontamination of Personnel and Equipment

I. Purpose

To provide general guidelines for the decontamination of personnel, sampling equipment, and monitoring equipment used in potentially contaminated environments.

II. Scope

This is a general description of decontamination procedures.

III. Equipment and Materials

- Demonstrated analyte-free, deionized ("DI") water (specifically, ASTM Type II water or lab-grade DI water)
- Potable water; must be from a municipal water supplier, otherwise an analysis must be run for appropriate volatile and semivolatile organic compounds and inorganic chemicals (e.g., Target Compound List and Target Analyte List chemicals)
- 2.5% (W/W) Liquinox® (or Alconox®) and water solution
- Concentrated (V/V) pesticide grade isopropanol (DO NOT USE ACETONE)
- Large plastic pails or tubs for Liquinox® and water, scrub brushes, squirt bottles for Liquinox® solution, methanol and water, plastic bags and sheets
- DOT approved 55-gallon drum for disposal of waste
- Personal Protective Equipment as specified by the Health and Safety Plan
- Decontamination pad and steam cleaner/high pressure cleaner for large equipment

IV. Procedures and Guidelines

A. PERSONNEL DECONTAMINATION

To be performed after completion of tasks whenever potential for contamination exists, and upon leaving the exclusion zone.

1. Wash boots in Liquinox® solution, then rinse with water. If disposable latex booties are worn over boots in the work area, rinse with Liquinox® solution, remove, and discard into DOT-approved 55-gallon drum.

2. Wash outer gloves in Liquinox® solution, rinse, remove, and discard into DOT-approved 55-gallon drum.

3. Remove disposable coveralls ("Tyveks") and discard into DOT-approved 55-gallon drum.

4. Remove respirator (if worn).

5. Remove inner gloves and discard.

6. At the end of the work day, shower entire body, including hair, either at the work site or at home.

7. Sanitize respirator if worn.

B. SAMPLING EQUIPMENT DECONTAMINATION—GROUNDWATER SAMPLING PUMPS

Sampling pumps are decontaminated after each use as follows.

1. Don phthalate-free gloves.

2. Spread plastic on the ground to keep equipment from touching the ground

3. Turn off pump after sampling. Remove pump from well and remove and dispose of tubing. Place pump in decontamination tube.

4. Turn pump back on and pump 1 gallon of Liquinox® solution through the sampling pump.

5. Rinse with 1 gallon of 10% isopropanol solution pumped through the pump. (DO NOT USE ACETONE). (Optional)

6. Rinse with 1 gallon of tap water.

7. Rinse with 1 gallon of deionized water.

8. Keep decontaminated pump in decontamination tube or remove and wrap in aluminum foil or clean plastic sheeting.

9. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.

10. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in either DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

C. SAMPLING EQUIPMENT DECONTAMINATION—OTHER EQUIPMENT

Reusable sampling equipment is decontaminated after each use as follows.

1. Don phthalate-free gloves.
2. Before entering the potentially contaminated zone, wrap soil contact points in aluminum foil (shiny side out).
3. Rinse and scrub with potable water.
4. Wash all equipment surfaces that contacted the potentially contaminated soil/water with Liquinox® solution.
5. Rinse with potable water.
6. Rinse with distilled or potable water and isopropanol solution (DO NOT USE ACETONE). (Optional)
7. Air dry.
8. Rinse with deionized water.
9. Completely air dry and wrap exposed areas with aluminum foil (shiny side out) for transport and handling if equipment will not be used immediately.
10. Collect all rinsate and dispose of in a DOT-approved 55-gallon drum.
11. Decontamination materials (e.g., plastic sheeting, tubing, etc.) that have come in contact with used decontamination fluids or sampling equipment will be disposed of in DOT-approved 55-gallon drums or with solid waste in garbage bags, dependent on Facility/project requirements.

D. HEALTH AND SAFETY MONITORING EQUIPMENT DECONTAMINATION

1. Before use, wrap soil contact points in plastic to reduce need for subsequent cleaning.
2. Wipe all surfaces that had possible contact with contaminated materials with a paper towel wet with Liquinox® solution, then a towel wet with methanol solution, and finally three times with a towel wet with distilled water. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

E. SAMPLE CONTAINER DECONTAMINATION

The outsides of sample bottles or containers filled in the field may need to be decontaminated before being packed for shipment or handled by personnel without hand protection. The procedure is:

1. Wipe container with a paper towel dampened with Liquinox® solution or immerse in the solution AFTER THE CONTAINERS HAVE BEEN SEALED. Repeat the above steps using potable water.

2. Dispose of all used paper towels in a DOT-approved 55-gallon drum or with solid waste in garbage bags, dependent on Facility/project requirements.

F. HEAVY EQUIPMENT AND TOOLS

Heavy equipment such as drilling rigs, drilling rods/tools, and the backhoe will be decontaminated upon arrival at the site and between locations as follows:

1. Set up a decontamination pad in area designated by the Facility

2. Steam clean heavy equipment until no visible signs of dirt are observed. This may require wire or stiff brushes to dislodge dirt from some areas.

V. Attachments

None.

VI. Key Checks and Items

- Clean with solutions of Liquinox®, methanol (optional), and distilled water.
- Do not use acetone for decontamination.
- Drum all contaminated rinsate and materials.
- Decontaminate filled sample bottles before relinquishing them to anyone.

STANDARD OPERATING PROCEDURE

Decontamination of Drilling Rigs and Equipment

I. Purpose and Scope

The purpose of this guideline is to provide methods for the decontamination of drilling rigs, downhole drilling tools, and water-level measurement equipment. Personnel decontamination procedures are not addressed in this SOP; refer to the site safety plan and SOP *Decontamination of Personnel and Equipment*. Sample bottles will not be field decontaminated; instead they will be purchased with certification of laboratory sterilization.

II. Equipment and Materials

- Portable steam cleaner and related equipment
- Potable water
- Phosphate-free detergent such as Liquinox®
- Buckets
- Brushes
- Isopropanol, pesticide grade
- Personal Protective Equipment as specified by the Health and Safety Plan
- ASTM–Type II grade water or Lab Grade DI Water
- Aluminum foil

III. Procedures and Guidelines

A. Drilling Rigs and Monitoring Well Materials

Before the onset of drilling, after each borehole, before drilling through permanent isolation casing, and before leaving the site, heavy equipment and machinery will be decontaminated by steam cleaning at a designated area. The steam-cleaning area will be designed to contain decontamination wastes and waste waters and can be an HDPE-lined, bermed pad. A pumping system will be used to convey decontaminated water from the pad to drums.

Surface casings may be steam cleaned in the field if they are exposed to contamination at the site prior to use.

B. Downhole Drilling Tools

Downhole tools will be steam cleaned before the onset of drilling, prior to drilling through permanent isolation casing, between boreholes, and prior to leaving the site. This will include, but is not limited to, rods, split spoons or similar samplers, coring equipment, augers, and casing.

Before the use of a sampling device such as a split-spoon sampler for the collection of a soil sample for physical characterization, the sampler shall be cleaned by scrubbing with a detergent solution followed by a potable water rinse.

Before the use of a sampling device such as a split-spoon sampler for the collection of a soil sample for chemical analysis, the sampler shall be decontaminated following the procedures outlined in the following subsection.

C. Field Analytical Equipment

1. Water Level Indicators

   Water level indicators that consist of a probe that comes into contact with the groundwater must be decontaminated using the following steps:

   a. Rinse with tap water
   b. Rinse with de-ionized water
   c. Solvent rinse with isopropanol (Optional)
   d. Rinse with de-ionized water

2. Probes

   Probes, for example, pH or specific ion electrodes, geophysical probes, or thermometers that would come in direct contact with the sample, will be decontaminated using the procedures specified above unless manufacturer's instructions indicate otherwise. For probes that make no direct contact, for example, OVM equipment, the probe will be wiped with clean paper-towels or cloth wetted with isopropanol.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- The effectiveness of field cleaning procedures may be monitored by rinsing decontaminated equipment with organic-free water and submitting the rinse water in standard sample containers for analysis.

STANDARD OPERATING PROCEDURE

Sampling Contents of Tanks and Drums

I. Scope and Application

This procedure provides an overview approach and guidelines for the routine sampling of drums and tanks. Its purpose is to describe standard procedures and precautions which are applied in sampling drums and tanks. Procedures for opening drums with the individual instruments are included in Attachment D.

The samples obtained may be used to obtain physical chemical or radiological data. The resulting data may be qualitative or quantitative in nature, and are appropriate for use in preliminary surveys as well as confirmatory sampling.

II. Summary of Methods

Drums are generally sampled by means of sampling tubes such as glass sample tubes or COLIWASA samplers. In either case, the sampling tube is manually inserted into the waste material. A sample of the drum contents is withdrawn by the sampling device. Should a drum contain bottom sludge, a glass tube will be used to retrieve a sample of this as well.

Storage tank and tank trailers, because of their greater depths, require sampling devices that can be lowered from the top, filled at a particular depth, then withdrawn. Such devices are a COLIWASA, a Kemmerer depth sampler, or a Bacon Bomb. Where samples of bottom sludge are desired, a gravity corer can be utilized. This heavy tube with a tapered nose piece will penetrate the sludge as it free falls through the tank.

III. Comments

The sampling of tanks, containers, and drums present unique problems not associated with environmental samples. Containers of this sort are generally closed except for small access ports, manways, or hatches on the larger vessels, or taps and bungs on smaller drums. The physical size, shape, construction material, and location of access limit the types of equipment and methods of collection that can be used.

When liquids are contained in sealed vessels, gas vapor pressure can build up, sludges can settle out, and density layerings (stratification) can develop. Bulging drums may be under pressure and extreme caution should be exercised. The potential exists for explosive reactions or the release of noxious gases when containers are opened. All vessels should be opened with extreme caution. Check the HSP for the level of personnel protection to be worn. A preliminary sampling of

any headspace gases is warranted. As a minimum, a preliminary check with a Multi RAE or equivalent may be of aid in selecting a sampling method.

In most cases it is impossible to observe the contents of these sealed or partially sealed vessels. Since some layering or stratification is likely in any solution left undisturbed over time, a sample must be taken that represents the entire depth of the vessel.

IV. Required Equipment and Apparatus

A. **Health and safety equipment/materials**: As listed in the site safety plan.

B. **Sampling equipment**: COLIWASA, glass sample tubes, Kemmerer depth sampler, Bacon Bomb, gravity corer.

C. **Tools**: Rubber mallet, bung wrench, speed wrench with socket, etc., (all non-sparking), paint marker.

D. **Heavy equipment**: Backhoe equipped with explosion shield, drum grappler, and 3-foot copper-beryllium (non-sparking) spike with 6-inch collar (to puncture top of drums for sampling, if necessary).

E. **Sample Containers**: As specified in the field sampling plan.

V. Procedures

A. Drums

NOTE: DO NOT open more than one drum at a time. Each drum must be handled and sampled as a separate entity to reduce vapors in the sampling area.

1. Drums will be sampled on an area-by-area basis. Drums will be sampled after they have been placed in overpack drums but before they are transferred from the excavation to the onsite storage area.

2. Record, in logbook, all pertinent information from visual inspection of drum (e.g., physical condition, leaks, bulges, and labels). Label each drum with a unique identifying number.

3. If possible, stage drums for easy access.

4. If necessary, attach ground strap to drums and grounding point.

5. Remove any standing material (water, etc.) from container top.

6. Using non-sparking tools, carefully remove the bung or lid while monitoring air quality with appropriate instruments. If necessary (and as a last resort), the non-sparking spike affixed to the backhoe can also be used to puncture the drum for sampling. See Attachment D for method of drum opening. Record air-quality monitoring results.

7. When sampling a previously sealed vessel, a check should be made for the presence of bottom sludge. This is accomplished by measuring the depth to apparent bottom, then comparing it to the known interior depth.

8. Agitation to disrupt the layers and rehomogenize the sample is physically difficult and almost always undesirable. If the vessel is greater than 3 feet in depth (say, a 55-gallon drum), the appropriate sampling method is to slowly lower the sampling device (i.e., suction line of peristaltic pump, glass tube) in known increments of length. Discrete samples can be collected from various depths, then combined or analyzed separately. If the depth of the vessel is greater than the lift capacity of the pump, an at-depth water sampler, such as the Kemmerer or Bacon Bomb type, may be required.

9. Extract a representative sample from the drum using a glass rod, COLIWASA, Bacon Bomb, Kemmerer bottle, or gravity corer (See Attachments). Ensure that the entire depth of material is penetrated. Depending on the size of the opening of the drum, three to four takes should be collected from random locations across the drum surface, to ensure a representative sample. Any observed stratification must be recorded in logbook, including number and thickness of the layers and a conceptualized sketch.

10. Record a visual description of the sample (e.g., liquid, solid, color, viscosity, and percent layers).

11. When possible, sampling equipment (like glass tubes) should be expendable and be left inside the drum for disposal with drum contents, once sampling is completed.

12. Place lid, bung, cap, etc., back in place on drum. Tighten hand tight. If necessary, the sampling port can be sealed using a cork.

13. Wipe up spilled material with lab wipes. Wipe off sample containers.

14. Mark the drum with a unique sample identification number and date using a paint marker.

15. Samples will be handled as high hazard samples. Samples will be placed in containers defined according to the analytical needs, wiped clean, and then packed in paint cans for shipping. Packaging, labeling, and preparation for shipment procedures will follow procedures as specified in the field sampling plan.

B. Underground Storage Tanks

1. A sampling team of at least two people is required for sampling—one will collect samples, the other will relay required equipment and implements.

2. Sampling team will locate a sampling port on the tank. Personnel should be wearing appropriate protective clothing at this time and carrying sampling gear.

3. Do not attempt to climb down into tank. Sampling MUST BE accomplished from the top.

4. Collect a sample from the upper, middle, and lower section of the tank contents with one of the recommended sampling devices.

5. If compositing is necessary, ship samples to laboratory in separate containers for laboratory compositing.

6. Samples will be handled as hazardous. Samples will be placed in appropriate containers and packed with ice in a cooler. Packaging, labeling, and preparation for shipment will follow procedures specified in the field sampling plan.

C. Tank Trailers or Above-Ground Storage Tanks

1. A sampling team of two is required. One will collect samples, the other will relay required equipment and implements.

2. Samples will be collected through the manhole (hatch) on top of the tanker or the fill port. Do not open valves at the bottom. Before opening the hatch, check for a pressure gauge or release valve. Open the release valve slowly to bring the tank to atmospheric pressure.

3. If tank pressure is too great, or venting releases large amounts of toxic gas, discontinue venting and sampling immediately. Measure vented gas with organic vapor analyzer and explosimeter.

4. If no release valve exists, slowly loosen hatch cover bolts to relieve pressure in the tank. (Again, stop if pressure is too great.)

5. Once pressure in tank has been relieved, open the hatch and withdraw sample using one of the recommended sampling devices.

6. Sample each trailer compartment.

7. If compositing is necessary, ship samples to laboratory in separate containers for laboratory compositing.

8. Samples will be handled as hazardous. Samples will be placed in appropriate containers and packed with ice in a cooler. Packaging, labeling, and preparation for shipment will follow procedures specified in the field sampling plan.

D. Refer to Attachment B for procedures for sampling with appropriate devices as follows:

Drum

Glass tube	–	Procedure 1
COLIWASA	–	Procedure 2

Storage Tank and Tank Trailer

COLIWASA	–	Procedure 2
Bacon Bomb	–	Procedure 3
Gravity Corer (for bottom sludge)	–	Procedure 4

VI. Contamination Control

Sampling tools, instruments, and equipment will be protected from sources of contamination prior to use and decontaminated after use as specified in SOP *Decontamination of Personnel and Equipment*. Liquids and materials from decontamination operations will be handled in accordance with the waste management plan. Sample containers will be protected from sources of contamination. Sampling personnel shall wear chemical resistant gloves when handling any samples. Gloves will be decontaminated or disposed of between samples.

VIII. Attachments

A. Collection of Liquid-Containerized Wastes Using Glass Tubes

B. Sampling Containerized Wastes Using the Composite Liquid Waste Sample (COLIWASA)

C. Sampling Containerized Wastes Using the Bacon Bomb Sampler

D. Gravity Corer for sampling Sludges in Large Containers

E. Construction of a Typical COLIWASA

F. Drum Opening Techniques and Equipment

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X. Field Checklist

_____ Sampling Instruments

_____ Tools

_____ Rubber Mallet

_____ Logbook

_____ Safety Glasses or Monogoggles

_____ Safety Shoes

_____ Ice/Cooler, as required

_____ Custody Seals, as required

_____ Chain-of-Custody Forms

_____ Drum Labels, as required

_____ Paint Marker, if drum sampling

_____ Black Indelible Pen

_____ Monitoring Instruments

_____ Labels

_____ Sampling and Analysis Plan

_____ Health and Safety Plan

_____ Decontamination Equipment

_____ Lab Wipes

_____ Lab Spatulas or Stainless Steel Spoons

_____ Chemical Preservatives, as required

_____ Appropriate Containers for Waste and Equipment

_____ Duct Tape

_____ Plastic Sheeting

Attachment A Collection of Liquid-Containerized Wastes Using Glass Tubes

Discussion

Liquid samples from opened containers (i.e., 55-gallon drums) are collected using lengths of glass tubing. The glass tubes are normally 122 centimeters long and 6 to 16 millimeters inside diameter. Larger diameter tubes may be used for more viscous fluids if sampling with the small diameter tube is not adequate. The tubing is broken and discarded in the container after the sample has been collected, eliminating difficult cleanup and disposal problems. This method should not be attempted with less than a two-person sampling team.

Uses

This method provides for a quick, relatively inexpensive means of collecting concentrated containerized wastes. The major disadvantage is from potential sample loss that is especially prevalent when sampling low-viscosity fluids. Splashing can also be a problem and proper protective clothing should always be worn.

Note: A flexible tube with an aspirator attached is an alternative method to the glass tube, and allows various levels to be sampled discretely.

Procedures for Use

1. Remove cover from sample container.
2. Insert glass tubing almost to the bottom of the container. Tubing should be of sufficient length so that at least 30 centimeters extend above the top of the container.
3. Allow the waste in the drum to reach its natural level in the tube.
4. Cap the top of the tube with a safety-gloved thumb or a stopper.
5. Carefully remove the capped tube from the drum. If the tube has passed through more than one layer, the boundary should be apparent in the glass tube.
6. Insert the bottom, uncapped end into the sample container.
7. Partially release the thumb or stopper on the top of the tube and allow the sample to slowly flow into the sample container. If separation of phases is desired, cap off tube before the bottom phase has completely emptied. It may be advisable to have an extra container for "waste," so that the fluid on either side of the phase boundary can be directed into a separate container, allowing collection of pure phase liquids in the sample containers. The liquid remaining after the boundary fluid is removed is collected in yet a third container. NOTE: It is not necessary to put phases in separate containers if analysis of separate phases is not desired.
8. Repeat steps 2 through 6 if more volume is needed to fill the sample container.
9. Remove the tube from the sample container and replace the tube in the drum, breaking it, if necessary, in order to dispose of it in the drum.

Optional Method (if sample of bottom sludge is desired)

1. Remove the cover from the container opening.
2. Insert glass tubing slowly almost to the bottom of the container. Tubing should be of sufficient length so that at least 30 cm extends above the top of the container.
3. Allow the waste in the drum to reach its natural level in the tube.
4. Gently push the tube towards the bottom of the drum into the sludge layer. Do not force it.
5. Cap the top of the tube with a safety-gloved thumb or stopper.
6. Carefully remove the capped tube from the drum and insert the uncapped end into the sample container.
7. Release the thumb or stopper on the top of the tube and allow the sample container to fill to approximately 90 percent of its capacity. If necessary, the sludge plug in the bottom of the tube can be dislodged with the aid of the stainless steel laboratory spatula.
8. Repeat if more volume is needed to fill sample container and recap the tube.

Note:

1. If a reaction is observed when the glass tube is inserted (violent agitation, smoke, light, etc.), the investigators should leave the area immediately.
2. If the glass tube becomes cloudy or smoky after insertion into the drum, the presence of hydrofluoric acid maybe indicated, and a comparable length of rigid plastic tubing should be used to collect the sample.
3. When a solid is encountered in a drum (either layer or bottom sludge) the optional method described above may be used to collect a core of the material, or the material may be collected with a disposable scoop attached to a length of wooden or plastic rod.

Attachment B: Sampling Containerized Wastes using the Composite Liquid Waste Sampler (COLIWASA)

Discussion

The COLIWASA is a much-cited sampler designed to permit representative sampling of multiphase wastes from drums and other containerized wastes. The sampler is commercially available or can be easily fabricated from a variety of materials, including PVC, glass, or Teflon. In its usual configuration it consists of a 152 cm by 4 cm (inside diameter) section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper. See Attachment E: Construction of a COLIWASA.

Uses

The COLIWASA is primarily used to sample containerized liquids. The PVC COLIWASA is reported to be able to sample most containerized liquid wastes except for those containing ketones, nitrobenzene, dimethylforamide, mesityloxide, and tetrahydrofuran. A glass COLIWASA is able to handle all wastes unable to be sampled with the plastic unit except strong alkali and hydrofluoric acid solutions. Due to the unknown nature of many containerized wastes, it would therefore be advisable to eliminate the use of PVC materials and use samplers composed of glass or Teflon.

The major drawback associated with using a COLIWASA is concern for decontamination and costs. The sampler is difficult, if not impossible, to decontaminate in the field, and its high cost in relation to alternative procedures (glass tubes) makes it an impractical throwaway item. It still has applications, however, especially in instances where a true representation of a multiphase waste is absolutely necessary.

Procedures for Use

1. Check to make sure the sampler is functioning properly. Adjust the locking mechanism, if present, to make sure the neoprene rubber stopper provides a tight closure.

2. Put the sampler in the open position by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block.

3. Slowly lower the sampler into the liquid waste. Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sample tube is lower than that outside the sampler, the sampling rate is too fast and will result in a non-representative sample.

4. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.

5. Slowly withdraw the sampler from the waste container with one hand while wiping the sampler tube with a laboratory wipe with the other hand. A phase boundary, if present, can be observed through the tube.

6. Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container.

7. Unscrew the T-handle of the sampler and disengage the locking block.

Attachment C: Sampling Containerized Wastes using the Bacon Bomb Sampler

Discussion

The Bacon Bomb is designed for the withdrawal of samples from various levels within a storage tank. It consists of a cylindrical body with an internal tapered plunger that acts as a valve to admit the sample. A line attached to the top of the plunger is used to open and close the valve. A removable cover provides a point of attachment for the sample line and has a locking mechanism to keep the plunger closed after sampling. The Bacon Bomb is usually constructed of chrome-plated brass and bronze with a rubber O-ring acting as the plunger-sealing surface. Stainless steel versions are also available. The volumemetric capacity is 8, 16, or 32 oz (237, 473, or 946 ml).

Uses

The Bacon Bomb is a heavy sampler suited best for viscous materials held in large storage tanks or in lagoons. If a more non-reactive sampler is needed, the stainless steel version would be used, or any of the samplers could be coated with Teflon.

Procedures for Use

1. Attach the sample line and the plunger line to the sampler.
2. Measure and then mark the sampling line at the desired depth.
3. Gradually lower the sampler by the sample line until the desired level is reached.
4. When the desired level is reached, pull up on the plunger line and allow the sampler to fill for a sufficient length of time before releasing the plunger line to seal off the sampler.
5. Retrieve the sampler by the sample line, being careful not to pull up on the plunger line, thereby accidentally opening the bottom valve.
6. Wipe off the exterior of the sampler body.
7. Position the sampler over the sample container and release its contents by pulling up on the plunger line.

Attachment D: Gravity Corer for Sampling Sludges in Large Containers

Discussion

A gravity corer is a metal tube with a replaceable tapered nosepiece on the bottom and a ball or other type of check valve on the top. The check valve allows water to pass through the corer on descent but prevents a washout during recovery. The tapered nosepiece facilitates cutting and reduces core disturbance during penetration. Most corers are constructed of brass or steel and many can accept plastic liners and additional weights.

Uses

Corers are capable of collecting samples of most sludges and sediments. They collect essentially undisturbed samples that represent the strata profile that may develop in sediments and sludges during variations in the deposition process. Depending on the density of the substrate and the weight of the corer, penetration to depths of 75 cm (30 in.) can be attained. Exercise care when using gravity corers in vessels or lagoons that have liners because penetration depths could exceed those of the substrate; this could result in damage to the liner material.

Procedures for Use

1. Attach a precleaned corer to the required length of sample line. Solid braided 5-mm (3/16-in.) nylon line is sufficient; however, 20-mm (3/4-in.) nylon is easier to grasp during hand hoisting. An additional weight can be attached to the outside of the corer if necessary.
2. Secure the free end of the line to a fixed support to prevent accidental loss of the corer.
3. Allow corer to free fall through the liquid to the bottom.
4. Retrieve corer with a smooth, continuous, up-lifting motion. Do not bump corer because this may result in some sample loss.
5. Remove nosepiece from corer and slide sample out of corer into stainless steel or Teflon pan (preferred).
6. Transfer sample into appropriate sample bottle with a stainless steel lab spoon or laboratory spatula.

Attachment E: Construction of a Typical COLIWASA

The sampling tube consists of a 1.52-m (5-ft) by 4.13-cm (1-5/8 in) I.D. translucent plastic pipe, usually polyvinyl chloride (PVC) or borosilicate glass plumbing tube. The closure-locking mechanism consists of a short-length, channeled aluminum bar attached to the sampler's stopper rod by an adjustable swivel. The aluminum bar serves both as a T-handle and lock for the samplers' closure system. When the sampler is in the open position, the handle is placed in the T-position and pushed down against the locking block. This manipulation pushes out the neoprene stopper and opens at the sampling tube. In the closed position, the handle is rotated until one leg of the T is squarely perpendicular against the locking block. This tightly seats the neoprene stopper against the bottom opening of he sampling tube and positively locks the sampler in the closed position. The closure tension can be adjusted by shortening or lengthening the stopper rod by screwing it in or out of the T-handle swivel. The closure system of the sampler consists of a sharply tapered neoprene stopper attached to a 0.95-cm (3/8-in) O.D. rod, usually PVC. The upper end of the stopper rod is connected to the swivel of the aluminum T-handle. The sharply tapered neoprene stopper can be fabricated according to specifications by plastic-products manufacturers at an extremely high price, or it can be made in-house by grinding down the inexpensive stopper with a shop grinder.

COLIWASA samplers are typically made out of plastic or glass. The plastic type consists of translucent plastic (usually PVC) sampling tube. The glass COLIWASA uses borosilicate glass plumbing pipe as the sampling tube and a Teflon plastic stopper rod. For purpose of multiphase sampling, clear plastic or glass is desirable in order to observe the profile of the multiphase liquid.

The sampler is assembled as follows:

a. Attach the swivel to the T-handle with the 3.18-cm (1-1/4 in) long bolt and secure with the 0.48-cm (3/16-in) National Coarse (NC) washer and lock nut.

b. Attach the PFTE stopper to one end of the stopper rod and secure with the 0.95-cm (3/8-in) washer and lock nut.

c. Install the stopper and stopper rod assembly in the sampling tube.

d. Secure the locking block sleeve on the block with glue or screw. This block can also be fashioned by shaping a solid plastic rod on a lathe to the required dimension.

e. Position the locking block on top of the sampling tube such that the sleeveless portion of the block fits inside the tube, the sleeve sits against the top end of the tube, and the upper end of the stopper rod slips though the center hole of the block.

f. Attach the upper end of the stopper rod to the swivel of the T-handle.

g. Place the sampler in the close position and adjust the tension on the stopper by screwing the T-handle in or out.

Attachment F: Drum Opening Techniques and Equipment [1]

I. Introduction

The opening of closed drums prior to sampling entails considerable risk if not done with the proper techniques, tools, and safety equipment. The potential for vapor exposure, skin exposure due to splash or spraying, or even explosion resulting from sparks produced by friction of the tools against the drum, necessitate caution when opening any closed container. Both manual drum opening and remote drum opening will be discussed in the following paragraphs. When drums are opened manually risks are greater than when opened remotely; for this reason, the remote opening of drums is advised whenever possible.

Prior to sampling, the drums should be staged to allow easy access. Also, any standing water or other material should be removed from the container top so that the representative nature of the sample is not compromised when the container is opened. There is also the possibility of encountering a water-reactive substance.

II. Manual Drum Opening

A. Bung Wrench

A common method for opening drums manually is using a universal bung wrench. These wrenches have fittings made to remove nearly all commonly encountered bungs. They are usually constructed of cast iron, brass, or a bronze-beryllium (a non-sparking alloy formulated to reduce the likelihood of sparks). The use of bung wrenches marked "NON SPARKING" is encouraged. However, the use of a "NON SPARKING" wrench does not completely eliminate the possibility of spark being produced. Such a wrench only prevents a spark caused by wrench-to-bung friction, but it cannot prevent sparking between the threads on the drum and the bung.

A simple tool to use, the fitting on the bung wrench matching the bung to be removed is inserted into the bung and the tool is turned counterclockwise to remove the bung. Since the contents of some drums may be under pressure (especially, when the ambient temperature is high), the bung should be turned very slowly. If any hissing is heard, the person opening the drum should back off and wait for the hissing to stop. Since drums under pressure can spray out liquids when opened, the wearing of appropriate eye and skin protection in addition to respiratory protection is critical.

B. Drum Deheader

One means by which a drum can be opened manually when a bung is not removable with a bung wrench is by using a drum deheader. This tool is constructed of forged steel with an alloy steel blade and is designed to cut the lid of a drum off or part way

[1] Taken from EPA Training Course: "Sampling for Hazardous Materials," U.S. Environmental Protection Agency, Office of Emergency and Remedial Response Support Division, March 24, 1987.

off by means of a scissors-like cutting action. A limitation of this device is that it can be attached only to closed head drums (i.e., DOT Specification 17E and 17F drums); drums with removable heads must be opened by other means.

Drums are opened with a drum deheader by first positioning the cutting edge just inside the top chime and then tightening the adjustment screw so that the deheader is held against the side of the drum. Moving the handle of the deheader up and down while sliding the deheader along the chime will enable the entire top to be rapidly cut off if so desired. If the top chime of a drum has been damaged or badly dented it may not be possible to cut the entire top off. Since there is always the possibility that a drum may be under pressure, the initial cut should be made very slowly to allow for the gradual release of any built-up pressure. A safer technique would be to employ a remote pressure release method prior to using the deheader.

C. Hand Pick or Spike

When a drum must be opened and neither a bung wrench nor a drum deheader is suitable, then it can be opened for sampling by using a hand pick, pickaxe, or spike. These tools are usually constructed of brass or a non-sparking alloy with a sharpened point that can penetrate the drum lid or head when the tool is swung. The hand picks or pickaxes that are most commonly used are commercially available, whereas the spikes are generally uniquely fabricated 4- foot long poles with a pointed end. Often the drum lid or head must be hit with a great deal of force in order to penetrate it. Because of this, the potential for splash or spraying is greater than with other opening methods and therefore this method of drum opening is not recommended, particularly when opening drums containing liquids. Some spikes used for drum opening have been modified by the addition of a circular splash plate near the penetrating end. This plate acts as a shield and reduces the amount of splash in the direction of the person using the spike. Even with this shield, good splash gear is essential.

Since drums, some of which may be under pressure, cannot be opened slowly with these tools, “sprayers” may result and appropriate safety measures must be taken. The pick or spike should be decontaminated after each drum is opened to avoid cross contamination and/or adverse chemical reaction from incompatible materials.

III. Remote Opening

A. Backhoe Spike

The most common means used to open drums remotely for sampling is the use of a metal spike attached or welded to a backhoe bucket. In addition to being very efficient, this method can greatly reduce the likelihood of personnel exposure.

Drums should be “staged,” or placed in rows with adequate aisle space to allow ease in backhoe maneuvering. Once staged, the drums can be quickly opened by punching a hole in the drum head or lid with the spike.

The spike should be decontaminated after each drum is opened to prevent cross contamination. Even though some splash or spray may occur when this method is

used, the operator of the backhoe can be protected by mounting a large shatter-resistant shield in front of the operator's cage. This, combined with the normal sampling safety gear, should be sufficient to protect the operator. Additional respiratory protection can be afforded by providing the operator with an on-board airline system. The hole in the drum can be sealed with a cork.

B. Hydraulic Devices

Recently, remotely operated hydraulic devices have been fabricated to open drums remotely. One such device is discussed here. This device uses hydraulic pressure to pierce through the wall of a drum. It consists of a manually operated pump that pressurizes oil through a length of hydraulic line. A piercing device with a metal point is attached to the end of this line and is pushed into the drum by the hydraulic pressure. The piercing device can be attached so that a hole for sampling can be made in either the side or the head/lid of the drum. Some of the metal piercers are hollow or tube-like so that they can be left in place, if desired, and serve as a permanent tap or sampling port. The piercer is designed to establish a tight seal after penetrating the container.

C. Pneumatic Devices

Pneumatically-operated devices utilizing compressed air have been designed to remove drum bungs remotely. A pneumatic bung remover consists of a compressed air supply (usually SCBA cylinders) that is controlled by a heavy-duty, 2-stage regulator. A high pressure air line of desired length delivers compressed air to a pneumatic drill that is adapted to turn a bung fitting (preferably, a bronze-beryllium alloy) selected to fit the bung to be removed. An adjustable bracketing system has been designed to position and align the pneumatic drill over the bung. This bracketing system must be attached to the drum before the drill can be operated. Once the bung has been loosened, the bracketing system must be removed before the drum can be sampled. This attachment and removal procedure is time- consuming and is the major drawback of this device. This remote bung opener does not permit the slow venting of the container, and therefore appropriate precautions must be taken. It also requires the container to be upright and relatively level. Bungs that are rusted shut cannot be removed with this device.

IV. Summary

The opening of closed containers is one of the most hazardous site activities. Maximum efforts would be made to ensure the safety of the sampling team. Proper protective equipment and a general wariness of the possible dangers will minimize the risk inherent to sampling operations. Employing proper drum opening techniques and equipment will also safeguard personnel. The use of remote sampling equipment whenever feasible is highly recommended.

STANDARD OPERATING PROCEDURE

Disposal of Waste Fluids and Solids

I. Purpose and Scope

This SOP describes the procedures used to dispose of hazardous fluid and solid materials generated as a result of the site operations. This SOP does not provide guidance on the details of Department of Transportation regulations pertaining to the transport of hazardous wastes; the appropriate Code of Federal Regulations (49 CFR 171 through 177) should be referenced. Also, the site investigation-derived waste management plan should be consulted for additional information and should take precedence over this SOP.

II. Equipment and Materials

A. Fluids

- DOT-approved 55-gallon steel drums or Baker® Tanks
- Tools for securing drum lids
- Funnel for transferring liquid into drum
- Labels
- Paint Pens
- Marking pen for appropriate labels
- Seals for 55-gallon steel drums

B. Solids

- DOT-approved 55-gallon steel drums or rolloffs
- Tools for securing drum lids
- Paint Pens
- Plastic sheets
- Labels
- Marking pen for appropriate labels

III. Procedures and Guidelines

A. Methodology

Clean, empty drums or rolloffs or Baker® Tanks will be brought to the site by the drilling subcontractor for soil and groundwater collection and storage. The empty drums will be located at the field staging area and moved to drilling locations as required. The drums will be filled with the drilling and well installation wastes, capped, sealed, and moved to the onsite drum storage area by the drilling subcontractor. The full drums will separate types of wastes by media. The drums will

be labeled as they are filled in the field and labels indicating that the contents are pending analysis affixed.

The drum contents will be sampled to determine the disposal requirements of the drilling wastes. The drum sampling will be accomplished through the collection and submittal of composite samples, one sample per 10 drums (check with disposal facility to determine sample frequency) containing the same media. Similar compositing will be performed in each rolloff to obtain a representative sample. The compositing of the sample will be accomplished by collecting a specific volume of the material in each drum into a large sample container. When samples from each of the drums being sampled in a single compositing are collected, the sample will be submitted for TCLP, ignitability, corrosivity, and reactivity analysis. The analysis will be used to determine if drilling wastes are covered by land disposal restrictions.

If rolloffs are used, compositing and sampling of soil will comply with applicable state and federal regulations.

B. Labels

Drums and other containers used for storing wastes from drilling operations will be labeled when accumulation in the container begins. Labels will include the following minimum information:

- Container number
- Container contents
- Origin (source area including individuals wells, piezometers, and soil borings)
- Date that accumulation began
- Date that accumulation ended
- Generator Contact Information
- When laboratory results are received, drum labels will be completed or revised to indicate the hazardous waste constituents in compliance with Title 40 of the Code of Federal Regulations, Part 262, Subpart C if the results indicate hazardous waste or labeled as non-hazardous if applicable.

C. Fluids

Drilling fluids generated during soil boring and groundwater discharged during development and purging of the monitoring wells will be collected in 55-gallon, closed-top drums. When a drum is filled, the bung will be secured tightly. Fluids may also be transferred to Baker® Tanks after being temporarily contained in drums to minimize the amount of drums used.

When development and purging is completed, the water will be tested for appropriate hazardous waste constituents. Compositing and sampling of fluids will comply with applicable state and federal regulations.

D. Solids

The soil cuttings from well and boring drilling will constitute a large portion of the solids to be disposed of.

The solid waste stream also will include plastic sheeting used for decontamination pads, Tyveks, disposable sampling materials, and any other disposable material used during the field operations that appears to be contaminated. These materials will be placed in designated drums.

E. Storage and Disposal

The wastes generated at the site at individual locations will be transported to the drum storage area by the drilling services subcontractor. Drums should be stored on pallets on plastic sheeting with a short berm wall (hay bales or 2 x 4 planks or equivalent) to capture small spills.

Waste solid materials that contain hazardous constituents will be disposed of at an offsite location in a manner consistent with applicable solid waste, hazardous waste, and water quality regulations. Transport and disposal will be performed by a commercial firm under subcontract.

The liquid wastes meeting acceptable levels of discharge contamination may be disposed of through the sanitary sewer system at the site. However, prior to disposal to the sanitary sewer system, approval and contract arrangements will be made with the appropriate authorities. Wastes exceeding acceptable levels for disposal through the sanitary sewer system will be disposed of through contract with a commercial transport and disposal firm.

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- Check that representative samples of the containerized materials are obtained.
- Be sure that all state and federal regulations are considered when classifying waste for disposal.

STANDARD OPERATING PROCEDURE

Global Positioning System

I. Purpose

The procedure describes the calibration, operation, and functions associated with a Trimble® Pro XRS GPS Unit with a TSC-1 Asset Surveyor for datalogging. GPS signal information is differentially corrected to sub-meter accuracy on a continual basis using a second satellite signal broadcast from OmniSTAR satellite subscription service. The procedure applies to all field data collection activities.

II. Scope

This procedure provides information regarding the field operation and general maintenance of a Trimble® Pro XRS GPS Unit with a TSC-1 Asset Surveyor for datalogging. The information contained herein presents the operation procedures for this equipment. Review of the equipment's instruction manual is a necessity for more detailed descriptions pertaining to the operation and maintenance of the equipment.

III. Definitions

GPS: Global Positioning System - A system of 24 satellites developed and operated by the US DOD. Continuous 3D coordinate information is broadcast free of charge on a worldwide basis enabling precise positional location. Three standard categories of positional accuracy are generally used:

1. Uncorrected Signal - accuracy +/-10 meters - a single satellite transmission is used
2. Differentially Corrected Signal - accuracy +/- <1 meter - additional positional transmissions are recorded simultaneously and used to triangulate coordinate position.
3. Carrier Phase Signal- accuracy +/- <1 centimeter - requires a second receiver and additional software. Both receivers need to be equipped to receive Carrier Phase signals.

IV. Procedures and Guidelines

The procedure for calibration, operation, and maintenance of the GPS unit is outlined below. Daily calibration and battery recharging is typical operating procedure; frequencies other than daily shall be noted in the logbook and reason for increased frequency recorded. If using a different instrument, the operation manual supplied by the manufacturer should be consulted for instructions.

The procedures described below include additional features pre-programmed into the GPS datalogger to aid the data collection process.

A. Calibration

1. Check to ensure that the datalogger and antenna cables are properly connected to the receiver and that the batteries are securely connected.
2. Turn the datalogger unit on by pressing the green **On** key in the bottom left corner. The datalogger will perform a self-calibration. Wait to ensure that the antenna is receiving a sufficient number of satellite signals (usually a minimum of 3).
3. Once the datalogger receives a satellite signal then it is ready for operation.

B. Operations for surveying coordinates of a location

1. The datalogger and GPS receiver are ready for use after the initial self-calibration.
2. Field data may be immediately recorded in the datalogger.
3. The first screen view is the 'Main Menu'. Use the round keypad to select 'Data Collection' and press the **Enter** key.
4. Use the round keypad to select either 'Create new file' or 'Open existing file' and press the **Enter** key. It is not necessary to create a new file at each new location; however, it may be useful to create a new file at the beginning of each day.
5. If a new file is created then the GPS unit will automatically assign it a file name. The file name may be changed if desired. Press the enter key after the file name is assigned. If opening an existing file then use the round keypad to scroll through existing file names.
6. The next screen is 'Antenna options'. Press the **Enter** key to move to the next screen.
7. Select the type of activity to be performed. At the beginning of each day 'Sample Site Detail' should be completed. This allows the operator to enter each field team member, weather, objectives, health and safety meetings, etc. Once the 'Sample Site Detail' is completed then data entry activities may begin including well purging, water level elevations, and sample collection
8. The datalogger prompts the operator when a data field is required and by using the round key pad, numeric, alphanumeric, enter, and escape keys, the operator can perform electronic data capture on the GPS datalogger.
9. Once all information pertaining to an individual site has been recorded, press enter to complete data entry. If GPS signal is obstructed (tree canopy, building height, etc) user may choose to remain in same location until satellite transmission clears the obstruction. This usually takes only a few moments. Data may still be captured and recorded electronically even if GPS signal is insufficient for positioning.
10. To shut down, press the **Escape** key to return to the 'Main Menu'. The unit can be turned off by pressing the green key in the left hand corner. The datalogger should only be turned off when the 'Main Menu' screen is displayed.
11. All data from the datalogger should be downloaded into Trimble Pathfinder Office software on a PC a minimum of once daily. It is recommended that data is downloaded twice daily. Data may be viewed and mapped using Pathfinder Office or exported to

other software. Export file formats support standard ASCII text, generic database .dbf and most GIS and CAD software.

C. Operations for locating a point using coordinates/reacquiring a previously surveyed location

1. The datalogger and GPS receiver are ready for use after the initial self-calibration.
2. Use the Trimble Pathfinder software to load the data file containing the coordinates for each desired location ("programmed location").
3. The first screen view is the 'Main Menu'. Use the keypad to select 'Navigation' and press the **Enter** key.
4. Use the round keypad to select 'Open existing file' to open the file loaded in Step 2 above.
5. Select the location to be reacquired from the screen and press the enter key.
6. A circle with an arrow will appear. As you begin walking, the arrow will point in the direction of the programmed location. Walk in the direction indicated by the arrow.
7. Once you are within 10-feet of the location being reacquired, the GPS unit will display a circle (representing the programmed location) and an "X" (representing the GPS unit). Continue to walk in the direction of the circle until the "X" is centered in the circle. Once the "X" is centered, you are standing at the programmed location.
8. To shut down, press the **Escape** key to return to the 'Main Menu'. The unit can be turned off by pressing the green key in the left hand corner. The datalogger should only be turned off when the 'Main Menu' screen is displayed.

D. Preventive Maintenance

The antenna and datalogger are weatherproof. It is recommended that the receiver remain in the provided backpack carrier. Care should be taken not to crease, pinch or bend the antenna cable. Data should be downloaded from the datalogger a minimum of once daily, twice daily is preferred. At the end of each day the receiver batteries should be recharged. For technical assistance call the rental company through which you acquired the Trimble® unit. Guidance is also provided in the manual and at http://www.trimble.com.

STANDARD OPERATING PROCEDURE

Homogenization of Soil and Sediment Samples

I. Purpose

The homogenization of soil and sediment samples is performed to minimize any bias of sample representativeness introduced by the natural stratification of constituents within the sample.

II. Scope

Standard techniques for soil and sediment homogenization and equipment are provided in this SOP. These procedures do not apply to aliquots collected for VOCs or field GC screening; samples for these analyses should NOT be homogenized.

III. Equipment and Materials

Sample containers, stainless steel spoons or spatulas, and stainless steel pans.

IV. Procedures and Guidelines

Soil and sediment samples to be analyzed for semivolatiles, pesticides, PCBs, metals, cyanide, or field XRF screening should be homogenized in the field. After a sample is taken, a stainless steel spatula should be used to remove the sample from the split spoon or other sampling device. The sampler should not use fingers to do this, as gloves may introduce organic interferences into the sample.

Samples for VOCs should be taken immediately upon collection and should not be homogenized.

Prior to homogenizing the soil or sediment sample, any rocks, twigs, leaves, or other debris should be removed from the sample. The sample should be placed in a decontaminated stainless steel pan and thoroughly mixed using a stainless steel spoon. The soil or sediment material in the pan should be scraped from the sides, corners, and bottom, rolled into the middle of the pan, and initially mixed. The sample should then be quartered and moved to the four corners of the pan. Each quarter of the sample should be mixed individually, and then rolled to the center of the pan and mixed with the entire sample again.

All stainless steel spoons, spatulas, and pans must be decontaminated following procedures specified in SOP *Decontamination of Personnel and Equipment* prior to homogenizing the sample. A composite equipment rinse blank of homogenization equipment should be taken each day it is used.

V. Attachments

None.

VI. Key Checks and Items

- Take VOC samples immediately and do not homogenize the soil.
- Homogenize soil for analyses other than VOCs in a clean, stainless steel bowl.

STANDARD OPERATING PROCEDURE

Preparing Field Log Books

I. Purpose

This SOP provides general guidelines for entering field data into log books during site investigation and remediation activities.

II. Scope

This is a general description of data requirements and format for field log books. Log books are needed to properly document all field activities in support of data evaluation and possible legal activities.

III. Equipment and Materials

- Log book
- Indelible pen

IV. Procedures and Guidelines

Properly completed field log books are a requirement for much of the work we perform under the Navy CLEAN contract. Log books are legal documents and, as such, must be prepared following specific procedures and must contain required information to ensure their integrity and legitimacy. This SOP describes the basic requirements for field log book entries.

A. PROCEDURES FOR COMPLETING FIELD LOG BOOKS

1. Field notes commonly are kept in bound, hard-cover logbooks used by surveyors and produced, for example, by Peninsular Publishing Company and Sesco, Inc. Pages should be water-resistant and notes should be taken only with water-proof, non-erasable permanent ink, such as that provided in Sanford Sharpie® permanent markers.

2. On the inside cover of the log book the following information should be included:

   - Company name and address
   - Log-holders name if log book was assigned specifically to that person
   - Activity or location

- Project name
- Project manager's name
- Phone numbers of the company, supervisors, emergency response, etc.

3. All lines of all pages should be used to prevent later additions of text, which could later be questioned. Any line not used should be marked through with a line and initialed and dated. Any pages not used should be marked through with a line, the author's initials, the date, and the note "Intentionally Left Blank."

4. If errors are made in the log book, cross a single line through the error and enter the correct information. All corrections shall be initialed and dated by the personnel performing the correction. If possible, all corrections should be made by the individual who made the error.

5. Daily entries will be made chronologically.

6. Information will be recorded directly in the field log book during the work activity. Information will not be written on a separate sheet and then later transcribed into the log book.

7. Each page of the log book will have the date of the work and the note takers initials.

8. The final page of each day's notes will include the note-takers signature as well as the date.

9. Only information relevant to the subject project will be added to the log book.

10. The field notes will be copied and the copies sent to the Project Manager or designee in a timely manner (at least by the end of each week of work being performed).

B. INFORMATION TO BE INCLUDED IN FIELD LOG BOOKS

1. Entries into the log book should be as detailed and descriptive as possible so that a particular situation can be recalled without reliance on the collector's memory. Entries must be legible and complete.

2. General project information will be recorded at the beginning of each field project. This will include the project title, the project number, and project staff.

3. Scope: Describe the general scope of work to be performed each day.

4. Weather: Record the weather conditions and any significant changes in the weather during the day.

5. Tail Gate Safety Meetings: Record time and location of meeting, who was present, topics discussed, issues/problems/concerns identified,

and corrective actions or adjustments made to address concerns/ problems, and other pertinent information.

6. Standard Health and Safety Procedures: Record level of personal protection being used (e.g., level D PPE), record air monitoring data on a regular basis and note where data were recording (e.g., reading in borehole, reading in breathing zone, etc). Also record other required health and safety procedures as specified in the project specific health and safety plan.

7. Instrument Calibration; Record calibration information for each piece of health and safety and field equipment.

8. Personnel: Record names of all personnel present during field activities and list their roles and their affiliation. Record when personnel and visitors enter and leave a project site and their level of personal protection.

9. Communications: Record communications with project manager, subcontractors, regulators, facility personnel, and others that impact performance of the project.

10. Time: Keep a running time log explaining field activities as they occur chronologically throughout the day.

11. Deviations from the Work Plan: Record any deviations from the work plan and document why these were required and any communications authorizing these deviations.

12. Heath and Safety Incidents: Record any health and safety incidents and immediately report any incidents to the Project Manager.

13. Subcontractor Information: Record name of company, record names and roles of subcontractor personnel, list type of equipment being used and general scope of work. List times of starting and stopping work and quantities of consumable equipment used if it is to be billed to the project.

14. Problems and Corrective Actions: Clearly describe any problems encountered during the field work and the corrective actions taken to address these problems.

15. Technical and Project Information: Describe the details of the work being performed. The technical information recorded will vary significantly between projects. The project work plan will describe the specific activities to be performed and may also list requirements for note taking. Discuss note-taking expectations with the Project Manager prior to beginning the field work.

16. Any conditions that might adversely affect the work or any data obtained (e.g., nearby construction that might have introduced excessive amounts of dust into the air).

17. Sampling Information; Specific information that will be relevant to most sampling jobs includes the following:

- Description of the general sampling area – site name, buildings and streets in the area, etc.
- Station/Location identifier
- Description of the sample location – estimate location in comparison to two fixed points – draw a diagram in the field log book indicating sample location relative to these fixed points – include distances in feet.
- Sample matrix and type
- Sample date and time
- Sample identifier
- Draw a box around the sample ID so that it stands out in the field notes
- Information on how the sample was collected – distinguish between "grab," "composite," and "discrete" samples
- Number and type of sample containers collected
- Record of any field measurements taken (i.e. pH, turbidity, dissolved oxygen, and temperature, and conductivity)
- Parameters to be analyzed for, if appropriate
- Descriptions of soil samples and drilling cuttings can be entered in depth sequence, along with PID readings and other observations. Include any unusual appearances of the samples.

C. SUGGESTED FORMAT FOR RECORDING FIELD DATA

1. Use the left side border to record times and the remainder of the page to record information (see attached example).

2. Use tables to record sampling information and field data from multiple samples.

3. Sketch sampling locations and other pertinent information.

4. Sketch well construction diagrams.

V. Attachments

Example field notes.

(47) MAY 12, 2003 EXAMPLE

0715 ARRIVE ON SITE AT XYZ SITE.
CH2M HILL STAFF:
John Smith: FIELD TEAM LEADER
Bob Builder: SITE SAFETY COORD.
WEATHER: OVERCAST + COOL, 45°F
CHANCE OF LATE SHOWERS
SCOPE: • COLLECT GROUNDWATER SAMPLES FOR LTM WORK AT SITE 14
• SUPERVISE SURVEY CREW
AT SITE 17
0725 BB ~~Con~~ ~~JS~~ (JS) CALIBRATES
PID: 101 ppm/100 ppm OK
PID Model #, SERIAL #
0730 BB CALIBRATES HORIBA METER
Model #, SERIAL #
→ LIST CALIBRATION RESULTS
0738 SURVEY CREW ARRIVES ON SITE
→ LIST NAMES
0745 BB HOLDS H+S TALK ON SLIPS, TRIPS, FALLS, TICKS + AIR MONITORING
JS + SURVEY CREW ATTEND
NO H+S ISSUES IDENTIFIED AS CONCERNS. All work is in "LEVEL D."
0755 JS CONDUCTS SITE-WIDE AIR MONITORING
All readings = 0.0 ppm in

JS 5-12-03

MAY 12, 2003 EXAMPLE (48)

SITE 14 LTM
BREATHING ZONE (BZ)
0805 Mobilize to well MW-22 to SAMPLE, SURVEYORS SETTING UP AT SITE 17
0815 PM (PAUL PAPER PUSHER) CALLS AND INFORMS JS to collect GW SAMPLE AT WELL MW-44 today for 24 hour TAT ANALYSIS OF VOCIS
0820 Purging MW-22
→ RECORD WATER QUALITY DATA
JS 5-12-03
0843 Collect SAMPLE AT MW-22 for total TAL Metals AND VOC'S. No Dissolved Metals Needed PER PM.
0905 JS + BB Mobilize to SITE 17 to show surveyors wells to Survey.
0942 Mobilize to well MW-22 to Collect SAMPLE
0950 CAN not ACCESS WELL MW-22 due to BASE OPERATIONS; CONTACT PAUL PAPER PUSHER AND HE STATED he will check on GAINING ACCESS with BASE contact.
0955 Mobilize to well MW-19

JS 5-12-03

STANDARD OPERATING PROCEDURE

Low-Flow Groundwater Sampling from Monitoring Wells – EPA Region I and III

I. Purpose and Scope

This SOP presents general guidelines for the collection of groundwater samples from monitoring wells using low-flow purging and sampling procedures. Operations manuals should be consulted for specific calibration and operating procedures.

II. Equipment and Materials

- Adjustable-rate positive-displacement pump, submersible pump, or peristaltic pump
- Horiba® U-22 or equivalent water quality meters to monitor pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature
- Flow-through cell with inlet/outlet ports for purged groundwater and watertight ports for each probe
- Generator or alternate power source depending on pump type
- Water-level indicator
- Disposable Teflon, Teflon-lined polyethylene tubing or polyethylene tubing for metals and other inorganics
- Plastic sheeting
- Well-construction information
- Calibrated container and stopwatch to determine flow rate
- Sample containers
- In-line disposable 0.45µm filters (QED® FF8100 or equivalent)
- Shipping supplies (labels, coolers, and ice)
- Field book

III. Procedures and Guidelines

A. Setup and Purging

1. Obtain information on well location, diameter(s), depth, and screen interval(s), and the method for disposal of purged water.
2. Calibrate instruments according to manufacturer's instructions.
3. The well number, site, date, and condition are recorded in the field logbook.

4. Plastic sheeting is placed on the ground, and the well is unlocked and opened. All decontaminated equipment to be used in sampling will be placed only on the plastic sheeting until after the sampling has been completed. To avoid cross-contamination, do not let any downhole equipment touch the ground.

5. All sampling equipment and any other equipment to be placed in the well is cleaned and decontaminated before sampling in accordance with SOP *Decontamination of Personnel and Equipment*.

6. Water level measurements are collected in accordance with the *Water Level Measurements* SOP. **Do not measure the depth to the bottom of the well at this time**; this reduces the possibility that any accumulated sediment in the well will be disturbed. Obtain depth to bottom information from well construction log.

7. Attach and secure the tubing to the low-flow pump. Lower the pump slowly into the well and set it at approximately the middle of the screen. Place the pump intake in the middle of the saturated screen length and should be at least two feet above the bottom of the well to avoid mobilization of any sediment present in the bottom.

8. Insert the measurement probes into the flow-through cell. The purged groundwater is directed through the cell, allowing measurements to be collected before the water contacts the atmosphere.

9. If using a generator, locate it 30 feet downwind from the well to avoid exhaust fumes contaminating the samples.

10. Start purging the well at 0.2 to 0.5 liters per minute. Avoid surging. Purging rates for more transmissive formations could be started at 0.5-liter to 1 liter per minute. The initial field parameters of pH, specific conductance, dissolved oxygen, ORP, turbidity, and temperature of water are measured and recorded in the field logbook.

11. The water level should be monitored during purging, and, ideally, the purge rate should equal the well recharge rate so that there is little or no drawdown in the well (i.e., less than 0.3-foot). The water level should stabilize for the specific purge rate. There should be at least 1 foot of water over the pump intake so there is no risk of the pump suction being broken, or entrainment of air in the sample. Record adjustments in the purge rate and changes in depth to water in the logbook. Purge rates should, if needed, be decreased to the minimum capabilities of the pump (0.1- to 0.2-liter per minute) to avoid affecting well drawdown.

12. During purging, the field parameters are measured frequently (every 5 minutes) until the parameters have stabilized. Field parameters are considered stable when measurements meet the following criteria:

    - pH: within 0.1 pH units
    - Specific conductance: within 3 percent

- Dissolved oxygen: within 10 percent
- Turbidity: within 10 percent for values greater than 5 NTU; if 3 turbidity values are less than 5 NTU, consider the values as stabilized
- ORP: within 10 mV
- Temperature: within 3 percent

B. Sample Collection

Once purging is complete the well is ready to sample. The elapsed time between completion of purging and collection of the groundwater sample should be minimized. Typically, the sample is collected immediately after the well has been purged, but this is also dependent on well recovery.

Samples will be placed in sample containers that have been cleaned to laboratory standards and are preserved in accordance with the analytical method. The containers are typically pre-preserved, if required.

VOC samples are normally collected first and directly into pre-preserved sample containers.

During purging and sampling, the centrifugal/peristaltic pump tubing must remain filled with water to avoid aeration of the groundwater. It is recommended that ¼ or 3/8 inch inside diameter tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, collect non-VOC dissolved gasses samples first, then increase flow rate slightly until water completely fills the tubing and collect the VOC/dissolved gases samples. Record new flow rate and drawdown depth.

The steps to be followed for sample collection are as follows:

1. The cap is removed from the sample bottle, and the bottle is tilted slightly.
2. The sample is slowly poured from the bailer or discharged from the pump so that it runs down the inside of the sample bottle with a minimum of splashing. The pumping rate should be reduced to approximately 100 ml per minute when sampling VOCs.
3. Inorganics, including metals, may be collected and preserved in the filtered form as well as the unfiltered form. Disposable in-line filters (0.45 micron filter), connected to the end of the sample tubing,, are typically used for field filtration. Samples are field filtered as the water is being placed into the sample container. If a bailer is used, filtration may be driven by a peristaltic pump.
4. Adequate space is left in the bottle to allow for expansion, except for VOC vials, which are filled to the top with a positive meniscus.

5. The bottle is capped and clearly labeled.

6. Immediately upon collection, all samples for chemical analysis are to be placed in a closed container on ice unless it is not possible to do so. Although unusual and uncommon, there may be instances where it is not possible to have containers with ice at the sample location. In these instances, the samples should be placed on ice as soon as practical and during the time between collection and placing the samples on ice, the samples should be kept as cool as possible.

7. Nondedicated equipment is cleaned and decontaminated in accordance with the *Decontamination of Personnel and Equipment* SOP.

The following information, at a minimum, will be recorded in the log book:

1. Sample identification (site name, location, and project number; sample name/number and location; sample type and matrix; time and date; sampler's identity)
2. Sample source and source description
3. Field observations and measurements (appearance, volatile screening, field chemistry, sampling method), volume of water purged prior to sampling, number of well volumes purged, and field parameter measurements
4. Sample disposition (preservative; laboratory name, date and time sent; laboratory sample number, chain-of-custody number, sample bottle lot number)
5. Additional remarks

C. Additional remarks

1. If the well goes dry during purging, wait until it recovers sufficiently to remove the required volumes to sample all parameters. It may be necessary to return periodically to the well but a particular sample (e.g., large amber bottles for semivolatile analysis) should be filled at one time rather than over the course of two or more visits to the well.

2. Disposable tubing is disposed of with PPE and other site trash.

IV. Attachments

White paper on reasons and rationale for low-flow sampling.

V. Key Checks and Preventative Maintenance

- The drawdown in the well should be minimized as much as possible (preferably no more than 0.5-foot to 1 foot) so that natural groundwater-flow conditions are maintained as closely as possible.

- The highest purging rate should not exceed 1 liter per minute. This is to keep the drawdown minimized.
- Stirring up of sediment in the well should be avoided so that turbidity containing adsorbed chemicals is not suspended in the well and taken in by the pump.
- Overheating of the pump should be avoided to minimize the potential for losing VOCs through volatilization.
- Keep the working space clean with plastic sheeting and good housekeeping.
- Maintain field equipment in accordance with the manufacturer's recommendations. This will include, but is not limited to:
    - Inspect sampling pump regularly and replace as warranted
    - Inspect quick-connects regularly and replace as warranted
    - Verify battery charge, calibration, and proper working order of field measurement equipment prior to initial mobilization and daily during field efforts

Attachment to the SOP on Low-Flow Sampling Groundwater Sampling from Monitoring Wells

White Paper on Low-Flow Sampling

EPA recommends low-flow sampling as a means of collecting groundwater samples in a way that minimizes the disturbance to the natural groundwater flow system and minimizes the introduction of contamination into the samples from extraneous sources. The following are details about these issues.

When a pump removes groundwater from the well at the same rate that groundwater enters the well through the screen, the natural groundwater-flow system around the well experiences a minimum of disturbance. Some disturbance is bound to occur because you are causing groundwater to flow to the well in a radial fashion that otherwise would have flowed past it. However, the resulting low-flow sample provides the most-representative indication we can get of groundwater quality in the immediate vicinity of the well.

Normally, when a well is pumped at an excessive rate that drops the water level in the well below the water level in the aquifer, the water cascades down the inside of the well screen when it enters the well. The turbulence from this cascading causes gases such as oxygen and carbon dioxide to mix with the water in concentrations that are not representative of the native groundwater and are higher than expected. This causes geochemical changes in the nature of the water that can change the concentrations of some analytes, particularly metals, in the groundwater sample, not mention it's effect on the dissolved oxygen levels that then will be measured in the flow-through cell. Such turbulence also may cause lower-than-expected concentrations of volatile organic compounds due to volatilization.

For wells in which the water level is above the top of the screen, the water up in the riser is out of the natural circulation of the groundwater and, therefore, can become stagnant. This stagnant water is no longer representative of natural groundwater quality because its pH, dissolved-oxygen content, and other geochemical characteristics change as it contacts the air in the riser. If we minimize the drawdown in the well when we pump, then we minimize the amount of this stagnant water that is brought down into the well screen and potentially into the pump. As a result, a more-representative sample is obtained.

Typically, wells contain some sediment in the bottom of the well, either as a residue from development that has settled out of the water column or that has sifted through the sand pack and screen since the well was installed. This sediment commonly has adsorbed on it such analytes as metals, SVOCs, and dioxins that normally would not be dissolved in the groundwater. If these sediments are picked up in the groundwater when the well is disturbed by excessive pumping, they can:

- Make filtering the samples for metals analysis more difficult
- Add unreasonably to the measured concentration of SVOCs and other organic compounds

The SOP for low-flow sampling has been modified recently and should be consulted for additional information about low-flow sampling and ways of dealing with wells in which the water level cannot be maintained at a constant level.

STANDARD OPERATING PROCEDURE

Mini RAE Photoionization Detector (PID)

I. Purpose

The purpose of this SOP is to provide general reference information for using the Mini RAE PID in the field. Calibration and operation, along with field maintenance, will be included in this SOP.

II. Scope

This procedure provides information on the field operation and general maintenance of the Mini RAE PID. Review of the information contained herein will ensure that this type of field monitoring equipment will be properly utilized. Review of the owner's instruction manuals is a necessity for more detailed descriptions.

III. Definitions

Volatile Organic Compound (VOC) – Expresses the VOC concentration in ppm

ppm - parts per million: parts of vapor or gas per million parts of air by volume.

IV. Procedures

The Mini RAE utilizes the principle of a detecting sensor. The PID operates on the principle that most organic compounds and some inorganic compounds are ionized when they are bombarded by high-energy ultraviolet light. These compounds absorb the energy of the light, which excites the molecules and results in a loss of electron and the formation of a positively charged ion. The number of ions formed and the ion current produced is directly proportional to mass and concentration. The amount of energy required to displace an electron is called photo ionization potential (PIP). The air sample is drawn into a UV lamp using a pump or a fan. The energy of the lamp determines whether a particular chemical will be ionized. Each chemical compound has a unique ionizing potential. When the UV light energy is greater than the ionization potential of the chemical, ionization will occur. When the sample is ionized, the electrical signal is displayed on an analog or digital output. Although the output does not distinguish between chemicals, it does detect an increase in the ion current. If only one chemical is present in the air, it is possible to use PIDs quantitatively. Chemical structure and lamp intensity affects the sensitivity of the instrument to a given contaminant. All PID readings are relative to the calibration gas, usually isobutylene. It is important to calibrate the PID in the same temperature and elevation that the equipment will be used, and to determine the background concentrations in the field before taking measurements. For environments where background readings are high, factory zero calibration gas should be used.

Note: For volatile and semi-volatile compounds, knowing the PIP is critical in determining the appropriate instrument to use when organic vapor screening. Consult the QAPP and manufacturer's manual to determine that the proper instrument has been selected for the contaminate vapors of interest. If an expected compound at a site has a PIP less than 11.7 eV, it is possible to use a PID. If the ionization potential is greater than 11.7eV, an FID is required.

The following subsections will discuss Mini RAE calibration, operation, and maintenance. These sections, however, do not take the place of the instruction manual.

A. Calibration

These instructions are for the Mini RAE 2000. If using the Mini RAE 3000, please see the operator's manual for instructions.

Start up Instrument

- Press **Mode** button
- Observe displays:

```
On!……..
```

```
Version X.XX
```

```
Model Number
SN XXXX
```

```
Date Time
Temp
```

- After the monitor is turned on and it runs through the startup menus, the display will read "Ready". Press the **[Y/+]** key to start the pump.
- The pump will start, the seconds will count down to zero, and the instrument will be ready for use

Calibration Check and Adjustment

Allow instrument to warm up for 15 minutes.

- Depress the **[N/-]** key first, then while depressing the **[N/-]**, depress the **[Mode]** key also and depress both keys for 5 seconds.
- Display will read:

```
Calibrate
Monitor?
```

- Press the **[Y/+]** key
- Display will read:

```
Fresh Air
Calibration?
```

- Perform the Fresh Air Calibration in an area free of any detectable vapor near your work zone.
- Press the **[Y/+]** key
- Display will read:

```
Zero….
In progress…
```

```
Wait…
```

```
Update data…
```

```
Zeroed…
```

```
Reading = X.X ppm
```

- Press any key and the display will go back to:

```
Fresh Air
Calibration?
```

- Press the **[N/+]** key
- Display will read:

```
Span/Cal?
```

- Press the **[Y/+]** key
- Display will read:

```
Isobutylene = 100 ppm
```

```
Apply Gas Now!
```

- Press the **[Y/+]** key
- Apply calibration gas – use either HAZCO Services Part Number R-SGRAE4 or Rae Systems Part Number 008-3002 – using a .5 LPM regulator and direct tubing.

```
Wait…30
```

- The display will count down showing the number of remaining seconds:

```
Reading = 100
```

Update data, span cal done. Turn off gas!

- Calibration readings between 99 and 102 ppm are within the acceptable range.
- Display will read:

Span/Cal?

- **CALIBRATION IS COMPLETE!**
- Press any key to return to operational mode.

B. Operation

Due to the Mini RAE having many functions in terms of operation, it is recommended that you follow the operational procedures as outlined in the instruction manual from pages 2-5 to 2-14.

C. Site Maintenance

After each use, the meter should be recharged and the outside of the instruments should be wiped clean with a soft cloth.

D. Scheduled Maintenance

Function	Frequency
Check alarm and settings	Monthly/before each use
Clean screens and gaskets around sensors	Monthly
Replace sensors	Biannually or when calibration is unsuccessful

V. Quality Assurance Records

Quality assurance records will be maintained for each air monitoring event. The following information shall be recorded in the field logbook.

- Identification - Site name, date, location, CTO number, activity monitored, (surface water sampling, soil sampling, etc), serial number, time, resulting concentration, comments and identity of air monitoring personnel.
- Field observations - Appearance of sampled media (if definable).
- Additional remarks (e.g, Mini RAE had wide range fluctuations during air monitoring activities.)

VI. References

Mini RAE 2000 Portable VOC PGM-7600, RAE Systems, Revision E, May 2005.

MiniRAE 2000

Portable VOC Monitor
PGM-7600

OPERATION AND MAINTENANCE MANUAL

(Document No.: 011-4001-000)
Revision E, May 2005

RAE SYSTEMS

ISO 9001 CERTIFIED

ATTENTION!

For European Applications

A. CE 0575 Ex II 1G/2G
DEMKO 03 ATEX 0204759X
Eex ia IIC T4

B. Recharge batteries only in non-hazardous locations.

C. Do not connect external cable to serial interface jack in hazardous locations.

D. Use RAE Systems Adapter P/N 500-0072 for connection to communication port and charging jack only in a non-hazardous area.

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⚠ WARNING ⚠

- Do NOT proceed before reading -

This manual must be carefully read by all individuals who have or will have the responsibility for using, maintaining, or servicing this product.

The product will perform as designed only if it is used, maintained, and serviced in accordance with the manufacturer's instructions.

CAUTION!!

To reduce the risk of electric shock, turn off power before removing the monitor cover. Disconnect the battery before removing sensor module for service. Never operate the monitor while the cover is removed. Remove monitor cover and sensor module only in an area known to be non-hazardous.

The model PGM-7600 equipment is classified as to intrinsic safety for use in class I, division 1, groups A, B, C, D, or non-hazardous locations only.

Special Notes

-1-

When the MiniRAE 2000 Monitor is taken out from the transport case and turned on for the first time, there may be some residual organic or inorganic vapor trapped inside the detector chamber. The initial PID sensor reading may indicate a few ppm. Enter an area known to be free of any organic vapor and turn on the monitor. After running for several minutes, the residual vapor in the detector chamber will be cleared and the reading should return to zero.

-2-

The battery of the MiniRAE 2000 monitor will discharge slowly even if it is turned off. If the monitor has not been charged for 5-7 days, the battery voltage will be low. Therefore, it is a good practice to always charge the monitor before using it. It is also recommended to fully charge the monitor FOR AT LEAST 10 HOURS before first use. See Section 7 for more information on battery charging and replacement.

WARNINGS

STATIC HAZARD: Clean only with damp cloth.

For safety reasons this equipment must be operated and serviced by qualified personnel only. Read and understand instruction manual completely before operating or servicing.

Use only RAE Systems battery packs, part nos. 012-3050, 012-3051 or 012-3052. This instrument has not been tested in an explosive gas/air atmosphere having an oxygen concentration greater than 21%. Substitution of components may impair intrinsic safety. Recharge batteries only in non-hazardous locations.

The calibration of all newly purchased RAE Systems instruments should be tested by exposing the sensor(s) to known concentration calibration gas before the instrument is put into service.

For maximum safety, the accuracy of the MiniRAE 2000 should be checked by exposing it to a known concentration calibration gas before each day's use.

AVERTISSEMENTS

DANGER RISQUE D'ORIGINE ELECTROSTATIQUE: Nettoyer uniquement avec un chiffon humide.

Pour des raisons de sécurité, cet équipment doit être utilisé, entretenu et réparé uniquement par un personnel qualifié. Étudier le manuel d'instructions en entier avant d'utiliser, d'entretenir ou de réparer l'équipement.

Utiliser seulement l'ensemble de batterie RAE Systems, la reference 012-3050, 012-3051 au 012-3052. Cet instrument n'a pas été essayé dans une atmosphère de gaz/air explosive ayant une concentration d'oxygène plus élevée que 21%. La substitution de composants peut compromettre la sécurité intrinsique. Ne charger les batteries que dans emplacements désignés non-dangereuse.

La calibration de toute instruments de RAE Systems doivent être testé en exposant l'instrument a une concentration de gaz connue par une procédure diétalonnage avant de mettre en service l'instrument pour la première fois.

Pour une securite maximale, la sensibilité du MiniRAE 2000 doit être verifier en exposant l'instrument a une concentration de gaz connue par une procédure diétalonnage avant chaque utilisation journalière.

1. GENERAL INFORMATION

MiniRAE 2000 Portable VOC Monitor (Model PGM 7600) is a compact monitor designed as a broadband VOC gas monitor and datalogger for work in hazardous environments. It monitors Volatile Organic Compounds (VOC) using a Photo-Ionization Detector (PID) with a 9.8 eV, 10.6 eV, or 11.7 eV gas discharge lamp. Features are:

- **Lightweight and Compact**
  -Compact, light weight (19 oz.) and rugged design
  -Built-in sample draw pump

- **Dependable and Accurate**
  - Up to 10 hours of continuous monitoring with rechargeable battery pack
  - Designed to continuously monitor VOC vapor at ppm levels

- **User Friendly**
  -Preset alarm thresholds for STEL, TWA, low and high level peak values. Audio buzzer and flashing LED display are activated when the limits are exceeded.

- **Datalogging Capabilities**
  -15,000 point datalogging storage capacity for data download to PC

MiniRAE 2000 consists of a PID with associated microcomputer and electronic circuit. The unit is housed in a rugged ABS + PC case with a backlit 1 line by 8 character dot matrix LCD and 3 keys to provide easy user interface.

1.1 General Specifications

Table 1.1

Portable VOC Monitor Specification	
Size:	8.2"L x 3.0"W x 2.0"H
Weight:	19.5 oz with battery pack
Detector:	Photo-ionization sensor with 9.8, 10.6, or 11.7 eV UV lamp
Battery:	A 4.8V /1250 mAH Rechargeable Nickel Metal Hydride battery pack (snap in, field replaceable)
Battery Charging:	10 hours charge through built-in charger
Operating Hours:	Up to10 hours continuous operation
Display:	1 line by 8 characters 5x7 dot matrix LCD (0.4" character height) with LED back light automatically in dim light
Range, Resolution & Response time (t_{90}):	
Isobutylene (calibration gas)	
	0-99 ppm 0.1 ppm 2 sec
	100-1,999 ppm 1.0 ppm 2 sec
	2000-10,000 ppm 1.0 ppm 2 sec
Measurement Accuracy (Isobutylene):	
	0 – 2000 ppm: ± 2 ppm or 10% of reading.
	> 2000 ppm: ± 20% of reading
PID Detector:	Easy access to lamp and sensor for cleaning and replacement
Correction Factors:	Built-in 102 VOC gases
Calibration:	Two-point field calibration of zero and standard reference gas
Calibration Memory:	
	Store up to 8 separate calibration, alarm limits and span value
Inlet Probe:	Flexible 5" tubing
Keypad:	1 operation key and 2 programming keys

Direct Readout:	Instantaneous, average, STEL and peak value, battery voltage and elapsed time
Intrinsic Safety:	UL & cUL Class 1, Division I, Group A,B,C,D, Temperature Code T3C (US & Canada); CE 0575 Ex II 1G DEMKO 02 ATEX 0204759 Eex ia IIC T4 (Europe)
EM Interference:	No effect when exposed to 0.43 W/cm^2 RF interference (5 watt transmitter at 12 inches)
Alarm Setting:	Separate alarm limit settings for Low, High, STEL and TWA alarm
Operating Mode:	Survey or Hygiene mode
Alarm:	90 dB buzzer and flashing red LEDs to indicate exceeded preset limits, low battery voltage, or sensor failure.
External Alarm:	Optional plug-in pen-size vibration alarm or remote alarm
Alarm Mode:	Latching or automatic reset
Real-time Clock:	Automatic date and time stamps on data logged information
Datalogging:	15,000 points with time stamp, serial number, user ID, site ID, etc.
Communication:	Upload data to PC and download instrument setup from PC through RS-232 port
Sampling Pump:	Internally integrated. Flow rate: 450-550 cc/min.
Temperature:	0° to 45°C (32° to 113°F)
Humidity:	0 % to 95 % relative humidity (non-condensing)
Housing:	ABS + PC, conductive coating, splash and dust proof, will withstand 1 meter drop test with rubber boot
Attachment:	Wrist strap, rubber boot and belt clip

2. OPERATION OF MINIRAE 2000

The MiniRAE 2000 Portable VOC Monitor is a compact Monitor designed as a broadband VOC gas monitor and datalogger for work in hazardous environments. It gives real time measurements and activates alarm signals whenever the exposure exceeds preset limits. Prior to factory shipment the MiniRAE 2000 is preset with default alarm limits and the sensor is pre-calibrated with standard calibration gas. However, the user should test the instrument and verify the calibration before the first use. After the monitor is fully charged and calibrated, it is ready for immediate operation.

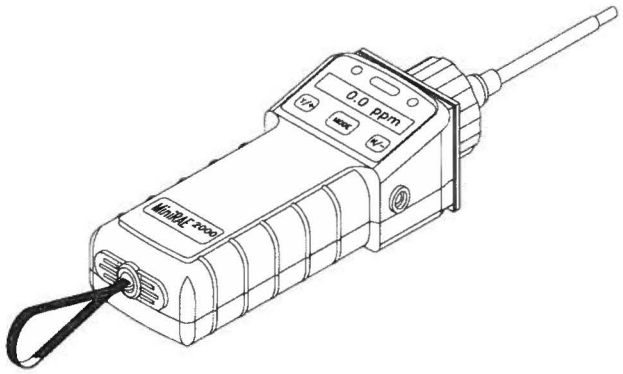


Figure 2-1 MiniRAE 2000

2.1 Physical Description

The main components of the MiniRAE 2000 Portable VOC monitor include:

- Three keys for user to interact with the monitor: 1 operation key and 2 programming keys for normal operation or programming of the monitor
- LCD display with back light for direct readout and calculated measurements
- Buzzer and red LED's for alarm signaling whenever the exposures exceed preset limits
- Wrist strap
- Charge contact for plugging directly to the charging station
- Gas entry and exit ports
- Serial communication port for PC interface
- External alarm and analog output port
- Protective rubber cover

2.2 Keys and Display

Figure 2.2 shows the LCD display and the keypad on the front panel of the monitor. The function of the 3 keys during normal operation are summarized below:

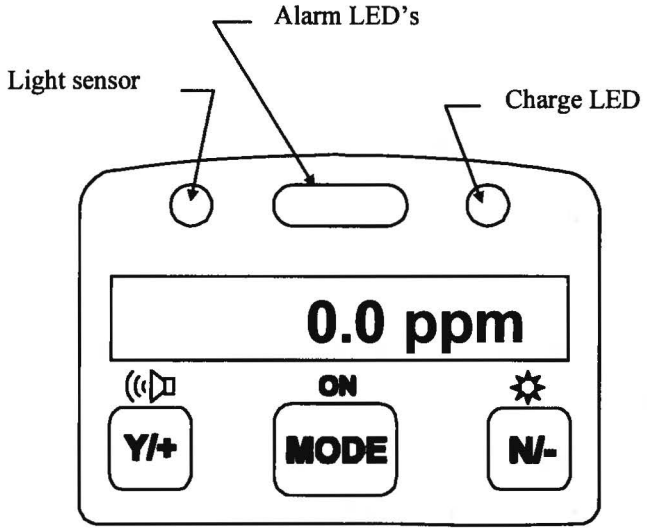


Figure 2-2 LCD Display and Keypad

Key	Function in Normal Operation
[MODE]	-Turn on/off the power* and step through menu items
[N/-]	-Toggle on/off the back light, negative acknowledge, decrease value
[Y/+]	-Start measurement, positive acknowledge, increase value value

* Pressing and holding **[MODE]** key for 5 seconds turns off the power to the monitor. Monitor will beep once per second and display countdown timer during power-down sequence. Press **[MODE]** key momentarily to step through menu items. To save time, press any key during message scrolling to skip to the end of the message.

2.3 Power On/Off

To turn on the MiniRAE 2000 portable VOC monitor, press **[MODE]** key for one second and release. The audio buzzer will beep once and the air pump will turn on. The display will show "ON!.." and then "Ver n.nn" to indicate the unit's current firmware version number. Next displayed are the serial number, the model number, Operating mode, current date and time, unit internal temperature, gas selected, high low, STEL, TWA/AVG alarm limits, battery voltage, and shut off voltage. Also displayed are internal mode settings such as User mode, Alarm mode, datalog time remaining and log periods in the respective order.

To turn off the MiniRAE 2000 portable VOC monitor, press and hold the **[MODE]** key for 5 seconds. The monitor will beep once per second during the power-down sequence with a count down timer showing the number of remaining seconds. The message "Off!.." flashes on the LCD display and the display will go blank indicating that the monitor is turned off.

Data protection during power off

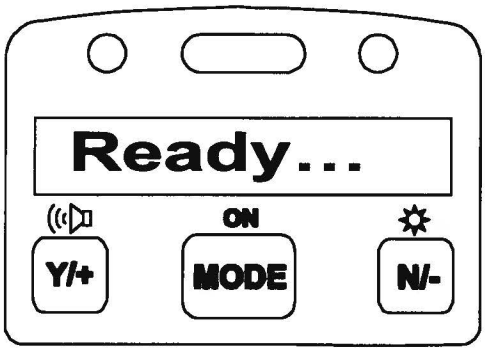
When the monitor is turned off, all the current real time data including last measured value are erased. However, the datalog data is preserved in non-volatile memory. Even if the battery is disconnected, the datalog data will not be lost. While the power is off, the real time clock will continue to operate until the battery is completely drained (usually in 4-5 days without any charging). If the battery is completely drained or is disconnected from the monitor for more than 30 minutes, the real time clock will be lost. In this case, the user needs to enter the real time clock information again, as described in Section 4, or send the PC clock during configuration through the PC communication.

2.4 Operation

The **MiniRAE 2000** VOC monitor has two operation modes: **Survey** and **Hygiene** mode. The **Survey mode** allows the user to manually start and stop the monitoring/measuring operation and display certain exposure values. In the **Hygiene mode,** the monitor runs continuously after the monitor is turned on. Refer to Section 4.7.1 for switching between the two modes.

2.4.1 Survey Mode

After the monitor is turned on, it runs through the start up menu. Then the message "**Ready...**" is displayed (see figure below).



At this point, the user has two options:

1. Step through the Main Menu.
2. Take a measurement.

Press the **[MODE]** button to step through the Main Menu. Press the **[Y/+]** button to proceed to take a measurement.

The Main Menu

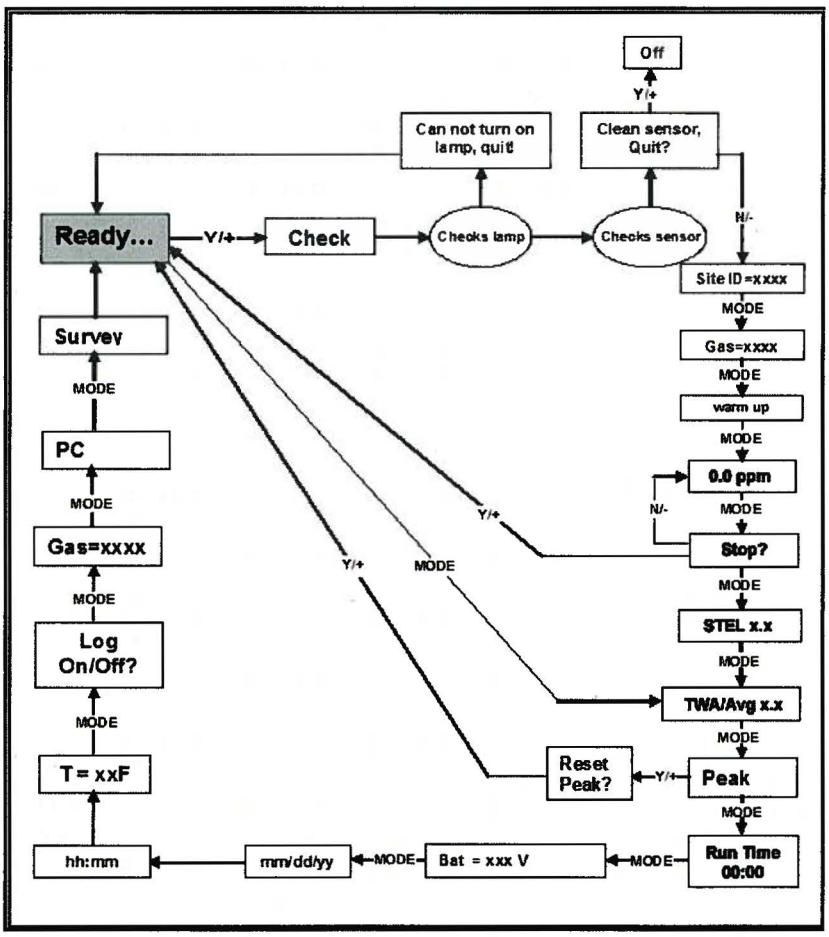
Press the **[MODE]** button to enter the Main Menu. Press the **[Y/+], [MODE]** or **[N/-]** as indicated in the flow chart below to step through the Main Menu. The PID sensor and pump are turned off during this time.

The Main Menu functions are:

- **Ready...**
- **Check**
- **Site ID = xxxx**
- **Gas = xxxx**
- **Warm up**
- **X.x ppm**
- **Stop?**
- **TWA/Avg x.x ppm**
- **STEL x.x ppm**
- **Peak x.x ppm**
- **Run time hh:mm**
- **Bat = X.XV**
- **Mm/dd/yy**
- **hh:mm**
- **T = xxxF [date, time and temperature (°C or °F)]**
- **Log On/Off?**
- **PC Comm?**
- **Survey**

These functions are arranged in a "round robin" order. To select a specific function, press the button as shown below until the desired function appears.

Main Menu



The Main Menu Functions

- **Ready...:** Indicates that the monitor is ready to take a measurement or to step through the Main Menu. Press the **[Y/+]** button to advance to taking a measurement (read "Taking a Measurement" on Page 2-12 for details).

  Note: The **Ready...** screen is skipped if the menu is cycled through while a measurement is running.

- **Check...:** This message displays while the system is checking the lamp and the sensor. If the lamp test succeeds, the system will progress to checking the sensor. If the lamp test does not succeed, the display will read **Can not turn on lamp, quit!**

  - **Can not turn on lamp, quit!:** This message displays when the lamp does not turn on. The system will automatically return to **Ready...** allowing the user to test the lamp again. If the lamp fails a second time, turn the monitor off and refer to Section 7.2 "**PID Sensor & Lamp Cleaning / Replacement**".

  - **Clean Sensor, Quit?:** This message displays when the sensor requires cleaning. Press the **[Y/+]** button to turn the monitor off and clean the sensor. Press the **[N/-]** button and the system will progress to the **Site ID = xx**

- **Site ID = xxxx:** This display shows the Site ID and indicates that the monitor is about to start taking measurements (read "Taking a Measurement" for details)

  Note: This display appears only after a measurement has been started. It does not appear when the user is cyling through the Main Menu and the monitor is idling.

- **Gas = xxxx:** This display identifies the gas to be measured and indicates that the monitor is about to take a measurement (read "Taking a Measurement" for details)

Note: This display appears only after a measurement has been started. It does not appear when the user is cyling through the Main Menu and the monitor is idling.

- **x.x ppm:** (read "Taking a Measurement" for details)

  Note: This display appears only after a measurement has been started. It does not appear when the user is cyling through the Main Menu and the monitor is idling.

- **TWA/Avg:** Displays (in ppm) the Time Weighted Average (TWA) or the Average since the start of the measurement. The average is recalculated every minute.

- **STEL:** Displays the Short Term Exposure Limit.

- **PEAK:** Displays (in ppm) the highest instantaneous reading since the start of the measurement. If **[Y/+]** is pressed while the peak reading is displayed, the unit will ask **Reset Peak?**. If **[Y/+]** is pressed again, the peak value will be cleared and the display will return to the **Ready...** message or instantaneous reading. The peak reading is automatically reset when a new measurement is started by pressing **[Y/+]** from the **Ready...** screen.

- **Run time hh:mm:** The duration of the current measurement period.

- **Bat = X.XV:** The current battery voltage.

  Note: A fully charged battery pack should show 4.8 volts or higher. When the battery voltage falls below 4.4 volts, a flashing **"Bat"** will appear as a warning message. At that point, you have 20-30 minutes of run time remaining. When the battery voltage falls below 4.2 volts the monitor turns off automatically.

- **Mm/dd/yy:** The current date.

- **hh:mm:** The current time (24-hour format)

- **T = xxxF:** The internal unit temperature in degrees Fahrenheit. (see Section 4.7.13 to change temperature units)
- **Log on/Off?:** Allows the user to start datalogging of the current measurement. A superscript "L" flashes in the ppm measurement display when datalogging is on. This screen is not shown when datalogging is disabled or when the monitor is not operating in manual start/stop mode.
- **PC Comm?:** This function enables the user to upload data from the MiniRAE 2000 to a Personal Computer (PC) or send/receive configuration information between a PC and the MiniRAE 2000. Press **[MODE]** to return to **Ready...** .

  To communicate with a PC, connect the monitor to the serial port of a PC and start the MiniRAE 2000 application software. Press the **[Y/+]** button and the LCD displays **"pause monitor, ok?"** Press the **[Y/+]** button one more time, and the display shows **"Comm..."** The monitor is now ready to receive commands from the PC.
- **Survey:** This function displays the Current Operating Mode (**Survey** or **Hygiene**).

Taking a Measurement

There are two ways to start a measurement.

1. Operating in Hygiene mode.
2. Manually start and stop measurement in Survey mode.

To start a measurement in Hygiene mode, please refer to Section 4.7.1, "**Change Operation Mode**". To start a measurement in Survey Mode, the MiniRAE 2000 monitor must first be in the "Ready..." mode. This is the mode to which the monitor normally powers up.

Measurement phases

1. Ready
2. Start measurement
3. Measurement display and datalogging
4. Stop measurement

Ready

The display reads **Ready...** indicating the unit is ready to start a measurement.

Start Measurement

Press the **[Y/+]** button to start the check cycle (see above), and then the measurement cycle.

After completing the **Check** cycle, the display will show the **Site ID** and then the **Gas** selected for measurement. The pump will start and the reading will be displayed. The **Peak** and **Average** values will be automatically reset to zero.

Measurement Display and Datalog

Instantaneous readings of the gas concentration in parts per million (ppm) are updated every second. A flashing superscript **L** is displayed when datalogging is on. Datalog information is saved only after one full datalog period is completed.

Stop Measurement

Press the **[MODE]** button and the display shows Stop? Press **[N/-]** to continue measurement and **[Y/+]** to stop the measurement and datalog event. The pump stops automatically when measurement is stopped. Peak and average values for the current measurement can be read in idle mode until a new measurement is started.

Automatic Increment of Site ID

Every time a measurement is taken, the site ID will be incremented by one automatically in Survey mode.

Variable Alarm Signal

In Survey Mode, if the measurement exceeds the low alarm limit, the buzzer and flashing alarm are activated and will beep/flash once per second. The alarms will increase in frequency as the gas concentration approaches the high alarm limit reaching 8 times per second when the high alarm has been exceeded.

Press **[Y/+]** key to clear if latching alarm.

2.4.2 Hygiene Mode

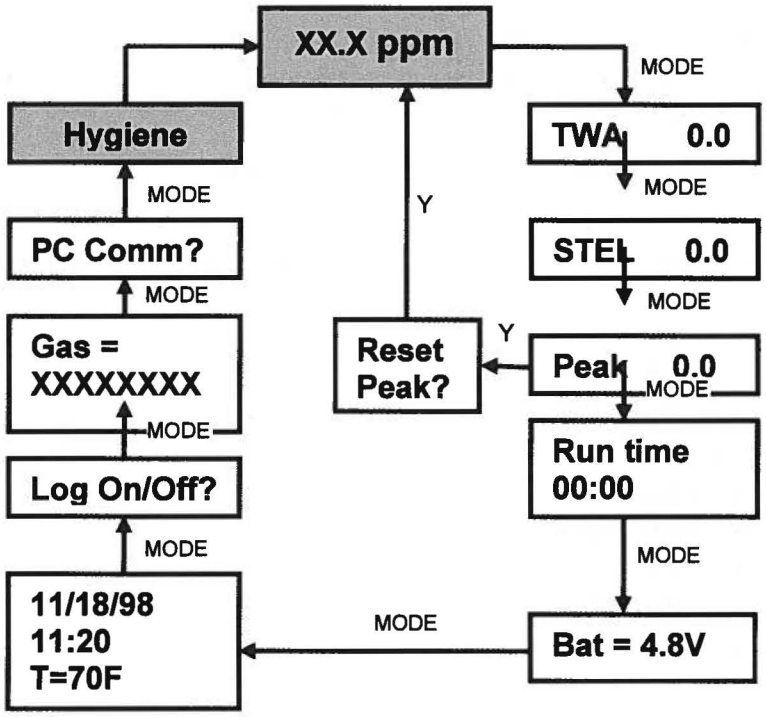
In Hygiene Mode, the unit will continuously taking measurements, once the power is turned on. After the initial start-up sequence displaying the current monitor settings, the LCD displays the instantaneous readings.

The Hygiene operation menu displays include:

- **Real time readings in ppm**
- **Current TWA/Avg, STEL and Peak values (see Section 4.6.6)**
- **Run time**
- **Current battery voltage**
- **Date, time and temperature**
- **Log on/off?**
- **Gas name**
- **PC communication?**
- **Hygiene**

Detailed description of most of these displays are the same as Section 2.4.1.

HYGIENE MODE MAIN MENU



To choose a specific display, press the **[MODE]** key one or more times until the desired display appears, or the **[Y/+]** key where indicated with a Y.

Note: To get back to instantaneous reading from any of the above display, press **[MODE]** key repeatedly until the "XX.X ppm" display appears.

2.5 Alarm Signals

During each measurement period, the gas concentration is compared with the programmed alarm limits (gas concentration alarm limit settings: Low, High, TWA and STEL). If the concentration exceeds any of the preset limits, the loud buzzer and red flashing LED are activated immediately to warn the user of the alarm condition.

In addition, the MiniRAE 2000 will alarm if one of the following conditions occurs: battery voltage falls below a pre-set voltage level (4.4 V), failure of UV lamp, pump stall, or when the datalog memory is full. When the low battery alarm occurs, there will be approximately 20-30 minutes of operating time remaining. When the battery voltage falls below 4.2 V, the monitor will turn off automatically.

Alarm Signal Summary:

Condition	Alarm Signal
Gas exceeds "High Alarm" limit	3 beeps/flashes per second
Gas exceeds "Low Alarm" limit	2 beeps/flashes per second
Gas exceeds "TWA" limit	1 Beeps/flashes per seconds
Gas exceeds "STEL" limit	1 Beeps/flashes per seconds
Pump failure	3 beeps/flashes per second plus "Pump" message on LCD
PID lamp failure	3 beeps/flashes per second plus "Lamp" message on LCD
Low battery	1 flash per second, 1 beep per minute plus "Bat" message on LCD
Memory full	1 flash per second plus "Mem" message on LCD

Alarm Signal Testing:

Under normal non-alarm conditions, it is possible to test the MiniRAE 2000 LED and buzzer in Special Diagnostic Mode (see Section 8 for details).

2.6 Preset Alarm Limits and Calibration

The MiniRAE 2000 portable VOC monitor is factory calibrated with standard calibration gas, and is programmed with default alarm limits. There are 102 gas settings stored in the library. Some examples of calibration and alarm limits are shown below. Refer to Section 4 on programming procedures for selecting a different gas, perform a calibration or set new alarm limits.

Factory Calibration and Preset Alarm Limits

Cal Gas	Cal Span	unit	Low	High	TWA	STEL
Isobutylene	100	ppm	50	100	100	250
Hexane, n-	100	ppm	500	750	500	750
Xylene, m-	100	ppm	100	150	100	150
Benzene	5	ppm	2	5	5	2
Styrene	50	ppm	20	40	20	40
Toluene	100	ppm	50	100	50	100
Vinyl Chloride	10	ppm	5	10	5	10
Custom	100	ppm	50	100	50	100

2.7 Integrated Sampling Pump

The MiniRAE 2000 portable VOC monitor includes an integrated sampling pump. This is a diaphragm type pump that provides a 500-600 cc per minute flow rate. Connecting a Teflon or metal tubing with 1/8 inch inside diameter to the gas inlet port of the MiniRAE 2000, this pump can pull in air samples from 200 feet away horizontally, or 90 feet vertically, at about 3 feet per second flow speed.

The pump turns on when a measurement is started, and turns off when the sample is manually stopped in Survey mode or when the unit is turned off from Hygiene Mode.

If liquid or other objects are pulled into the inlet port filter, the monitor will detect the obstruction and shut down the pump immediately. The alarm will be activated and a flashing error message "Pump" will be also displayed on the LCD display.

The user should acknowledge the pump shut off condition by clearing the obstruction and pressing the **[Y/+]** key to re-start the pump.

The pump stall threshold is set in the special Diagnostic Mode (Section 8).

2.8 Back Light

The LCD display is equipped with an LED back light to assist in reading the display under poor lighting conditions. Pressing and holding the **[N/-]** key for one second in normal operation can turn on the backlight. The backlight can be turned off by pressing **[N/-]** a second time. If the **[N/-]** key is not pressed, the back light will be turned off automatically after a pre-programmed time-out period to save power.

In addition, the ambient light is sensed and the back light will be turned on automatically if the ambient light is below a threshold level. The back light is turned off automatically when the ambient light exceeds the threshold level.

See Section 8 for instructions on how to set the light threshold level.

Note: The LED backlight consumes about 20-30% of the total average current, when the instrument is idle or not taking a measurement.

2.9 Datalogging

During datalogging, the MiniRAE 2000 Portable VOC monitor flashes a superscript "L", on the display to indicate that datalogging is enabled. The monitor stores the time stamp, sample number, and measured gas concentration at the end of every sample period (when data logging is enabled). In addition, the following information are stored: user ID, site ID, serial number, last calibration date, and alarm limits. All data are retained (even after the unit is turned off) in non-volatile memory so that it can be down loaded at a later time to a PC.

Datalogging event

When Datalogging is enabled, measurement readings are being saved. These data are stored in "groups" or "events. A new event is created and stored each time the monitor is turned on, or a configuration parameter is changed, or datalogging is interrupted (e.g. Communication with PC during Hygiene mode). Information, such as start time, user ID, site ID, gas name, serial number, last calibration date, and alarm limits will be recorded.

Datalogging sample

After an event is recorded, the unit records a shorter form of the data. This data contains: the sample number, time (hour/minute) and gas concentration.

3. OPERATION OF ACCESSORIES

The accessories for the MiniRAE 2000 include:

- An AC Adapter (Battery Charger)
- Alkaline battery holder
- Water Trap Filter

Optional Accessories:

- Dilution Fitting
- Calibration adapter
- Calibration regulator and Flow controller
- Organic Vapor Zeroing kit

3.1 Standard Kit and Accessories

1) AC Adapter (Battery Charger)

WARNING

To reduce the risk of ignition of hazardous atmospheres, recharge battery only in area known to be non-hazardous. Remove and replace battery only in area known to be non-hazardous.

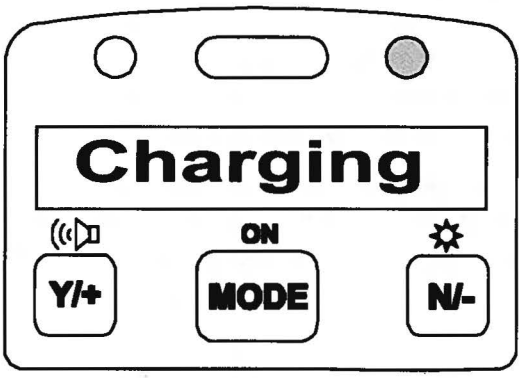
Ne charger les batteries que dans emplacements designés non-dangereuses.

A battery charging circuit is built into the MiniRAE 2000 monitor. It only needs a regular AC to 12 V DC adapter (wall mount transformer) to charge the monitor.

To charge the battery inside the MiniRAE 2000 monitor:

1. Power off the Monitor.
2. Connect the AC adapter (or the optional automotive charging adapter) to the DC jack on the MiniRAE 2000 monitor. If the unit was off, it will automatically turn on.
3. The first message displayed will be "Deep discharge?" The unit will ask this question for three times. If the user wants to discharge the battery pack, affirm this query with the **[Y/+]** key, otherwise the unit will move on to the charge mode directly.

4. While charging, the display message will alternate between "Charging" and "Bat=x.xV" (x.x is the present battery voltage). The LED should be red in color when charging.



5. When the battery is fully charged, the LED will change from red to green and the message "Fully charged" will appear on the display. After the battery is fully charged, the unit will enter the "trickle charge" mode. In which, the red LED will turn on for several seconds every minute, to maintain the full charge.

A completely discharged MiniRAE 2000 monitor will be charged to full capacity within 10 hours. The battery will be drained slowly even if the monitor is turned off. If the monitor has not been charged for 7-10 days, the battery voltage will be low.

The factory-supplied battery is designed to last for 10 hours of normal operation (no alarm, no back light condition), for a new battery under the best condition. As the battery becomes older or is subject to adverse conditions (such as cold ambient temperature), the battery capacity will be reduced significantly.

2) Alkaline Battery Holder

An alkaline battery holder is supplied with each MiniRAE 2000. It accepts four AA size alkaline batteries and can be used in place of the Ni-MH or Ni-Cd battery pack to provide approximately 12-14 hours of operation. The adapter is intended to be used in emergency situations when there is no time to charge the Ni-Cd or Ni-MH battery pack.

To install the adapter, remove the cover of the battery compartment. Remove the Ni-Cd or Ni-MH battery pack from the battery compartment and replace with the alkaline battery adapter. Replace the battery compartment cover.

The internal charging circuit is designed to prevent damage to alkaline batteries and the charging circuit when alkaline batteries are installed inside the monitor.

***Note*:** The AA Alkaline battery adapter supplied by RAE Systems Inc. is intrinsically safe!

3) Water Trap Filter

The water trap filter is made of PTFE (Teflon®) membrane with a 0.45 micron pore size to prevent water from being sucked into the sensor manifold, which would cause extensive damage to the monitor. It will also remove any dust and other particles from entering the monitor and prolong the operating life of the sensor. To install the water trap, simply insert it to the front of the inlet tube of the MiniRAE 2000 monitor.

3.2 Optional Accessories

1) Dilution Fitting

The user may wish to install a dilution fitting on the inlet to dilute the gas samples. One application for a dilution fitting is to measure organic gas when the concentration exceeds the upper limit of the sensor range.

Make sure to set the dilution ratio in the programming mode (see Section 4.7.9) so that the correct gas reading will be displayed when the dilution fitting is used.

WARNING: To use a dilution fitting, the user must have the monitor located in a clean atmosphere outside the confined space and use a remote access probe or Tygon tubing to measure the gas concentration inside the confined space.

2) Calibration Adapter

The calibration adapter for the MiniRAE 2000 is a simple 6-inch Tygon tubing with a metal adapter on one end. During calibration, simply insert the metal adapter into the regular gas inlet probe of the MiniRAE 2000 and the tubing to the gas regulator on the gas bottle.

3) Calibration Regulator and Flow Controller

The Calibration Regulator and Flow controller is used in the calibration process. It regulates the gas flow rate from the Span gas cylinder into the gas inlet of the MiniRAE 2000 monitor during calibration process. The maximum flow rate allowed by the flow controller is about 0.5L/min (500 cc per min.). Alternatively, a Demand-flow Regulator or a Tedlar gas bag may be used to match the pump flow precisely.

4) Organic Vapor Zeroing kit (Charcoal filter)

The Organic Vapor Zeroing Kit is used for filtering organic air contaminants that may affect the zero calibration reading. To use the Organic Vapor Zeroing Kit, simply connect the filter to the inlet port of the MiniRAE 2000.

4. PROGRAMMING OF MINIRAE 2000

The MiniRAE 2000 Monitor is built with a microcomputer to provide programming flexibility. Authorized users can re-calibrate the monitor, change the alarm limits, change site ID, user ID, lamp type, and real time clock, etc.

Programming is menu-driven to provide intuitive end-user operation. The display shows the menu options and the key pad used for menu selection and data entry.

4.1 Programming Mode

The programming mode allows the users to change the setups in the monitor, calibrate the monitor, modify the sensor configuration and enter user information, etc. The programming mode has four menu items. Each menu item includes several sub-menus to perform additional programming functions. Appendix A shows a more detailed menu tree structure.

Programming Menu

Calibrate/Select Gas?

Change Alarm Limits?

Change Datalog?

Change Monitor Setup?

Once inside the programming mode, the LCD will display the first menu. Each subsequent menu item can be viewed by pressing the **[N/-]** repeatedly until the desired menu is displayed. To enter the sub-menu of a particular menu, press **[Y/+]** key, the sub-menu will be displayed.

Return to Operation mode: To exit the programming mode and return to operation, press the **[MODE]** key once at any of the programming menu displays.

4.2 Keys for Programming Mode

The three keys perform a different set of functions during the programming mode as summarized below.

Key	Function in Programming Mode
[MODE]:	Exit menu when pressed momentarily or exit data entry mode when pressed and held for 1 second
[Y/+]:	Increase alphanumerical value for data entry or confirm (yes) for a question
[N/-]:	Decrease alphanumerical value for data entry or deny (no) for a question

4.3 Entering into Programming Mode

1. Turn on the MiniRAE 2000 monitor and wait for the **"Ready.."** message or the instantaneous reading display **"0.0 ppm"** message displayed.
2. Press and hold down both **[N/-]** and **[MODE]** keys for three seconds to enter programming mode. This delay is to prevent the user from entering programming mode by accident.
3. The first menu item "Calibrate/select Gas?" will be displayed.
4. Release both **[MODE]** and **[N/-]** keys simultaneously to start the programming mode
5. Press **[N/-]** key to scroll to the next menu item of the programming menu. Press **[Y/+]** key to select the displayed menu item.

The following Sections 4.4 - 4.7 describe the details of each menu options.

4.4 Calibrate and Select Gas

WARNINGS

The calibration of all newly purchased RAE Systems instruments should be tested by exposing the sensor(s) to known concentration calibration gas before the instrument is put into service for the first time.

For maximum safety, the accuracy of the MiniRAE 2000 should be checked by exposing it to known concentration calibration gas before each day's use.

In the first menu of the programming mode, the user can perform functions such as calibration of the MiniRAE 2000 Monitor, select default cal memories, and modify cal memories (see Table 4.4).

Table 4.4

Calibrate/Select Gas Sub-Menu
Fresh Air Cal?
Span Cal?
Select Cal Memory?
Change Span Value?
Modify Cal Memory?
Change Correction Factor?

Calibrating the MiniRAE 2000 monitor is a two-point process using "fresh air " and the standard reference gas (also known as span gas). First a "Fresh air" calibration, which contains no detectable VOC (0.0 ppm), is used to set the zero point for the sensor. Then a standard reference gas that contains a known concentration of a given gas is used to set the second point of reference.

Note: The span value must be set prior to calibrating for fresh air or span.

The user can store calibrations for up to 8 different measurement gases. The default gas selections are as follows:

Cal Memory #0.....Isobutylene

Cal Memory #1.....Hexane

Cal Memory #2.....Xylene

Cal Memory #3.....Benzene

Cal Memory #4.....Styrene

Cal Memory #5.....Toluene

Cal Memory #6.....Vinyl Chloride

Cal Memory #7.....Custom?

Memory #0 functions differently than the other 7 memories. For Memory #0, isobutylene is always the calibration gas. When the gas is changed in Memory #0 to one of 100 other preprogrammed chemicals or to a user-defined custom gas, a correction factor is applied to all the readings. During calibration, the unit requests isobutylene gas and displays the isobutylene concentration immediately following calibration, but when the unit is returned to the normal reading mode, it displays the selected gas and applies the correction factor.

The other 7 cal memories require the same calibration gas as the measurement gas. These memories may also be modified to a preprogrammed chemical or to a user-defined custom gas. In the gas library, only the gases that can be detected by the installed UV lamp will actually be displayed. Note that although the correction factor for the new gas will be displayed and can be modified, this factor is not applied when Memories #1-7 are

used. Therefore the factor will not affect the readings in these memories.

Once each of the memories has been calibrated, the user can switch between the calibrated gases by changing the cal memory without the need to recalibrate. Or the user can switch the measurement gas in Memory #0 and the appropriate correction factor will automatically be applied without the need to recalibrate. If the gas is changed in Memories #1-7, it is necessary to recalibrate.

To change a default gas from the list above to a library or custom gas, first go to Select Cal Memory (Section 4.4.3) and then proceed to Modify Cal Memory (Section 4.4.5) to enter the desired gas. If the desired compound does not appear in the preprogrammed library, the user can use the Custom_VOC entry in the library, or the name and correction factor of any of the existing compounds can be changed as described in Section 4.4.5. A list of some 300 correction factors is given in Technical Note 106, available at the website www.raesystems.com.

4.4.1 Fresh Air Calibration

This procedure determines the zero point of the sensor calibration curve. To perform a fresh air calibration, use the calibration adapter to connect the MiniRAE 2000 to a "fresh" air source such as from a cylinder or Tedlar bag (option accessory). The "fresh" air is clean dry air without any organic impurities. If such an air cylinder is not available, any clean ambient air without detectable contaminant or a charcoal filter can be used.

1. The first sub-menu shows: "Fresh air Cal?"
2. Make sure that the MiniRAE 2000 is connected to one of the "fresh" air sources described above.
3. Press the **[Y/+]** key, the display shows "zero in progress" followed by "wait.." and a countdown timer.

After about 15 seconds pause, the display will show the message "update data…zeroed… reading = X.X ppm…" Press any key or wait about 20 seconds, the monitor will return back to "Fresh air Calibration?" submenu.

4.4.2 Span Calibration

This procedure determines the second point of the sensor calibration curve for the sensor. A cylinder of standard reference gas (span gas) fitted with a 500 cc/min. flow-limiting regulator or a flow-matching regulator is the simplest way to perform this procedure. Choose the 500 cc/min. regulator only if the flow rate matches or slightly exceeds the flow rate of the instrument pump. Alternatively, the span gas can first be filled into a Tedlar Bag, or delivered through a demand-flow regulator. Connect the calibration adapter to the inlet port of the MiniRAE 2000 Monitor, and connect the tubing to the regulator or Tedlar bag.

Another alternative is to use a regulator with >500 cc/min flow but allow the excess flow to escape through a T or an open tube. In the latter method, the span gas flows out through an open tube slightly wider than the probe, and the probe is inserted into the calibration tube.

Before executing a span calibration, make sure the span value has been set correctly (see next sub-menu).

1. Make sure the monitor is connected to one of the span gas sources described above.
2. Press the **[Y/+]** key at the "Span Cal?" to start the calibration. The display shows the gas name and the span value of the corresponding gas.
3. The display shows "Apply gas now!" Turn on the valve of the span gas supply.

4. Display shows "wait.... 30" with a count down timer showing the number of remaining seconds while the monitor performs the calibration.
5. To abort the calibration, press any key during the count down. The display shows "Aborted!" and return to "Span Cal?" sub-menu.
6. When the count down timer reaches 0, the display shows the calibrated value.

   Note: The reading should be very close to the span gas value.
7. During calibration, the monitor waits for an increased signal before starting the countdown timer. If a minimal response is not obtained after 35 seconds, the monitor displays "No Gas!" Check the span gas valve is on and for lamp or sensor failure before trying again.
8. The calibration can be started manually by pressing any key while the "Apply gas now!" is displayed.
9. After a span calibration is completed, the display will show the message "Update Data Span Cal Done! Turn Off Gas."
10. Turn off the flow of gas. Disconnect the calibration adapter or Tedlar bag from the MiniRAE 2000 Monitor.
11. Press any key and it returns back to "Span Gas Cal?"

4.4.3 Select Cal Memory

This function allows the user to select one of eight different memories for gas calibration and measurement. For Memories #1-7, the calibration and measurement gas is the same and no correction factor is applied. For Memory #0, the calibration gas is always isobutylene and the measurement gas may be different, in which case the correction factor for that gas is automatically applied. The default gas selections are listed in Section 4.4

1. "Select Cal Memory?" is the third sub-menu item in the Calibration sub-menu. Pressing the **[Y/+]** key, the display will show "Gas =" gas name followed by "Mem # x?"
2. Press **[N/-]** to scroll through all the memory numbers and the gas selections respectively. Press **[Y/+]** to accept the displayed Cal Memory number.
3. After the **[Y/+]** key is pressed, the display shows "Save?" Press **[Y/+]** key to save and proceed. Press **[N/-]** to discard the entry and advance to the next sub-menu.
4. If the gas in a newly selected Cal Memory number is not calibrated, the display shows "CF= x.xx". A correction factor with the value "x.xx" will be applied.
5. If the gas of a newly selected cal memory number has been calibrated previously, the display shows "Last calibrated xx/xx/xx".

4.4.4 Change Span Value

This function allows the user to change the span values of the calibration gases.

1. "Change Span Value?" is the fourth sub-menu item in the Calibration sub-menu
2. Press **[Y/+]**, display shows the gas name and the span value. A cursor will blink at the first digit of the Span value. To modify the span gas value, go to Step 3. Otherwise, press and hold the **[MODE]** key for 1 second to accept the previously stored span gas value and move to the next sub-menu.
3. Starting from the left-most digit of the span gas value, use the **[Y/+]** or **[N/-]** key to change the digit value and press **[MODE]** key momentarily to advance to next digit. Repeat this process until all digits are entered. Press and hold the **[MODE]** for 1 second to exit.
4. The display shows "Save?" To accept the new value, press the **[Y/+]** key. Press the **[N/-]** key or the **[MODE]** key to discard the change and move to the next sub-menu.

4.4.5 Modify Cal Memory

If the current cal memory number selected is not memory 0, users will be prompted whether to modify the settings of the selected cal memory. Press **[Y/+]** to modify the cal memory and **[N/-]** to go to the next sub-menu.

Once **[Y/+]** is pressed the LCD display will show the current memory number, current Gas selected and prompt user for acceptance of current gas selected.

1. Press **[N/-]** to modify the gas selection if desired. Or press **[Y/+]** key to skip the change of gas selection, and proceed to the next sub-menu.
2. After pressing **[N/-]**, display shows "Copy gas from library?" Press **[Y/+]** to accept or **[N/-]** for the next sub-menu, "Enter Custom gas?"
3. In the "Copy gas from library" submenu, use **[Y/+]** and **[N/-]** keys to scroll through the selections in the library. Press **[MODE]** key momentarily to select the gas. The display shows "Save?" Press **[Y/+]** to save or **[N/-]** to discard the changes and proceed to next sub-menu.
4. In the Custom gas sub-menu, the user can enter the gas name. Press the **[Y/+]** or **[N/-]** key to cycle through all 26 letters and 10 numerals. Press the **[MODE]** key momentarily to advance to the next digit. The flashing digit will move to the next digit to the right. Repeat this process until all digits (up to 8 digits) of the custom gas name is entered.

Press and hold the **[MODE]** key for 1 second to exit the name entry mode. The display will show "Save?" Press **[Y/+]** to save the entry, or **[N/-]** to discard the changes.

4.4.6 Change Correction Factor

This function allows the user to change the Correction Factor of the standard calibration gas (only for Cal Memory #0).

1. "Change Correction Factor?" is the sixth sub-menu in the Calibration sub-menu.
2. Press **[Y/+]** key. Display shows the gas name, then the correction factor.

   A cursor blinks at the left-most digit of the correction factor. If user wants to modify the correction factor, go to Step 3. Otherwise, press and hold the **[MODE]** key for 1 second to accept the previously stored correction factor value and return to the first sub-menu of the calibrate/select gas menu.
3. Starting from the left-most digit of the correction factor, use **[Y/+]** or **[N/-]** key to change the digit value and press **[MODE]** key momentarily to advance to the next digit, the cursor will move to the next digit to the right. Repeat this process until all digits are entered. Press and hold the **[MODE]** for 1 second to exit.
4. The display shows "Save?" To confirm the new value, press **[Y/+]** to accept the change. Press **[N/-]** or **[MODE]** to discard the change and return to the first sub-menu, Calibrate and Select Gas.

4.5 Change Alarm Limits

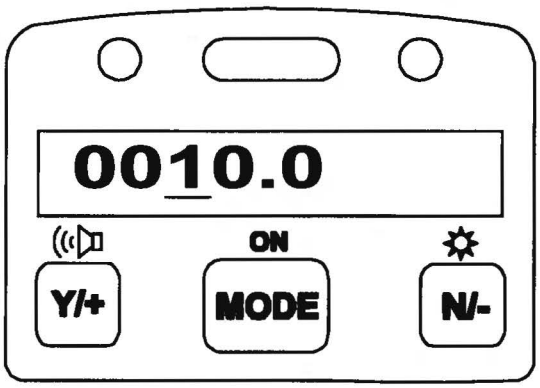
In this menu, the user can change the high and low alarm limits, the STEL limit and the TWA limit (see Table 4.5 below). Press the **[Y/+]** key and the display shows the current gas selected followed by the first sub-menu item below.

Table 4.5

Alarm Limit Sub-Menu
Change High Alarm limit?
Change Low Alarm limit?
Change STEL limit?
Change TWA limit?

1. Scroll through the Alarm Limit sub-menu using the **[N/-]** key until the display shows the desired limit to be changed, e.g.,"High limit?", "STEL limit?", etc.

2. Press the **[Y/+]** key to select the desired limit and the display shows a flashing cursor on the left-most digit of the previously stored alarm limit.



3. To modify this limit value, use the **[Y/+]** or **[N/-]** key to change the digit value and press the **[MODE]** key momentarily to advance to the next digit. The flashing digit will move to the next digit to its right. Repeat this process until the new limit value is entered. Press and hold the **[MODE]** key for 1 second to exit data entry mode.

4. If there is any change to the existing value, the display shows "Save?" Press **[Y/+]** to accept the new value and move to the next sub-menu. Press **[N/-]** to discard the changes and move to the next sub-menu.

4.5.1 Change Low Alarm Limit

The second sub-menu item in the Alarm Limit sub-menu allows the user to change the Low Alarm limit. The LCD displays "Low limit?" To change Low Alarm limit, press **[Y/+]** key, or Press **[N/-]** key advance to next sub-menu in Table 4.5.

1. Press **[Y/+]** and the display will show a flashing cursor on the left-most digit of the previously stored Low alarm limit.
2. To modify this limit value, use the **[Y/+]** or **[N/-]** key to change the digit value and press the **[MODE]** key momentarily to advance to the next digit. The flashing digit will move to the next digit to its right. Repeat this process until the new limit values is entered. Press and hold the **[MODE]** key for 1 second to exit data entry mode.
3. If there is any change to the existing value, the display shows "Save?" Press **[Y/+]** to accept the new value and move to the next sub-menu. Press **[N/-]** to discard the changes and move to the next sub-menu.

4.5.2 Change STEL Limit

This sub-menu item allows the user to change the STEL limit. The display shows "STEL limit?"

1. Press the **[Y/+]** key and the display will show a flashing cursor on the left-most digit of the previously stored STEL limit.
2. To modify this limit value, use the **[Y/+]** or **[N/-]** key to change the digit value and press the **[MODE]** key momentarily to advance to the next digit. The flashing digit will move on to next digit to its right. Repeat this process until the new limit values is entered. Press and hold the **[MODE]** key for 1 second to exit data entry mode.
3. If there is any change to the existing value, the display shows "Save?" Press **[Y/+]** to accept the new value and move to the next sub-menu. Press **[N/-]** to discard the changes and move to the next sub-menu.

4.5.3 Change TWA Limit

This sub-menu item allows the user to change the TWA limit. The LCD displays "TWA limit?"

1. Press **[Y/+]** and the display will show a flashing cursor on the left-most digit of the previously stored TWA limit.
2. To modify this limit value, use the **[Y/+]** or **[N/-]** key to change the digit value and press the **[MODE]** key momentarily to advance to the next digit. The flashing digit will move on to next digit to its right. Repeat this process until the new limit values is entered. Press and hold the **[MODE]** key for 1 second to exit data entry mode.
3. If there is any change to the existing value, the display shows "Save?" Press **[Y/+]** to accept the new value and move to the next sub-menu. Press **[N/-]** to discard the changes and move to the next sub-menu.

4.6 Change Datalog

The MiniRAE 2000 monitor calculates and stores the concentration and ID of each sample taken. In the datalog sub-menu, a user can perform the tasks and functions shown below.

Datalog Sub-Menu

Reset Peak/Minimum?

Clear Data?

Change Data Period?

Change Average Type?

4.6.1 Reset Peak

This function will reset the peak and minimum stored in the data memory. Note: this function will not clear the STEL or TWA data.

1. "Reset Peak?" is the first sub-menu item in the Datalog sub-menu (Table 4.6).
2. Press the **[Y/+]** key to reset the Peak/Minimum Values. The display shows "Are You Sure?"
3. Pressing the **[Y/+]** key again will reset the values. The display shows "Peak/Minimum Cleared" and moves to the next submenu.
4. Press the **[N/-]** or **[MODE]** key to exit without resetting the values and move to the next sub-menu.

4.6.2 Clear Data

This function will erase all data stored in the non-volatile datalog memory. Note: This function does not change STEL, TWA, Peak, Minimum and run time values, which are stored in the regular data memory.

1. "Clear Data?" is the third sub-menu item in the Datalog sub-menu.
2. Press the **[Y/+]** key to clear the datalog memory. The display shows "Are you sure?"
3. Press the **[Y/+]** key again to confirm erasure of all the datalog memory.
4. Press the **[N/-]** or **[MODE]** key to exit without clearing the datalog memory and move to the next datalog sub-menu.

4.6.3 Change Data Period

The datalog period can be programmed from 1 to 3,600 seconds (1 hour).

1. "Change Data Period?" is the fifth sub-menu item in the Datalog sub-menu.
2. Press the **[Y/+]** key and the display shows "Datalog Period = XXXX" with the left-most digit flashing, where "XXXX" is the previously stored data log period.
4. To modify this period, starting from the left-most digit, use the **[Y/+]** or **[N/-]** key to change the digit value and press the **[MODE]** key momentarily to advance to the next digit. The flashing digit will move to the next digit to the right. Repeat this process until all 4 digits of the new period are entered. Press and hold the **[MODE]** key for 1 second to exit data entry mode.
5. If there is any change to the existing value, the display will show "Save?" Press **[Y/+]** to accept the new value or **[N/-]** to discard the changes and move to the next sub-menu.

4.6.4 Change Average Type

The user can select either an 8-hour Time Weighted Average (TWA) or a running Average. The running average is simply the average of all instantaneous (1-second) readings since the measurement was started. This average may increase or decrease with time depending on the readings. The TWA is a cumulative value used to estimate the fraction of the 8-hour limit to which the user has been exposed since the start of the measurement. This value can only increase or remain constant, never decrease. Refer to Technical Note 119 for more information on how TWA is calculated.

1. "Change Average Type?" is the sixth sub-menu in the Datalog sub-menu.
2. Press the **[Y/+]** key to enter the function.
3. The display will show "Running Average?" or " Time Weighted Average?" depending on the current average type.
4. Press **[N/-]** key to toggle between the average types. Press **[Y/+]** key to select the displayed average type.
5. If there is any change to the existing setting, the display shows "Save?" Press **[Y/+]** to save the change. Press **[N/-]** or **[MODE]** to discard the change and return to the first sub-menu.

4.7 Change Monitor Setup

Several monitor specific variables can be changed in this menu. The following is a list of configuration data that can be modified by the user.

Monitor Setup Sub-Menu	Diagnostic Mode
Change Operation Mode?	"
Change Site ID?	Change Unit ID?
Change User ID?	Change Host ID?
Change Alarm Mode?	"
Change User Mode?	"
Change Date?	"
Change Time?	"
Change Lamp?	"
Change Pump Duty Cycle?	"
Change Unit?	"
Change Dilution Ratio?	"
Change Output?	"
Change DAC Range?	"
Set Temperature Unit?	"

4.7.1 Change Operation Mode

MiniRAE 2000 supports two operation modes: Survey and Hygiene mode.

Survey mode: Manual start/stop of measurements and display of certain exposure values.

Hygiene mode: Automatic measurements, running and datalogging continuously and calculates additional exposure values.

1. "Change Op Mode?" is the first sub-menu item in the Monitor Setup menu (Table 4.7).
2. Press the **[Y/+]** key and the display shows the current user mode: "Op Mode = *current mode*?"
3. Press the **[Y/+]** key to accept the currently displayed operation (Op) mode. Press **[N/-]** to toggle to the other operation mode. Press **[MODE]** to exit this sub-menu and move to the next monitor setup sub-menu.
4. When changing Op mode from Hygiene to Survey, the display shows the additional message "Warning! Exit Hygiene?" to prevent accidental exit from Hygiene mode. Press the **[Y/+]** key to acknowledge.
5. If there is any change to the existing setting, the display will show "Save?" Press the **[Y/+]** key to accept or the **[N/-]** key to discard and move to the next sub-menu.

Note: If a new Op Mode is saved, the display shows "Op Mode changed!!" when exiting the programming mode.

4.7.2 Change Site ID

The user can enter an 8-digit alphanumeric site ID in the programming mode. This site ID will be included in the datalog report.

1. "Change Site ID?" is the second sub-menu item in the Monitor Setup menu (Table 4.7).
2. Press the **[Y/+]** key and the display shows the current site ID: "Site ID = xxxxxxx" with the left most digit flashing.
3. Press the **[Y/+]** or **[N/-]** key to cycle through all 26 letters and 10 numerals. Press **[MODE]** momentarily to advance to the next digit. The flashing digit will move to the next digit to the right. Repeat this process until all 8 digits of the new site ID are entered.
4. Press and hold the **[MODE]** key for 1 second to exit the data entry mode.
5. If there is any change to the existing site ID, the display shows "Save?" Press the **[Y/+]** key to accept the new site ID. Press the **[N/-]** key to discard the change and move to the next sub-menu.

4.7.3 Change User ID

The user can enter an 8-digit alphanumeric user ID in the programming mode. This user ID will be included in the datalog report.

1. "Change User ID?" is the third sub-menu item the Monitor Setup menu.
2. Press the **[Y/+]** key and the display shows the current user ID: "User ID = xxxxxxxx" with the left most digit flashing.
3. Press the **[Y/+]** or **[N/-]** key to cycle through all 26 letters and 10 numerals. Press **[MODE]** momentarily to advance to the next digit. The flashing digit will move to the next digit to the right. Repeat this process until all 8 digits of the new user ID are entered.
4. Press and hold the **[MODE]** key for 1 second to exit the data entry mode.
5. If there is any change to the existing user ID, the display shows "Save?" Press the **[Y/+]** key to accept the new user ID. Or press the **[N/-]** key to discard the changes and move to the next sub-menu.

4.7.4 Change Alarm Mode?

There are two different alarm modes: **Latched** and **Automatic Reset** (Auto Reset) in the MiniRAE 2000 that can be selected from the programming menu.

1. "Change Alarm Mode?" is the fourth sub-menu item in the Monitor Setup menu.
2. Press the **[Y/+]** key; the display shows the current alarm mode.
3. Press the **[Y/+]** key to accept the currently displayed alarm mode. Press **[N/-]** key to toggle to the other alarm mode. Press **[MODE]** to exit this sub-menu and move to the next monitor setup sub-menu.
4. If there is any change to the existing setting, the display will show "Save?" Press **[Y/+]** to save the change. Press **[N/-]** or **[MODE]** to discard the change and move to the next sub-menu.

4.7.5 Change User Mode

There are two different user modes: **Display** and **Program** that can be selected from the programming menu.

1. "Change User Mode?" is the fifth sub-menu item in the Monitor Setup menu (Table 4.7).
2. Press the **[Y/+]** key; the display shows the current user mode selected.
3. Press the **[Y/+]** key to accept the currently displayed user mode. Press **[N/-]** key to toggle to the alternate user modes. Press **[MODE]** to exit this sub-menu and move to the next monitor setup sub-menu.
4. If there is any change to the existing selection, the display shows messages "Program change" and "Are you sure?" Press **[Y/+]** to confirm the change or press **[N/-]** or **[MODE]** to discard the changes and move to the next sub-menu.

CAUTION: If the user mode is changed to **Display** mode, the user can no longer enter the programming mode. Therefore, the user can not change the user mode back to **Program** mode in normal mode.

To restore the user mode back to **Program** mode, turn the unit off and back on in Diagnostic Mode. Next enter Program mode by holding the **[MODE] and [N/-]** keys for three seconds. Enter the password at the prompt (the default is 0000). Once program mode is entered, go to the "Change Monitor Setup" / "Change User Mode" and change the mode back to **Program.**

An alternative way to change Display mode back to Program mode is through the PC and the ProRAE-Suite software.

4.7.6 Change Date

The MiniRAE 2000 monitor is equipped with a real time clock (RTC). The user can enter the correct date and time (see 4.7.7) for the real time clock.

1. "Change Date?" is the sixth sub-menu item in the Monitor Setup menu.
2. Press **[Y/+]** and the display shows the current date "mm / dd / yy" with the left most digit of the date flashing.
5. To modify this value, use the **[Y/+]** or **[N/-]** key to change the digit value and press the **[MODE]** key momentarily to advance to the next digit. The flashing digit will move on to next digit to its right. Repeat this process until the new date and time values are entered. Press and hold the **[MODE]** key for 1 second to exit data entry mode.
4. If there is any change to the existing value, the display shows "Save?" Press **[Y/+]** to confirm the new value or press **[N/-]** or **[MODE]** to discard the changes and move to the next sub-menu.

4.7.7 Change Time

To change the time in the RTC of the MiniRAE 2000:

1. "Change Time?" is the seventh sub-menu item in the Monitor Setup menu.
2. Press **[Y/+]** and the display shows the current time in the 24-hour format "hh : mm" with the left most digit of the time flashing.
3. To modify this value, use the **[Y/+]** or **[N/-]** key to change the digit value and press the **[MODE]** key momentarily to advance to the next digit. The flashing digit will move on to next digit to its right. Repeat this process until the new date and time values are entered. Press and hold the **[MODE]** key for 1 second to exit data entry mode.
4. If there is any change to the existing value, the display shows "Save?" Press **[Y/+]** to confirm the new value or press **[N/-]** or **[MODE]** to discard the changes and move to the next sub-menu.

4.7.8 Change Lamp

There are three UV lamps with different photon energies available for the PID sensor: **9.8 eV, 10.6 eV** and **11.7 eV**. The user can select any one of the lamps from the programming mode.

1. "Change Lamp Type?" is the eighth sub-menu item in the Monitor Setup menu (Table 4.7).
2. Press the **[Y/+]** key; the display shows the current PID lamp selection.
3. Press the **[Y/+]** key to accept the currently displayed lamp. Press **[N/-]** key to scroll through the sub-menu for other lamp selections. Press **[MODE]** to exit this sub-menu and return to the next sub-menu in Table 4.7.
4. If there is any change to the existing selection, the display will show "Save?" Press **[Y/+]** to save the new selection or press **[N/-]** or **[MODE]** to discard the change and return to the next sub-menu in Table 4.7.

4.7.9 Change Unit

User can change the display and datalog unit from parts per million (ppm) to milli-gram per cubic meter (mg/m^3).

1. "Change Unit?" is the ninth sub-menu item in the Monitor Setup sub-menu.
2. Press the **[Y/+]** key, the display should show the current unit "Display Unit = ppm?" or "Display Unit = mg?"
3. Press **[Y/+]** key to accept the currently displayed unit. Press **[N/-]** key to toggle to the other unit. Press **[MODE]** key to exit this sub-menu.
4. If there is any change to the existing selection, press **[Y/+]** to confirm the new selection or press **[N/-]** or **[MODE]** to discard the changes and move to the next sub-menu.

Caution:

1. **The correction factor in the gas library is calculated based on "ppm" unit. If "mg" unit is selected, the built-in correction factor library is not valid.**
2. **No automatic conversion between "ppm" and "mg/m^3" reading is performed by the monitor.**
3. **When the unit name is changed from "ppm" to "mg", the unit must be recalibrated with the span gas concentration entered in mg/m^3. The converse rule applies when the unit is changed from "mg" to "ppm".**

4.7.10 Change Dilution Ratio

If a dilution system is used upstream of the MiniRAE 2000 inlet port, the user can enter the dilution ratio (from 1 to 10) to compensate the readings. The unit will then display the actual concentration of the gas before dilution. The dilution ratio should be 1 in normal operation where no dilution gas is applied to the sample gas. Dilution improves accuracy and linearity when the concentrations are above a few thousand ppm.

1. "Change Dilution Ratio?" is the tenth sub-menu item in the Monitor Setup menu.
2. Press the **[Y/+]** key; the display shows the current dilution ratio: "Dilution Ratio = xx" with the left most digit flashing.
3. Press the **[Y/+]** or **[N/-]** key to increase or decrease the value of the digit. Press **[MODE]** momentarily to advance to the next digit. The flashing digit will move to the next digit to the right. Repeat this process until both digits of the new dilution ratio are entered.
4. Press and hold the **[MODE]** key for 1 second to exit the data entry mode and move to the next sub-menu.
5. If there is any change to the existing dilution ratio, the display shows "Save?" Press **[Y/+]** to confirm the new value or press **[N/-]** or **[MODE]** to discard the changes and move to the next sub-menu.

4.7.11 Change Output?

There are two different external output options: DAC (Analog output) and Alarm in the MiniRAE 2000 that can be selected from the programming menu. The alarm output can be used to connect to the optional vibration alarm (vibrator) only. The analog output, which is proportional to the gas concentration, can be connected a chart recorder or can be queried by a computer to download data in real time (see Technical Note 141).

1. "Change External Output?" is the eleventh sub-menu item in the Monitor Setup menu.
2. Press the **[Y/+]** key and the display shows the current output option selection: "Output = DAC?"
3. Press the **[Y/+]** key to accept the currently displayed output option. Press **[N/-]** to change to the other external option: "Output = Alarm?" Press **[MODE]** to exit this sub-menu and move to the next monitor setup sub-menu.
4. If there is any change to the existing selection the display will show "Save?" Then, press **[Y/+]** to save the change, press **[N/-]** to go back to Step 2, or press **[MODE]** to exit this sub-menu and move to the next monitor setup sub-menu.

4.7.12 Change DAC Range?

There are four different DAC (Digital-to-Analog Conversion) range values available in the **MiniRAE 2000: 20, 200, 2000** and **10K ppm**. The maximum 2.5V DC analog signal output from the unit will represent the range value chosen. (See for analog signal output connection.)

1. "Change DAC Range?" is the twelfth sub-menu item in the Monitor Setup menu.
2. Press the **[Y/+]** key, the display shows the current DAC Range value: "DAC Range = 2000 ppm?"
3. Press the **[Y/+]** key to accept the currently displayed value. Press **[N/-]** to scroll through the sub-menu for other range values. Press **[MODE]** to exit this sub-menu and return to the first sub-menu in Table 4.7.
4. If there is any change to the existing selection, press the **[Y/+]** key and the display will show "Save?" Press the **[Y/+]** key to save the change or press the **[N/-]** key to discard and return to the first sub-menu in Table 4.7.

4.7.13 Set Temperature Unit?

The temperature display can be switched between Fahrenheit and Celsius units.

1. "Set Temperature Unit?" is the thirteenth sub-menu item in the Monitor Setup menu.
2. Press the **[Y/+]** key, and the display shows the current setting: "Temperature Unit = Fahrenheit?"
3. Press the **[Y/+]** key to accept the currently displayed value. Press **[N/-]** to select the sub-menu "Temperature Unit = Celsius?" Press **[MODE]** to exit this sub-menu and return to the first sub-menu in Table 4.7.
4. If there is any change to the existing selection, press the **[Y/+]** key and the display will show "Save?" Press the **[Y/+]** key to save the change and return to the first sub-menu in Table 4.7 or press the **[N/-]** key to discard and return to Step 3..

4.8 Exit Programming Mode

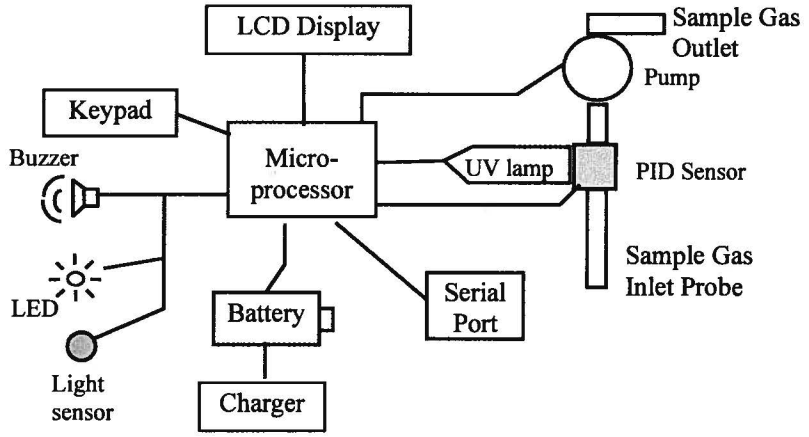
1. To exit programming mode from the first tier menu level, press the **[MODE]** key once.
2. To exit programming mode from 2nd tier sub-menu, press the **[MODE]** key twice.
3. To return to programming mode, press and hold down both the **[MODE]** and **[N/-]** keys for 3 seconds.

5. THEORY OF OPERATION

The MiniRAE 2000 monitor uses a newly developed electrodeless discharge UV lamp as the high-energy photon source for the PID. As organic vapors pass by the lamp, they are photo-ionized and the ejected electrons are detected as a current. The PID sensor with a standard 10.6 eV lamp detects a broad range of organic vapors. A lamp with high photon energy (e.g. 11.7 eV) will measure the more kinds of compounds, whereas low photon energies (e.g. 9.8 eV) are selective for easily ionizable compounds such as aromatics. In principle, any compound with an ionization energy lower than that of the lamp photons can be measured.

The PID sensor for the MiniRAE 2000 monitor is constructed as a small cavity in front of the UV lamp. A diaphragm pump draws the gas sample into the sensor and then pumps it out through the side of the instrument.

Figure 5-1 MiniRAE 2000 Block Diagram



A single chip microcomputer is used to control the operation of the alarm buzzer, LED, pump and light sensor. It measures the sensor readings and calculates the gas concentrations based on calibration to known standard gases. The data are stored in non-volatile memory so that they can be sent to a PC for record keeping. RS-232 transceivers provide a serial interface between the monitor and the serial port of a PC. An LCD display consisting of a single row of eight alpha/numeric characters is used to display the readings. The user interacts with the monitor through three keys on the front panel keypad.

A rechargeable NiMH, NiCd battery, or an alkaline battery pack powers the monitor.

6. MAINTENANCE

The major maintenance items of the MiniRAE 2000 are:

- Battery pack
- Sensor module
- PID lamp
- Sampling pump
- Inlet connectors and filters

Note: Maintenance should be performed by qualified personnel only.

NOTE: The printed circuit board of the monitor is connected to the battery pack even if the power is turned off. Therefore, it is very important to disconnect the battery pack before servicing or replacing any components inside the monitor. Severe damage to the printed circuit board or battery may occur if the battery pack is not disconnected before servicing the unit.

6.1 Battery Charging and Replacement

When the display shows a flashing message "Bat", the battery requires recharging (see Section 3.1 for Battery charging). It is recommended to recharge the MiniRAE 2000 monitor upon returning from fieldwork. A fully charged battery runs a MiniRAE 2000 monitor for 10 hours continuously. The charging time is less than 10 hours for a fully discharged battery. The built-in charging circuit is controlled by the micro-controller to prevent over-charging. The battery may be replaced in the field (in area known to be non-hazardous) if required.

WARNING

To reduce the risk of ignition of hazardous atmospheres, recharge battery only in area known to be non- hazardous. Remove and replace battery only in area known to be non-hazardous.

Replacing Battery Pack

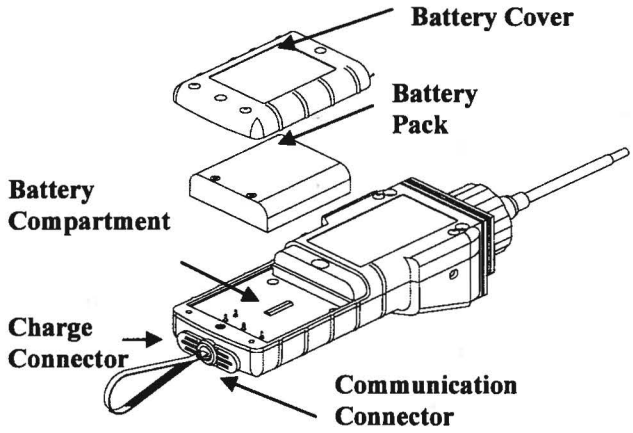


Figure 6-1 Battery Replacement

1.

Turn off the power of the MiniRAE 2000.

2. Unscrew the two battery compartment screws, located on the bottom of the monitor, and remove the cover.
3. Remove the battery pack from the battery compartment.
4. Replace a fully charged spare battery pack inside the battery compartment. Make sure the battery pack is oriented properly inside the compartment
5. Close the battery cover and tighten the two screws.

Replacing Alkaline Battery Adapter

1. Insert four fresh AA size alkaline batteries into the alkaline battery holder. Make sure that the polarity of the batteries is correct.
2. Follow the same procedure as described above to replace the battery holder.

Note: The internal charging circuit is designed to prevent charging to alkaline batteries.

6.2 PID Sensor & Lamp Cleaning/Replacement

The sensor module is made of several components and is attached to the lamp-housing unit as shown in Figure 7-2.

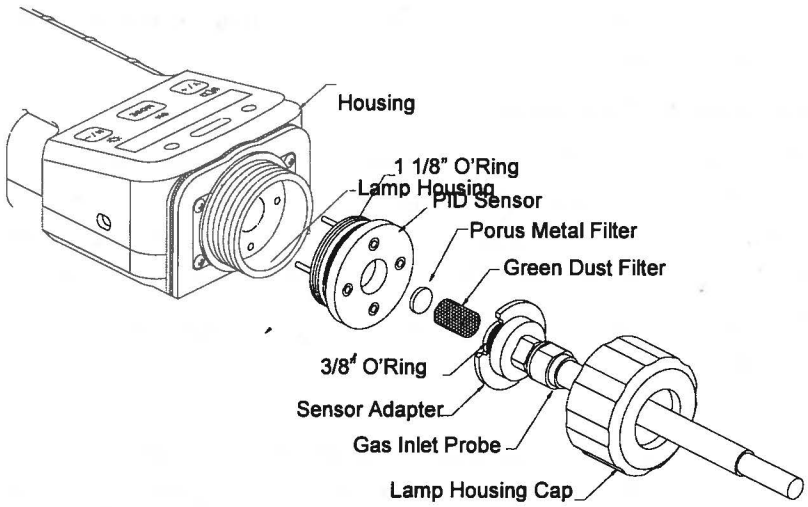


Figure 7-2 Sensor Components

Note: Normally the cleaning procedure is not needed. Clean the PID sensor module, the lamp and the lamp housing only when one of the following happened:

1. The reading is inaccurate even after calibration.
2. The reading is very sensitive to air moisture.
3. A chemical liquid has been sucked into the unit and damaged the unit.

Use of the water trap filter will help prevent contamination and accidentally drawing liquid into the sensor.

To access the sensor components and lamp, gently unscrew the lamp-housing cap, remove the sensor adapter with the gas inlet probe and the metal filter all together. Then hold the PID sensor and pull straight out to avoid bending the electrical pins on the sensor (see Figure 7-2). A slight, gentle rocking motion helps release the sensor.

To clean the PID sensor:

Place the entire PID sensor module into GC grade methanol. It is highly recommended that an ultrasound bath to be used to clean the sensor for at least 15 minutes. Then dry the sensor thoroughly. Never touch the electrodes of the sensor by hand.

Also use a methanol-soaked cotton swab to wipe off the lamp housing where it contacts the sensor when the sensor is installed.

Turn over the sensor so that the pins point up and the sensor cavity is visible. Examine the sensor electrodes for any corrosion, damage, or bending out of alignment. The metal sensor electrode "fingers" should be flat and straight. If necessary, carefully bend the sensor fingers to ensure that they do not touch the Teflon portions and that they are parallel to each other. Make sure that the nuts on the sensor pins are snug but not overtight. If the sensor is corroded or otherwise damaged, it should be replaced.

To clean lamp housing or change the lamp:

To clean lamp housing or change the lamp:

If the lamp does not turn on, the monitor will display an error message to indicate replacement of the lamp may be required.

1. If the lamp is operational, clean the lamp window surface and the lamp housing by wiping it with GC grade methanol using a cotton swab using moderate pressure. After cleaning, hold the lamp up to the light at an angle to detect any remaining film. Repeat the process until the lamp window is clean. Never use water solutions to clean the lamp. Dry the lamp and the lamp housing thoroughly after cleaning.

   CAUTION: Never touch the window surface with the fingers or anything else that may leave a film. Never use acetone or aqueous solutions.

2. If the lamp does not turn on, remove the lamp from the lamp housing. Place the lamp O-ring onto the new lamp. Insert the new lamp, avoiding contact with the flat window surface.
3. Reinstall the PID sensor module.
4. Tighten the Lamp Housing Cap.
5. If the lamp type has been changed, adjust the lamp type setting in the programming mode (Section 4.7.8).

6.3 Sampling Pump

When approaching the end of the specified lifetime of the pump, it will consume higher amount of energy and reduce its sample draw capability significantly. When this occurs, it is necessary to replace or rebuild the pump. When checking the pump flow, make sure that the inlet connector is tight and the inlet tubing is in good condition. Connect a flow meter to the gas inlet probe. The flow rate should be above 450 cc/min when there is no air leakage.

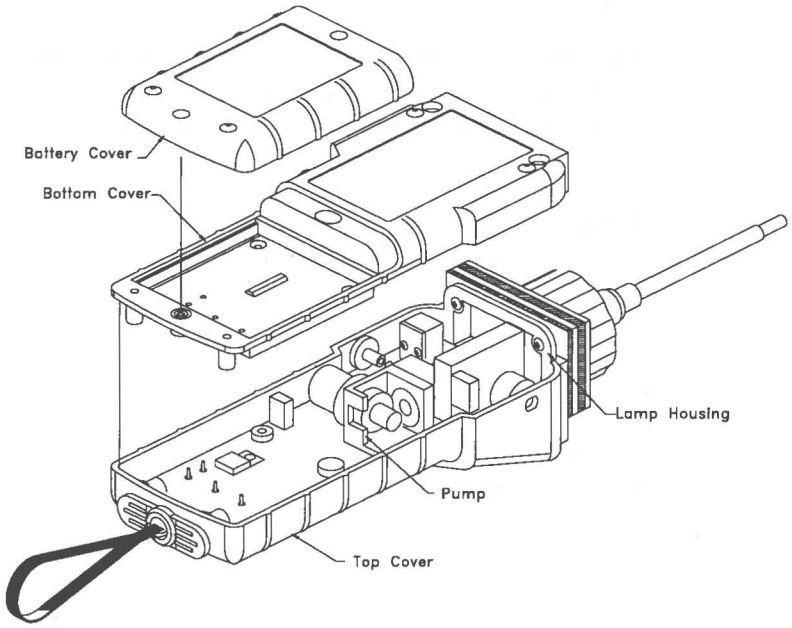


Figure 7-3 Sampling Pump

Pump Replacement

1. Turn off the MiniRAE 2000 power.
2. Open the battery cover, remove the battery pack, and carefully unscrew the six screws to open the bottom cover.
3. Unplug the pump from the PCB. Unscrew the two screws that hold the pump assembly to the PCB. Disconnect the Tygon tubing that connects the pump to the gas inlet port and gas outlet port.
4. Insert a new pump assembly. Connect the Tygon tubing to the gas inlet port. Plug the pump connector back into the PCB and screw down the pump assembly to the board.
5. Replace the bottom cover and tighten the six screws. Reconnect the battery pack. Replace the battery pack and its cover.

6.4 Turning on the UV Lamp

The UV lamp is made of a glass envelope and a UV window (salt crystal) on one end of the envelope. The inside of the lamp is filled with low pressure gases. To turn on the lamp, a high voltage electric field is applied from the outside of the glass envelope. The molecules inside the lamp are ionized and produce a glow discharge that generates the UV light. The MiniRAE 2000 has a built-in sensing mechanism to monitor the status of the UV lamp and display a "Lamp" error message if it is not on.

If the UV lamp has not been used for a long period of time (> 1 month) or is cold, it may become slightly harder to turn on. If such a condition occurs, the "Lamp" message will appear in the monitor display during the power on sequence. This phenomenon is more significant in 0.25" UV lamps used in ToxiRAE and MultiRAE Plus products, because of the relatively small lamp size. To solve this problem, simply turn on and off the monitor a few times and the lamp should turn on. After the UV lamp is turned on for the first time, it should be easier to turn on the UV lamp next time.

It is possible that the UV lamp is actually on when the lamp error message appears. This is because when the lamp becomes old, the internal threshold level to detect lamp failure may have shifted and cause a false alarm. To eliminate such possibility, simply check to see the UV lamp is actually on. This can be done easily by removing the sensor cap and observing the glow light of the UV lamp in a dark place. The user can also feed the monitor with calibration gas and observe if the sensor reading changes. If the reading changes significantly with the gas, the UV lamp is actually on.

A possible failure mechanism for the UV lamp is a leak developed along the seal of the glass envelope. When such condition occurs, the lamp will become very hard or impossible to turn on and will need to be replaced.

7. TROUBLESHOOTING

To aid the user in diagnosing the monitor, a special diagnostic mode can be used displays critical, low level parameters. Section 7.1 describes the operation of the diagnostic mode. Section 7.2 summarizes the frequently encountered problems and suggested solutions. By turning on the MiniRAE 2000 monitor in diagnostic mode and by using the troubleshooting table in Section 7.2, the user can usually correct the problem without having to return the monitor for repair.

WARNING

This function should be used by qualified personnel only! The diagnostic mode allows the user to set several low-level parameters that are very critical to the operation of the monitor. Extra care should be taken when setting these parameters. If the user is not familiar with the function of these parameters and sets them incorrectly, it may cause the monitor to shut down or malfunction.

7.1 Troubleshooting Table

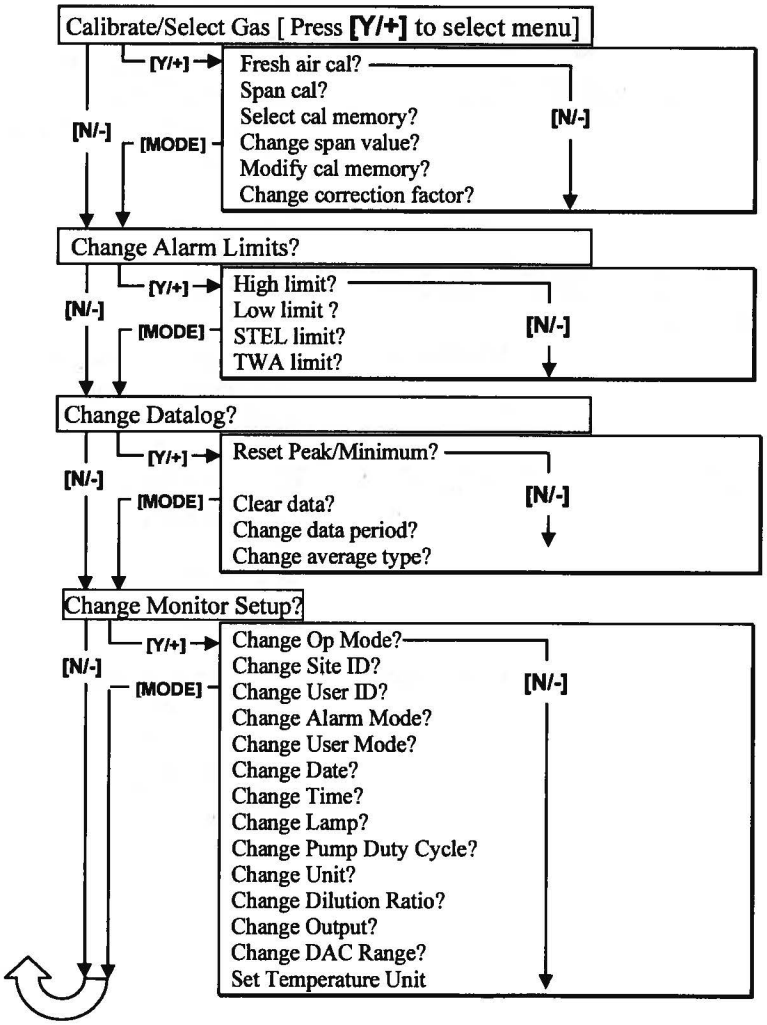
Problem	Possible Reasons & Solutions
Cannot turn on power after charging the battery	**Reasons:** Discharged battery. Defective battery. Microcomputer hang-up. **Solutions:** Charge or replace battery. Disconnect, then connect battery to reset computer.
No LCD back light	**Reasons:** Trigger level too low, the current mode is not user mode, and the mode does not support automatic turn on back light. **Solutions:** Adjust trigger level. Verify the back light can be turned on in user mode. Call authorized service center.
Lost password	**Solutions:** Call Technical Support at +1.408 .752 .0723 or +1. 888 .723 .4800
Reading abnormally High	**Reasons:** Dirty sensor module. Dirty water trap filter. Excessive moisture and water condensation. **Solutions:** Clean sensor module and lamp housing. Replace water trap filter. Blow dry the sensor module.
Buzzer Inoperative	**Reasons:** Bad buzzer. **Solutions:** Call authorized service center.

Inlet flow too low	**Reasons:**	Pump diaphragm damaged or has debris. Flow path leaks.
	Solutions:	Check flow path for leaks; sensor module O-ring, tube connectors, Teflon tube compression fitting. Replace pump or diaphragm.
"Lamp" message during operation	**Reasons:**	Lamp drive circuit. Weak or defective PID lamp, defective.
	Solutions:	Turn the unit off and back on Replace UV lamp
Full scale measurement in humid environment	**Reasons:**	Dirty or wet sensor.
	Solutions:	Clean and dry sensor and lamp housing. Adjust sensor fingers to ensure not touching Teflon. Use water trap filter.
Reading abnormally low	**Reasons:**	Incorrect calibration. Low sensitivity to the specific gas. Weak or dirty lamp. Air leakage.
	Solutions:	Calibrate the monitor. Replace sensor. Clean or replace lamp. Check air leakage.

APPENDIX A. QUICK REFERENCE GUIDE

Press [N/-] and [MODE], simultaneously, for 3 seconds, to enter Programming Mode. Press [MODE] to return to Survey Mode.

PROGRAMMING MODE



RAE Systems, Inc. Contact Information

Main Office:	3775 N. First St. San Jose, CA 95134-1708 USA
Telephone:	408-952-8200
Fax:	408-952-8480
Instrument Sales:	877-723-2878
Email:	RaeSales@raesystems.com
Website:	www.raesystems.com
Technical Service:	888-723-4800 Tech@raesystems.com

Special Note

If the monitor needs to be serviced, contact either:

1. The RAE Systems distributor from whom the monitor was purchased; they will return the monitor on your behalf.
2. The RAE Systems Technical Service Department. Before returning the monitor for service or repair, obtain a Returned Material Authorization (RMA) number for proper tracking of your equipment. This number needs to be on all documentation and posted on the outside of the box in which the monitor is returned for service or upgrade. Packages without RMA Numbers will be refused at the factory.

MiniRAE 3000
User's Guide

Rev. C
August 2010
P/N 059-4020-000

FCC Information

Contains FCC ID: PI4411B

The enclosed device complies with part 15 of the FCC rules. Operation is subject to the following conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation.

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Read Before Operating

This manual must be carefully read by all individuals who have or will have the responsibility of using, maintaining, or servicing this product. The product will perform as designed only if it is used, maintained, and serviced in accordance with the manufacturer's instructions. The user should understand how to set the correct parameters and interpret the obtained results.

CAUTION!

To reduce the risk of electric shock, turn the power off before removing the instrument cover. Disconnect the battery before removing sensor module for service. Never operate the instrument when the cover is removed. Remove instrument cover and sensor module only in an area known to be non-hazardous.

Special Notes

When the instrument is taken out of the transport case and turned on for the first time, there may be some residual organic or inorganic vapor trapped inside the detector chamber. The initial PID sensor reading may indicate a few ppm. Enter an area known to be free of any organic vapor and turn on the instrument. After running for several minutes, the residual vapor in the detector chamber will be cleared and the reading should return to zero.

The battery of the instrument discharges slowly even if it is turned off. If the instrument has not been charged for 5 to 7 days, the battery voltage will be low. Therefore, it is a good practice to always charge the instrument before using it. It is also recommended to fully charge the instrument for *at least 10 hours* before first use. Refer to this User Guide's section on battery charging for more information on battery charging and replacement.

WARNINGS

STATIC HAZARD: Clean only with damp cloth.

For safety reasons, this equipment must be operated and serviced by qualified personnel only. Read and understand instruction manual completely before operating or servicing.

Use only RAE Systems battery packs, part numbers 059-3051-000, 059-3052-000, and 059-3054-000. This instrument has not been tested in an explosive gas/air atmosphere having an oxygen concentration greater than 21%. Substitution of components may impair intrinsic safety. Recharge batteries only in non-hazardous locations.

Do not mix old and new batteries or batteries from different manufacturers.

The calibration of all newly purchased RAE Systems instruments should be tested by exposing the sensor(s) to known concentration calibration gas before the instrument is put into service.

For maximum safety, the accuracy of the instrument should be checked by exposing it to a known concentration calibration gas before each day's use.

Do not use USB/PC communication in hazardous locations.

AVERTISSEMENT

DANGER RISQUE D'ORIGINE ELECTROSTATIQUE: Nettoyer uniquement avec un chiffon humide.

Pour des raisons de sécurité, cet équipment doit être utilisé, entretenu et réparé uniquement par un personnel qualifié. Étudier le manuel d'instructions en entier avant d'utiliser, d'entretenir ou de réparer l'équipement.

Utiliser seulement l'ensemble de batterie RAE Systems, la reference 059-3051-000 au 059-3052-000 au 059-3054-000. Cet instrument n'a pas été essayé dans une atmosphère de gaz/air explosive ayant une concentration d'oxygène plus élevée que 21%. La substitution de composants peut compromettre la sécurité intrinsique. Ne charger les batteries que dans emplacements désignés non-dangereuse.

Ne pas melanger les anciennes et les nouvelles batteries, ou bien encore les batteries de differents fabriquants.

La calibration de toute instruments de RAE Systems doivent être testé en exposant l'instrument a une concentration de gaz connue par une procédure diétalonnage avant de mettre en service l'instrument pour la première fois.

Pour une securite maximale, la sensibilité du l'instrument doit être verifier en exposant l'instrument a une concentration de gaz connue par une procédure diétalonnage avant chaque utilisation journalière.

Ne pas utiliser de connection USB/PC en zone dangereuse.

Standard Contents

Instrument
Calibration Kit
Charging Cradle
AC/DC Adapter
Alkaline Battery Adapter
Data Cable
CD-ROM With User's Guide, Quick Start Guide, and related materials

General Information

The compact instrument is designed as a broadband VOC gas monitor and datalogger for work in hazardous environments. It monitors Volatile Organic Compounds (VOC) using a photoionization detector (PID) with a 9.8 eV, 10.6 eV, or 11.7 eV gas-discharge lamp. Features are:

Lightweight and Compact

- Compact, lightweight, rugged design
- Built-in sample draw pump

Dependable and Accurate

- Up to 16 hours of continuous monitoring with rechargeable battery pack
- Designed to continuously monitor VOC vapor at parts-per-million (ppm) levels

User-friendly

- Preset alarm thresholds for STEL, TWA, low- and high-level peak values.
- Audio buzzer and flashing LED display are activated when the limits are exceeded.

Datalogging Capabilities

- 260,000-point datalogging storage capacity for data download to PC

The instrument consists of a PID with associated microcomputer and electronic circuit. The unit is housed in a rugged case with a backlit LCD and 3 keys to provide easy user interface. It also has a built-in flashlight for operational ease in dark locations.

Physical Description

The main components of the portable VOC monitoring instrument include:

- Three keys for user to interact with the instrument: 3 operation/programming keys for normal operation or programming
- LCD display with back light for direct readout and calculated measurements
- Built-in flashlight for illuminating testing points in dark environments
- Buzzer and red LEDs for alarm signaling whenever exposures exceed preset limits
- Charge contacts for plugging directly to its charging station
- Gas entry and exit ports
- USB communication port for PC interface
- Protective rubber cover

Specifications

Size:	9.25" L x 3.6" W x 2.9" H
Weight:	28 oz with battery pack
Detector:	Photoionization sensor with 9.8, 10.6, or 11.7 eV UV lamp
Battery:	A 3.7V rechargeable Lithium-Ion battery pack (snap in, field replaceable, at non-hazardous location only)
	Alkaline battery holder (for 4 AA batteries)
Battery Charging:	Less than 8 hours to full charge
Operating Hours:	Up to16 hours continuous operation
Display:	Large dot matrix screen with backlight

Measurement range & resolution

Lamp	Range	Resolution
10.6 eV	0.1 ppm to 15,000 ppm	0.1 ppm
9.8 eV	0.1 ppm to 5,000 ppm	0.1 ppm
11.7 eV	0.1 ppm to 2,000 ppm	0.1 ppm

Response time (T_{90}): 2 seconds

Accuracy (Isobutylene): 10 to 2000 ppm: ±3% at calibration point.

PID Detector: Easy access to lamp and sensor for cleaning and replacement

Correction Factors: Over 200 VOC gases built in (based on RAE Systems Technical Note TN-106)

Calibration: Two-point field calibration of zero and standard reference gases

Calibration Reference: Store up to 8 sets of calibration data, alarm limits and span values

Inlet Probe: Flexible 5" tubing

Radio module: Bluetooth (2.4GHz), RF module (433MHz, 868MHz , 915MHz, or 2.4GHz)

Keypad: 1 operation key and 2 programming keys; 1 flashlight switch

Direct Readout: Instantaneous, average, STEL, TWA and peak value, and battery voltage

Intrinsic Safety: US and Canada: Class I, Division 1, Groups A, B, C, D

Europe: ATEX (0575 Ex II 2G Ex ia IIC/IIB T4 Gb)
KEMA 07 ATEX 0127
Complies with EN60079-0:2009, EN60079-11:2007

	IECEx CSA 10.0005 Ex ia IIC/IIB T4 Gb Complies with IEC 60079-0:2007, IEC 60079-11:2006 (IIC: 059-3051-000 Li-ion bat pack or 059-3054-000 NiMH bat pack; IIB: 059-3052-000 alkaline bat pack)
EM Interference:	Highly resistant to EMI/RFI. Compliant with EMC R&TTE (RF Modules)
Alarm Setting:	Separate alarm limit settings for Low, High, STEL and TWA alarm
Operating Mode:	Hygiene or Search mode
Alarm:	Buzzer 95dB at 30cm and flashing red LEDs to indicate exceeded preset limits, low battery voltage, or sensor failure
Alarm Type:	Latching or automatic reset
Real-time Clock:	Automatic date and time stamps on datalogged information
Datalogging:	260,000 points with time stamp, serial number, user ID, site ID, etc.
Communication:	Upload data to PC and download instrument setup from PC via USB on charging station.
Sampling Pump:	Internally integrated. Flow rate: 450 to 550 cc/min.
Temperature:	-20º C to 50º C (-4º to 122º F)
Humidity:	0% to 95% relative humidity (non-condensing)
Housing (including rubber boot):	Polycarbonate, splashproof and dustproof Battery can be changed without removing rubber boot.

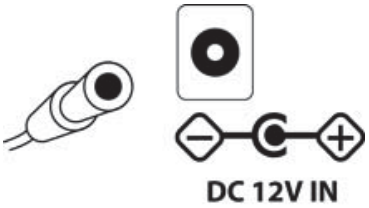
Charging The Battery

Always fully charge the battery before using the instrument. The instrument's Li-ion battery is charged by placing the instrument in its cradle. Contacts on the bottom of the instrument meet the cradle's contacts, transferring power without other connections.

Note: Before setting the instrument into its charging cradle, visually inspect the contacts to make sure they are clean. If they are not, wipe them with a soft cloth. Do not use solvents or cleaners.

Follow this procedure to charge the instrument:

1. Plug the AC/DC adapter's barrel connector into the instrument's cradle.



2. Plug the AC/DC adapter into the wall outlet.
3. Place the instrument into the cradle, press down, and lean it back. It locks in place and the LED in the cradle glow

The instrument begins charging automatically. The "Primary" LED in the cradle blinks green to indicate charging. During charging, the diagonal lines in the battery icon on the instrument's display are animated and you see the message "Charging..."

When the instrument's battery is fully charged, the battery icon is no longer animated and shows a full battery. The message "Fully charged!" is shown. The cradle's LED glows continuously green.

Note: If you see the "Battery Charging Error" icon (a battery outline with an exclamation mark inside), check that the instrument or rechargeable battery has been set into the cradle

properly. If you still receive the message, check the Troubleshooting section of this guide.

Note: If the instrument or battery has been in the cradle for more than 10 hours and you see the "Battery Charging Error" icon and a message that says, "Charging Too Long," this indicates that the battery is not reaching a full charge. Try changing the battery and make sure the contacts between the instrument (or battery) are meeting the cradle. If the message is still shown, consult your distributor or RAE Systems Technical Services.

Charging A Spare Rechargeable Battery

A rechargeable Li-ion battery can be charged when it is not inside the monitor. The charging cradle is designed to accommodate both types of charging. Contacts on the bottom of the battery meet the contacts on the cradle, transferring power without other connections, and a spring-loaded capture holds the battery in place during charging.

1. Plug the AC/DC adapter into the monitor's cradle.
2. Place the battery into the cradle, with the gold-plated contacts on top of the six matching charging pins.
3. Plug the AC/DC adapter into the wall outlet.

The battery begins charging automatically. During charging, the Secondary LED in the cradle blinks green. When charging is complete, it glows steady green.

Release the battery from the cradle by pulling it back toward the rear of the cradle and tilting it out of its slot.

Note: If you need to replace the Li-ion battery pack, replacements are available from RAE Systems. The part number is 059-3051-000.

Note: An Alkaline Battery Adapter (part number 059-3052-000), which uses four AA alkaline batteries (Duracell MN1500), may be substituted for the Li-Ion battery.

WARNING!

To reduce the risk of ignition of hazardous atmospheres, recharge and replace batteries only in areas known to be non-hazardous. Remove and replace batteries only in areas known to be non-hazardous.

Low Voltage Warning

When the battery's charge falls below a preset voltage, the instrument warns you by beeping once and flashing once every minute, and the "empty battery" icon blinks on and off once per second. You should turn off the instrument within 10 minutes and either recharge the battery by placing the instrument in its cradle, or replace the battery with a fresh one with a full charge.

Clock Battery

An internal clock battery is mounted on one of the instrument's printed circuit boards. This long-life battery keeps settings in memory from being lost whenever the Li-ion battery or alkaline batteries are removed. This backup battery should last approximately five years, and must be replaced by an authorized RAE Systems service technician. It is not user-replaceable.

Data Protection While Power Is Off

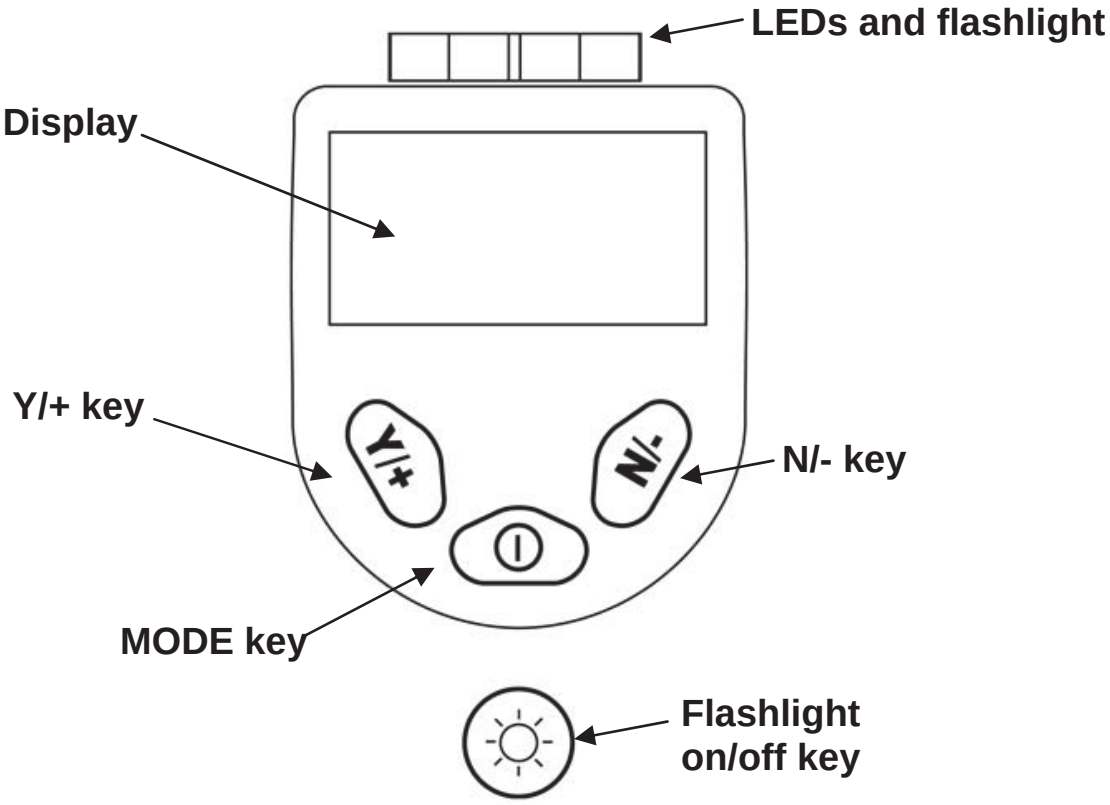
When the instrument is turned off, all the current real-time data including last measured values are erased. However, the datalog data is preserved in non-volatile memory. Even if the battery is disconnected, the datalog data will not be lost.

User Interface

The instrument's user interface consists of the display, LEDs, an alarm transducer, and four keys. The keys are:

Y/+
MODE
N/-
Flashlight on/off

The LCD display provides visual feedback that includes the reading, time, battery condition, and other functions.

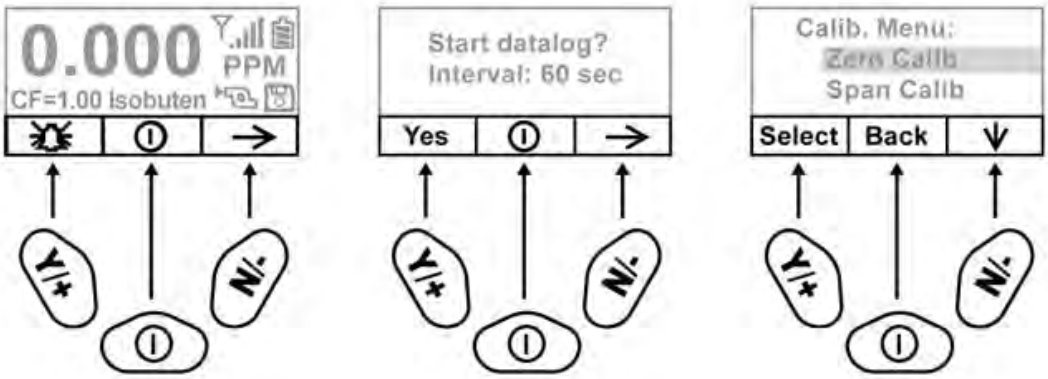


In addition to their labeled functions, the keys labeled Y/+, MODE, and N/- act as "soft keys" that control different parameters and make different selections within the instrument's menus. From menu to

menu, each key controls a different parameter or makes a different selection.

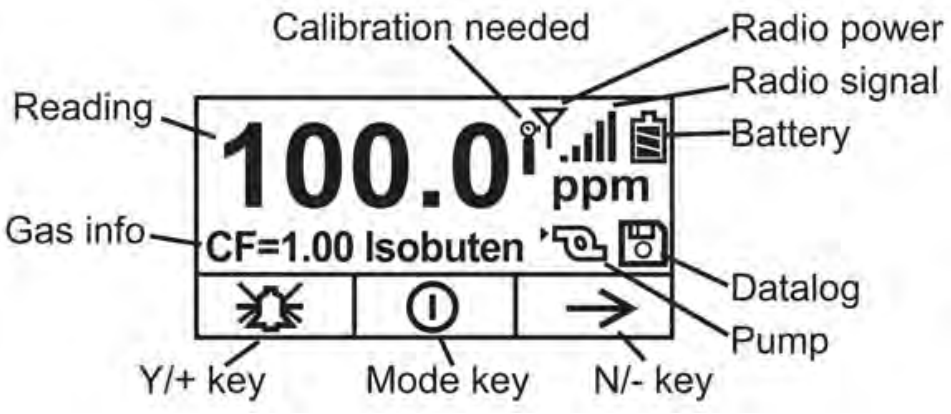
Three panes along the bottom of the display are "mapped" to the keys. These change as menus change, but at all times the left pane corresponds to the [Y/+] key, the center pane corresponds to the [MODE] key, and the right pane corresponds to the [N/-] key. Here are three examples of different menus with the relationships of the keys clearly shown:

RELATIONSHIP OF BUTTONS TO CONTROL FUNCTIONS



Display

The display shows the following information:



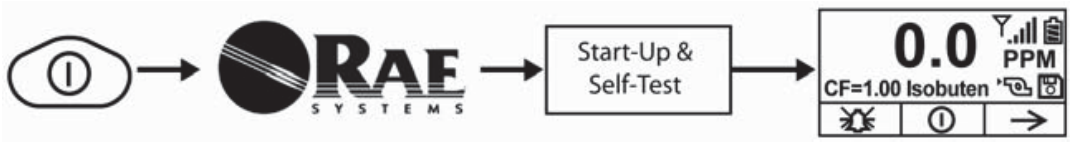
Graph	Graphic representation of concentration plotted over time
Gas info	Tells the Correction Factor and type of calibration gas
Reading	Concentration of gas as measured by the instrument
Calibration needed	Indicates that calibration should be performed
Radio power	Indicates whether radio connection is on or off
Radio signal	Indicates signal strength in 5-bar bargraph
Battery	Indicates battery level in 3 bars
Pump	Indicates that pump is working
Datalog	Indicates whether datalog is on or off
Y/+	Y/+ key's function for this screen
MODE	MODE key's function for this screen
N/-	N/- key's function for this screen

Operating The Instrument

The instrument is designed as a broadband VOC gas monitor and datalogger for work in hazardous environments. It gives real-time measurements and activates alarm signals whenever the exposure exceeds preset limits. Prior to factory shipment, the instrument is preset with default alarm limits and the sensor is pre-calibrated with standard calibration gas. However, you should test the instrument and verify the calibration before the first use. After the instrument is fully charged and calibrated, it is ready for immediate operation.

Turning The Instrument On

1. With the instrument turned off, press and hold [MODE].
2. When the display turns on, release the [MODE] key.



The RAE Systems logo should appear first. (If the logo does not appear, there is likely a problem and you should contact your distributor or RAE Systems Technical Support.) The instrument is now operating and performs self tests. If any tests (including sensor and memory tests fail), refer to the Troubleshooting section of this guide.

Once the startup procedure is complete, the instrument shows a numerical reading screen with icons. This indicates that the instrument is fully functional and ready to use.

Turning The Instrument Off

1. Press and hold the Mode key for 3 seconds. A 5-second countdown to shutoff begins.
2. Once the countdown stops, the instrument is off. Release the Mode key.
3. When you see "Unit off..." release your finger from the [MODE] key. The instrument is now off.

Note: You must hold your finger on the key for the entire shutoff process. If you remove your finger from the key during the countdown, the shutoff operation is canceled and the instrument continues normal operation.

Operating The Built-In Flashlight

The instrument has a built-in flashlight that helps you point the probe in dark places. Press the flashlight key to turn it on. Press it again to turn it off.

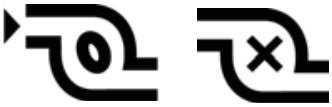
Note: Using the flashlight for extended periods shortens the battery's operating time before it needs recharging.

Pump Status

IMPORTANT!

During operation, make sure the probe inlet and the gas outlet are free of obstructions. Obstructions can cause premature wear on the pump, false readings, or pump stalling. During normal operation, the pump icon alternately shows inflow and outflow as shown here:

During duty cycling (PID lamp cleaning), the display shows these icons in alternation:



If there is a pump failure or obstruction that disrupts the pump, you will see this icon blinking on and off:

If you see this blinking icon, consult the Troubleshooting section of this guide.

Calibration Status

The instrument displays this icon if it requires calibration:

Calibration is required (and indicated by this icon) if:

- The lamp type has been changed (for example, from 10.6 eV to 9.8 eV).
- The sensor has been replaced.
- It has been 30 days or more since the instrument was last calibrated.
- If you have changed the calibration gas type without recalibrating the instrument.

Operating Modes

Your instrument operates in different modes, depending on the model and its factory default settings. In some cases, you can change modes using a password and using the instrument's navigation. In other cases, you must use ProRAE Studio software.

The default setting for your instrument is:

User Mode: Basic
Operation Mode: Hygiene

This is outlined in detail on page 74.

The other options, covered later in this guide, are:

User Mode: Advanced (page 78)
Operation Mode: Hygiene

User Mode: Advanced (page 82)
Operation Mode: Search

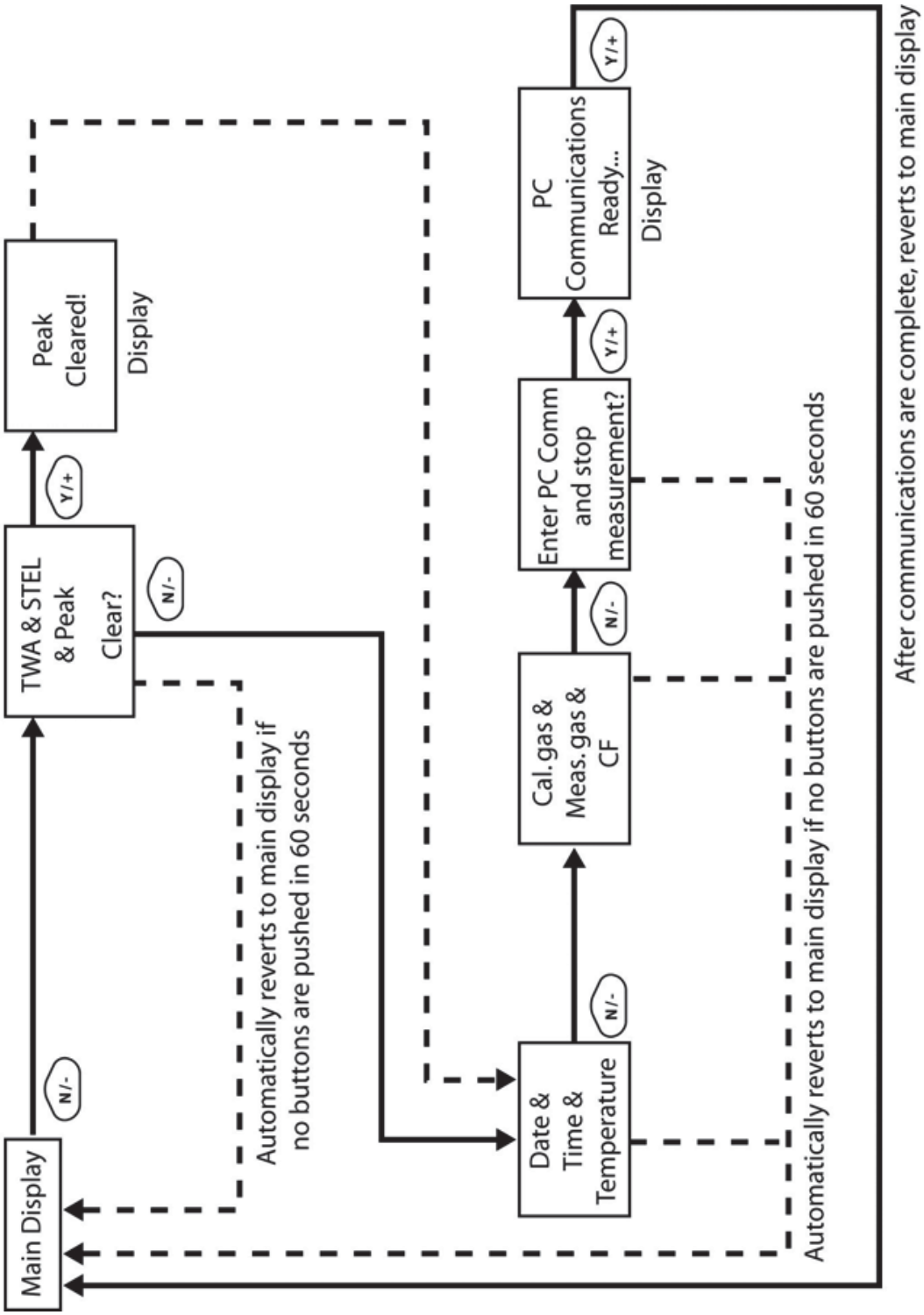
Using ProRAE Studio allows access to other options. In addition, Diagnostic Mode (page 83) is available for service technicians.

Basic User Level/Hygiene Mode (Default Settings)

The instrument is programmed to operate in Basic User Level/Hygiene Mode as its default. This gives you the most commonly needed features while requiring the fewest parameter adjustments.

Pressing [N/-] steps you from one screen to the next, and eventually return to the main display. If you do not press a key within 60 seconds after entering a display, the instrument reverts to its main display.

Note: While viewing any of these screens, you can shut off your instrument by pressing [MODE].



Note: Dashed line indicates automatic progression.

After the instrument is turned on, it runs through the start-up menu. Then the message "**Please apply zero gas…**" is displayed.

At this point, you can perform a zero air (fresh air) calibration. If the ambient air is clean, you can use that. Otherwise, use a cylinder of zero air. Refer to Zero Calibration on page 37 for a more detailed description of zero calibration.

Start zero calibration by pressing Start. You see the message "Zeroing…" followed by a 30-second countdown.

Note: You can press [MODE] to quit, bypassing the zero air calibration.

When zero calibration is complete, you see the message:

Zeroing is done!

Reading = 0.0 ppm

The instrument is now sampling and collecting data.

Note: At the Average & Peak, Date & Time & Temperature, Calibration Gas & Measurement Gas & Correction Factor, and PC Communications screens, the instrument automatically goes to the main display after 60 seconds if you do not push a key to make a selection.

Alarm Signals

During each measurement period, the gas concentration is compared with the programmed alarm limits (gas concentration alarm limit settings). If the concentration exceeds any of the preset limits, the loud buzzer and red flashing LED are activated immediately to warn you of the alarm condition.

In addition, the instrument alarms if one of the following conditions occurs: battery voltage falls below a preset voltage level, failure of the UV lamp, or pump stall.

Alarm Signal Summary

Message	Condition	Alarm Signal
HIGH	Gas exceeds "High Alarm" limit	3 beeps/flashes per second*
OVR	Gas exceeds measurement range	3 beeps/flashes per second*
MAX	Gas exceeds electronics' maximum range	3 beeps/flashes per second*
LOW	Gas exceeds "Low Alarm" limit	2 beeps/flashes per second*
TWA	Gas exceeds "TWA" limit	1 Beep/flash per second*
STEL	Gas exceeds "STEL" limit	1 Beep/flash per second*
Pump icon flashes	Pump failure	3 beeps/flashes per second
Lamp	PID lamp failure	3 beeps/flashes per second plus "Lamp" message on display
Battery icon flashes	Low battery	1 flash, 1 beep per minute plus battery icon flashes on display
CAL	Calibration failed, or needs calibration	1 beep/flash per second
NEG	Gas reading measures less than number stored in calibration	1 beep/flash per second

* Hygiene mode only. In Search mode, the number of beeps per second (1 to 7) depends upon the concentration of the sampled gas. Faster rates indicate higher concentrations.

Preset Alarm Limits & Calibration

The instrument is factory calibrated with standard calibration gas, and is programmed with default alarm limits.

Cal Gas (Isobutylene)	Cal Span	unit	Low	High	TWA	STEL
MiniRAE 3000	100	ppm	50	100	10	25

Testing The Alarm

You can test the alarm whenever the main (Reading) display is shown. Press [Y/+], and the audible and visible alarms are tested.

Integrated Sampling Pump

The instrument includes an integrated sampling pump. This diaphragm-type pump that provides a 450 to 550 cc per minute flow rate. Connecting a Teflon or metal tubing with 1/8" inside diameter to the gas inlet port of the instrument, this pump can pull in air samples from 100' (30 m) away horizontally or vertically.

Note: In Search Mode, the pump turns on when a sample measurement is started, and turns off when the sample is manually stopped.

If liquid or other objects are pulled into the inlet port filter, the instrument detects the obstruction and immediately shuts down the pump. The alarm is activated and a flashing pump icon is displayed.

You should acknowledge the pump shutoff condition by clearing the obstruction and pressing the [Y/+] key while in the main reading display to restart the pump.

Backlight

The LCD display is equipped with an LED backlight to assist in reading the display under poor lighting conditions.

Datalogging

During datalogging, the instrument displays a disk icon to indicate that datalogging is enabled. The instrument stores the measured gas concentration at the end of every sample period (when data logging is enabled). In addition, the following information is stored: user ID, site ID, serial number, last calibration date, and alarm limits. All data are retained (even after the unit is turned off) in non-volatile memory so that it can be down- loaded at a later time to a PC.

Datalogging event

When Datalogging is enabled, measurement readings are being saved. These data are stored in "groups" or "events." A new event is created and stored each time the instrument is turned on and is set to automatic datalogging, or a configuration parameter is changed, or datalogging is interrupted. The maximum time for one event is 24 hours or 28,800 points. If an event exceeds 24 hours, a new event is automatically created. Information, such as start time, user ID, site ID, gas name, serial number, last calibration date, and alarm limits are recorded.

Datalogging sample

After an event is recorded, the unit records a shorter form of the data. When transferred to a PC running ProRAE Studio, this data is arranged with a sample number, time, date, gas concentration, and other related information.

Auto/Manual/Snapshot Datalogging

The instrument has three datalog types:

Auto	Default mode. Collects datalog information when the instrument is sampling.
Manual	Datalogging occurs only when the instrument's datalogging is manually started (see page 63 for details).
Snapshot	Datalogs only during snapshot (single-event capture, initiated by pressing [MODE]) sampling. See page 65 for details.

Note: You can only choose one datalog type to be active at a time.

Accessories

The following accessories are included with the instrument:

- An AC Adapter (Battery Charger)
- Alkaline battery adapter
- External Filter
- Organic Vapor Zeroing kit

Hard-case kits also include these accessories:

- Calibration adapter
- Calibration regulator and Flow controller

Standard Kit & Accessories

AC Adapter (Battery Charger)

WARNING

To reduce the risk of ignition of hazardous atmospheres, recharge battery only in area known to be non-hazardous. Remove and replace battery only in area known to be non-hazardous.

Ne charger les batteries que dans emplacements designés non-dangereuses.

A battery charging circuit is built into the instrument cradle. It only needs a regular AC to 12 VDC adapter (wall-mount transformer, part number 500-0114-000) to charge the instrument.

To charge the battery inside the instrument:

1. Power off the instrument.
2. Connect the AC adapter to the DC jack on the instrument's cradle. If the instrument is off, it automatically turns on.
3. While charging, the display message shows "Charging." The Primary LED on the cradle flashes green when charging.
4. When the battery is fully charged, the LED changes to glowing green continuously, and the message "Fully charged" appears on the

display. If there is a charging error, the LED glows red continuously.

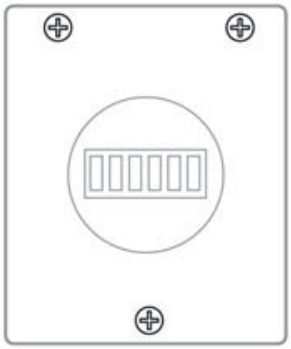
A completely discharged instrument can be charged to full capacity within 8 hours. Batteries drain slowly even if an instrument is off. Therefore, if the instrument has been in storage or has not been charged for several days or longer, check the charge before using it.

The factory-supplied battery is designed to last for 16 hours of normal operation (no alarm), for a new battery under the optimum circumstances. As the battery becomes older or is subject to adverse conditions (such as cold ambient temperature), its capacity will be significantly reduced.

Alkaline Battery Adapter

An alkaline battery adapter is supplied with each instrument. The adapter (part number 059-3052-000) accepts four AA alkaline batteries (use only Duracell MN1500) and provides approximately 12 hours of operation. The adapter is intended to be used in emergency situations when there is no time to charge the Li-ion battery pack.

To insert batteries into the adapter:



1. Remove the three Philips-head screws to open the compartment in the adapter.
2. Insert four fresh AA batteries as indicated by the polarity (+/-) markings.
3. Replace the cover. Replace the three screws.

To install the adapter in the instrument:

1. Remove the Li-ion battery pack from the instrument by sliding the tab and tilting out the battery.
2. Replace it with the alkaline battery adapter
3. Slide the tab back into place to secure the battery adapter.

IMPORTANT!

Alkaline batteries cannot be recharged. The instrument's internal circuit detects alkaline batteries and will not allow recharging. If you place the instrument in its cradle, the alkaline battery will not be recharged. The

internal charging circuit is designed to prevent damage to alkaline batteries and the charging circuit when alkaline batteries are installed inside the instrument. If you try to charge an alkaline batteries installed in the instrument, the instrument's display will say, "Alkaline Battery," indicating that it will not charge the alkaline batteries.

Note: When replacing alkaline batteries, dispose of old ones properly.

WARNING!

To reduce the risk of ignition of hazardous atmospheres, recharge the battery only in areas known to be non-hazardous. Remove and replace the battery only in areas known to be non-hazardous.

External Filter

The external filter is made of PTFE (Teflon®) membrane with a 0.45 micron pore size to prevent dust or other particles from being sucked into the sensor manifold, which would cause extensive damage to the instrument. It prolongs the operating life of the sensor. To install the external filter, simply connect it to the instrument's inlet tube.

Optional Accessories

Calibration Adapter

The calibration adapter for the instrument is a simple 6-inch Tygon tubing with a metal adapter on one end. During calibration, simply insert the metal adapter into the regular gas inlet probe of the instrument and the tubing to the gas regulator on the gas bottle.

Calibration Regulator

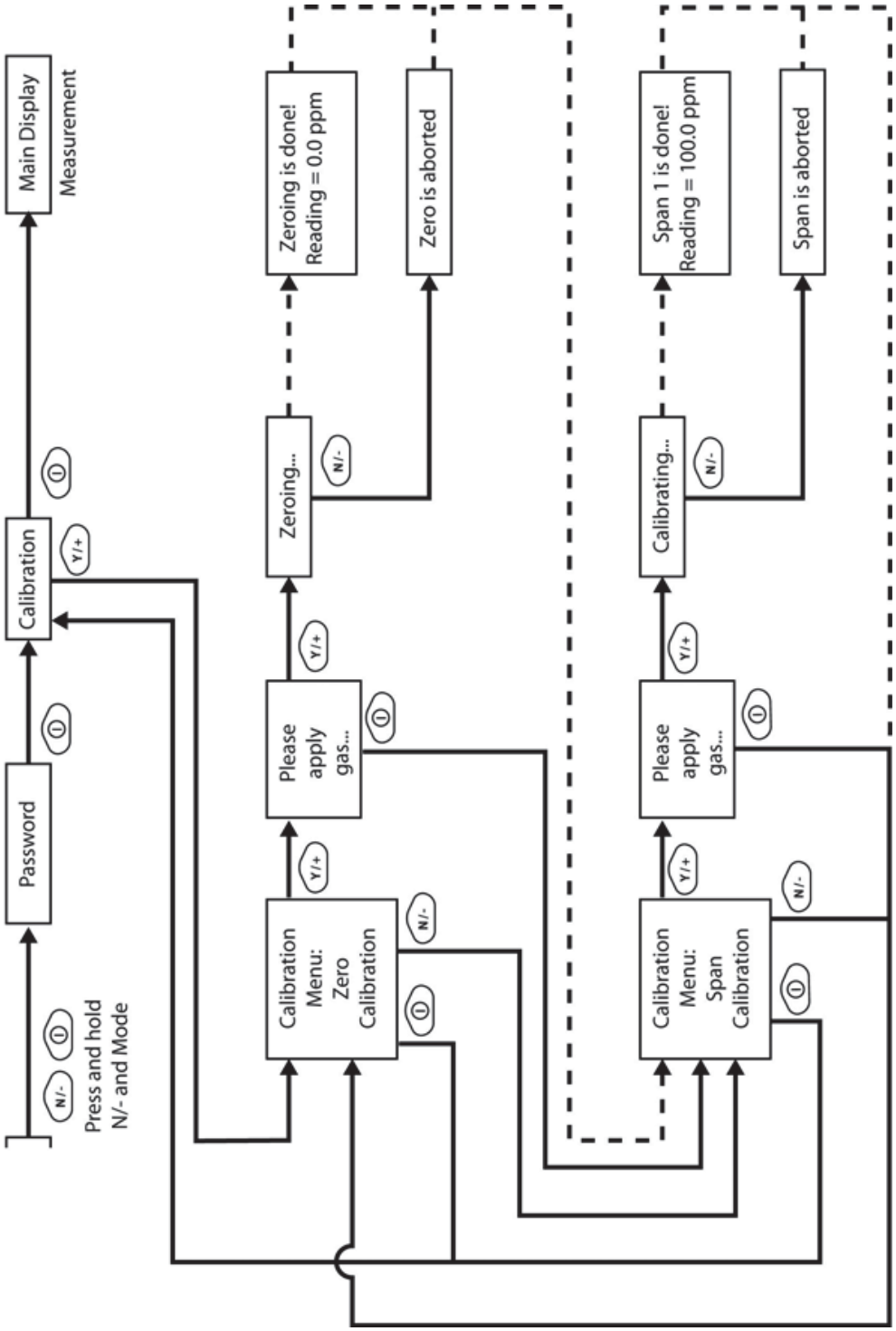
The Calibration Regulator is used in the calibration process. It regulates the gas flow rate from the Span gas cylinder into the gas inlet of the instrument during calibration process. The maximum flow rate allowed by the flow controller is about 0.5L/min (500 cc per min.). Alternatively, a demand-flow regulator or a Tedlar gas bag may be used to match the pump flow precisely.

Organic Vapor Zeroing Kit

The Organic Vapor Zeroing Kit is used for filtering organic air contaminants that may affect the zero calibration reading. To use the Organic Vapor Zeroing Kit, simply connect the filter to the inlet port of the instrument.

Standard Two-Point Calibration (Zero & Span)

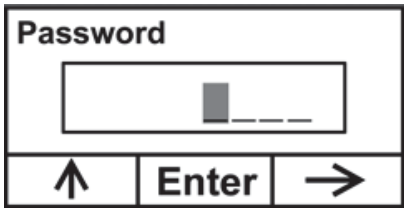
The following diagram shows the instrument's calibrations in Basic/Hygiene mode.



Note: Dashed line indicates automatic progression.

Entering Calibration

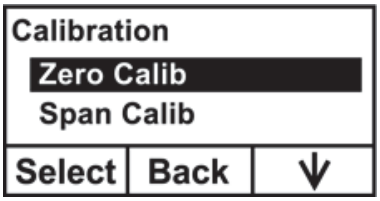
1. Press and hold [MODE] and [N/-] until you see the Password screen.



2. In Basic User Level, you do not need a password to perform calibrations. Instead of inputting a password, enter calibration by pressing [MODE].

   Note: If you inadvertently press [Y/+] and change any of the numbers, simply press [MODE] and you will be directed to the calibration menu.

The Calibration screen is now visible with Zero Calibration highlighted.



These are your options:

- Press [Y/+] to select the highlighted calibration (Zero Calib or Span Calib).
- Press [MODE] to exit calibration and return to the main display and resume measurement.
- Press [N/-] to toggle the highlighted calibration type.

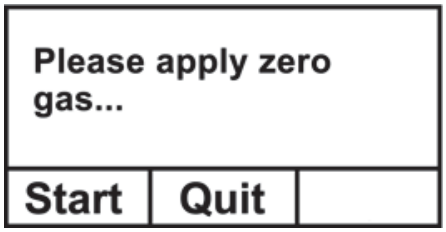
Zero (Fresh Air) Calibration

This procedure determines the zero point of the sensor calibration curve. To perform a fresh air calibration, use the calibration adapter to connect the instrument to a "fresh" air source such as from a cylinder or Tedlar bag (optional accessory). The "fresh" air is clean, dry air without organic impurities and an oxygen value of 20.9%. If such an air cylinder is not available, any clean ambient air without detectable contaminants or a charcoal filter can be used.

At the Zero Calibration menu, you can proceed to perform a Zero calibration or bypass Zero calibration and perform a Span calibration. You may also go back to the initial Calibration menu if you want to exit calibration.

- Press [Y/+] to start calibration.
- Press [MODE] to quit and return to the main calibration display.

If you have pressed [Y/+] to enter Zero calibration, then you will see this message:



1. Turn on your Zero calibration gas.
2. Press [Y/+] to start calibration.

   Note: At this point, you may press [MODE] if you decide that you do not want to initiate calibration. This will take you directly to the Calibration menu, highlighted for Span calibration.

3. Zero calibration starts a 30-second countdown and displays this message:

   Zeroing...

During the zeroing process, the instrument performs the Zero calibration automatically and does not require any action on your part.

Note: To abort the zeroing process at any time and proceed to Span calibration, press [N/-] at any time while zeroing is being performed. You will see a confirmation message that says "Zero aborted!" and then the Span calibration menu appears.

When Zero calibration is complete, you see this message:

Zeroing is done!
Reading = 0.0 ppm

The instrument will then show the Calibration menu on its display, with Span Calib highlighted.

Span Calibration

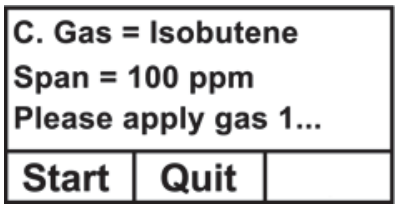
This procedure determines the second point of the sensor calibration curve for the sensor. A cylinder of standard reference gas (span gas) fitted with a 500 cc/min. flow-limiting regulator or a flow-matching regulator is the simplest way to perform this procedure. Choose the 500 cc/min. regulator only if the flow rate matches or slightly exceeds the flow rate of the instrument pump. Alternatively, the span gas can first be filled into a Tedlar bag or delivered through a demand-flow regulator. Connect the calibration adapter to the inlet port of the instrument, and connect the tubing to the regulator or Tedlar bag.

Another alternative is to use a regulator with >500 cc/min flow but allow the excess flow to escape through a T or an open tube. In the latter method, the span gas flows out through an open tube slightly wider than the probe, and the probe is inserted into the calibration tube.

At the Span Calibration menu, you perform a Span calibration. You may also go back to the Zero calibration menu or to the initial Calibration menu if you want to exit calibration.

- Press [Y/+] to enter Span calibration.
- Press [N/-] to skip Span calibration and return to Zero calibration.
- Press [MODE] to exit Span calibration and return to the top calibration menu.

If you have pressed [Y/+] to enter Span calibration, then you will see the name of your Span gas (the default is isobutylene) and the span value in parts per million (ppm). You will also see this message that prompts you:



1. Turn on your span calibration gas.
2. Press [Y/+] to initiate calibration.

Note: You may press [MODE] if you decide that you do not want to initiate calibration. This will abort the span calibration and take you directly to the Calibration menu for Zero calibration.

3. Span calibration starts and displays this message:

   Calibrating...

During the Span calibration process, there is a 30-second countdown and the instrument performs the Span calibration automatically. It requires no actions on your part.

Note: If you want to abort the Span calibration process, press [N/-] at any time during the process. You will see a confirmation message that says "Span is aborted!" and then the Zero calibration menu appears. You can then proceed to perform a Zero calibration, perform a Span calibration, or exit to the topmost Calibration menu.

When Span calibration is complete, you see a message similar to this (the value is an example only):

Span 1 is done!
Reading = 100.0 ppm

The instrument then exits Span calibration and shows the Zero calibration menu on its display.

Note: The reading should be very close to the span gas value.

Exiting Two-Point Calibration In Basic User Level

When you are done performing calibrations, press [MODE], which corresponds with "Back" on the display. You will see the following message:

Updating settings…

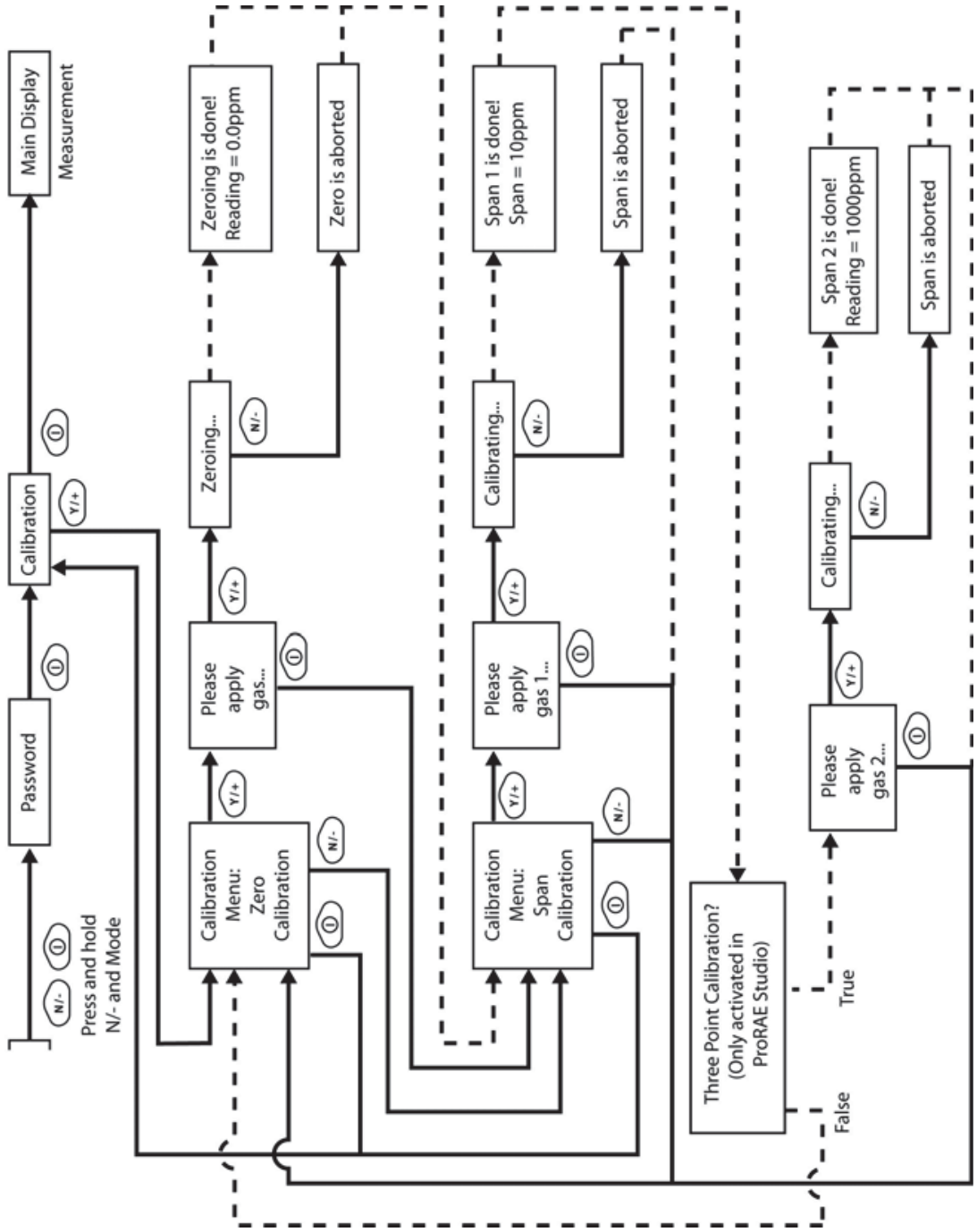
The instrument updates its settings and then returns to the main display. It begins or resumes monitoring.

Three-Point Calibration

For enhanced accuracy, it is possible to perform a second Span calibration in addition to the Zero and Span calibrations outlined in the previous section. Your instrument first must be set to allow this third calibration. This requires using ProRAE Studio software and a PC, as well as a higher concentration of calibration gas.

Note: Once the third calibration is set, you do not need to use ProRAE Studio to allow future 3-point calibrations. Also, you can only disable 3-point calibration capability by using ProRAE Studio again.

Perform the Zero and Span calibrations. After the first Span calibration (Span 1) is completed, the display a second Span calibration (Span 2) can be performed. The process is identical to the first calibration. As in the Span 1 calibration, you may exit and return to the Zero calibration screen if you choose not to perform this calibration or to abort it.



Note: Dashed line indicates automatic progression.

Span 2 Calibration

A cylinder of standard reference gas (span gas) fitted with a 500 cc/min. flow-limiting regulator or a flow-matching regulator is the simplest way to perform this procedure.

Note: This gas should be of a higher concentration than the gas used for Span 1 calibration.

Choose the 500 cc/min. regulator only if the flow rate matches or slightly exceeds the flow rate of the instrument pump. Alternatively, the span gas can first be filled into a Tedlar bag or delivered through a demand-flow regulator. Connect the calibration adapter to the inlet port of the instrument, and connect the tubing to the regulator or Tedlar bag.

Another alternative is to use a regulator with >500 cc/min flow but allow the excess flow to escape through a T or an open tube. In the latter method, the span gas flows out through an open tube slightly wider than the probe, and the probe is inserted into the calibration tube.

At the Span Calibration menu, you perform a Span calibration. You may also go back to the Zero calibration menu or to the initial Calibration menu if you want to exit calibration.

- Press [Y/+] to enter Span 2 calibration.
- Press [N/-] to skip Span calibration and return to Zero calibration.
- Press [MODE] to exit Span calibration and return to the top calibration menu.

If you have pressed [Y/+] to enter Span calibration, then you will see the name of your Span gas (the default is isobutylene) and the span value in parts per million (ppm). You will also see this message that prompts you:

Please apply gas...

4. Turn on your span calibration gas.
5. Press [Y/+] to initiate calibration.

Note: You may press [MODE] if you decide that you do not want to initiate calibration. This will take you directly to the Calibration menu for Zero calibration.

6. Span calibration starts a 30-second countdown and displays this message:

   Calibrating...

During the Span calibration process, the instrument performs the Span calibration automatically and does not require any action on your part.

Note: If you want to abort the Span calibration process, press [N/-] at any time during the process. You will see a confirmation message that says "Span is aborted!" and then the Zero calibration menu will appear. You can then proceed to perform a Zero calibration, perform a Span calibration, or exit to the topmost Calibration menu.

When Span calibration is complete, you will see a message similar to this (the value shown here is for example only):

Span 2 is done!
Reading = 1000 ppm

The instrument then exits Span calibration and shows the Zero calibration menu on its display.

Note: The reading should be very close to the span gas value.

Exiting Three-Point Calibration

When you are done performing calibrations, press [MODE], which corresponds with "Back" on the display. You will see the following message:

Updating settings…

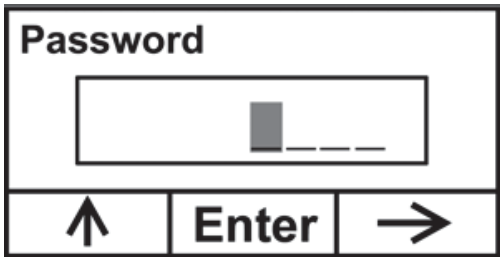
The instrument updates its settings and then returns to the main display. It begins or resumes monitoring.

Programming Mode

Programming Mode can be entered from either Hygiene Mode or Search Mode. If the current user mode is Basic, you must provide a 4-digit password to enter.

Entering Programming Mode

1. Press and hold [MODE] and [N/-] until you see the Password screen.



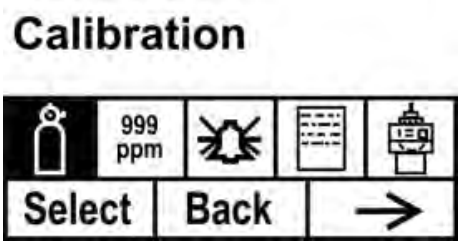
2. Input the 4-digit password:

- Increase the number from 0 through 9 by pressing [Y/+].
- Step from digit to digit using [N/-].
- Press [MODE] when you are done.

If you make a mistake, you can cycle through the digits by pressing [N/-] and then using [Y/+] to change the number in each position.

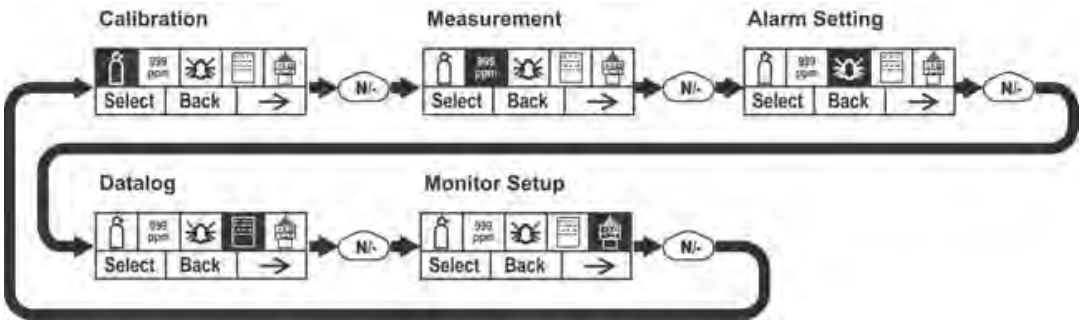
Note: The default password is 0000.

When you have successfully entered Programming Mode, you see this screen:



Note: The password can only be changed by connecting the instrument to a PC running ProRAE Studio software. Follow the instructions in ProRAE Studio to change it.

The Calibration label is shown and its icon is highlighted, but you can press [N/-] to step from one programming menu to the next, with the name of the menu shown at the top of the display and the corresponding icon highlighted. As you repeatedly press [N/-], the selection moves from left to right, and you see these screens:



Note: When you reach Monitor Setup and press [N/-], the menu cycles back to Calibration.

Programming Mode Menus

The Programming Mode allows anyone with the password to change the instrument's settings, calibrate the instrument, modify the sensor configuration, enter user information, etc. Programming Mode has five menus. Each menu includes several sub-menus to perform additional programming functions.

This table shows the menus and sub-menus:

	999 ppm			
Calibration	**Measurement**	**Alarm Setting**	**Datalog**	**Monitor Setup**
Zero Calibration	Meas. Gas	High Alarm	Clear Datalog	Op Mode
Span Calibration	Meas. Unit	Low Alarm	Interval	Site ID
		STEL Alarm	Data Selection	User ID
		TWA Alarm	Datalog Type	User Mode
		Alarm Type		Date
		Buzzer & Light		Time
				Pump Duty Cycle
				Pump Speed
				Temperature Unit
				Language
				Radio Power
				Real Time Protocol
				Power On Zero
				Unit ID
				LCD Contrast

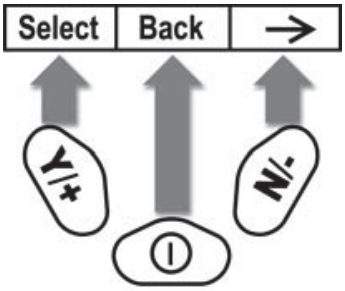
Once you enter Programming Mode, the LCD displays the first menu, Calibration. Each subsequent menu is accessed by pressing [N/-] repeatedly until the desired menu is displayed. To enter a sub-menu of a menu, press [Y/+].

Exiting Programming Mode

To exit Programming Mode and return to normal operation, press [MODE] once at any of the programming menu displays. You will see "Updating Settings…" as changes are registered and the mode changes.

Navigating Programming Mode Menus

Navigating through the Programming Mode menus is easy and consistent, using a single interface format of "Select," "Back" and "Next" at the top level. The three control buttons correspond to these choices as shown:



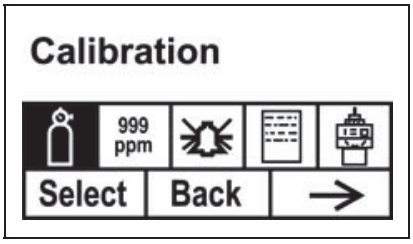
Note: Pressing [MODE] in the Programming Mode's top level causes the instrument to exit Programming Mode and return to monitoring.

The three keys perform the following functions in Programming Mode:

Key	Function in Programming Mode
[MODE]:	Exit menu when pressed momentarily or exit data entry mode
[Y/+]:	Increase alphanumerical value for data entry or confirm (yes) for a question
[N/-]:	Provides a "no" response to a question

Calibration

Two types of calibration are available: Zero (fresh air) and Span.



Select Zero or Span Calibration by pressing [N/+]. Once your choice is highlighted, press [Y/+].

Zero Calibration

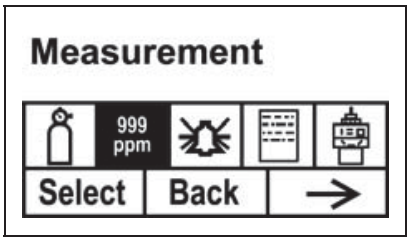
The procedure for performing a zero calibration is covered on page 35.

Span Calibration

The procedure for performing a basic span calibration is covered on page 35.

Measurement

The sub-menus for Measurement are Measurement Gas and Measurement Unit.



Meas. Gas

Measurement gases are organized in four lists:

- My List is a customized list of gases that you create. It contains a maximum of 10 gases and can only be built in ProRAE Studio on a PC and transferred to the instrument. **Note:** The first gas in the list is always isobutylene (it cannot be removed from the list).
- Last Ten is a list of the last ten gases used by your instrument. The list is built automatically and is only updated if the gas selected from Custom Gases or Library is not already in the Last Ten. This ensures that there is no repetition.
- Gas Library is a library that consists of all the gases found in RAE Systems' Technical Note TN-106 (available online at www.raesystems.com).
- Custom Gases are gases with user-modified parameters. Using ProRAE Studio, all parameters defining a gas can be modified, including the name, span value(s), correction factor, and default alarm limits.

1. Scroll through each list by pressing [N/-].
2. Press [Y/+] to select one (My List, Last Ten, Gas Library, or Custom Gases).

3. Once you are in one of the categories, press [N/-] to scroll through its list of options and [Y/+] to select one. (If you press [MODE], you exit to the next submenu.)
4. Press [Y/+] to save your choice or [N/-] to undo your selection.

Leave the sub-menu and return to the Programming Mode menus by pressing [MODE].

Meas. Unit

Standard available measurement units include:

Abbreviation	Unit	MiniRAE 3000
ppm	parts per million	Yes
ppb	parts per billion	
mg/m3	milligrams per cubic meter	Yes
ug/m3	micrograms per cubic meter	

- Scroll through the list by pressing [N/-].
- Select by pressing [Y/+].
- Save your selection by pressing [Y/+] or undo your selection by pressing [N/-].

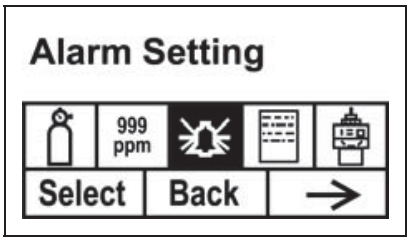
Leave the sub-menu and return to the Programming Mode menus by pressing [MODE].

Alarm Setting

During each measurement period, the gas concentration is compared with the programmed alarm limits (gas concentration alarm limit settings: Low, High, TWA and STEL). If the concentration exceeds any of the preset limits, the loud buzzer and red flashing LED are activated immediately to warn of the alarm condition.

An alarm signal summary is shown on page 27.

In this menu, you can change the High and Low alarm limits, the STEL limit, and the TWA. Press [Y/+] to to enter the Alarm Setting menu. **Note:** All settings are shown in ppb (parts per billion), or $\mu g/m^3$ (micrograms per cubic meter), depending on your setting.



1. Scroll through the Alarm Limit sub-menu using the [N/-] key until the display shows the desired limit to be changed (High Alarm, Low Alarm, STEL Alarm, and TWA Alarm)
2. Press [Y/+] to select one of the alarm types. The display shows a flashing cursor on the left-most digit of the previously stored alarm limit.
3. Press [Y/+] to increase each digit's value.
4. Press [N/-] to advance to the next digit.
5. Again, use [Y/+] to increase the number.

Repeat this process until all numbers are entered.

Press [MODE] when you are done.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

When all alarm types have been changed or bypassed, press [MODE] to exit to the Programming Menu.

High Alarm

You can change the High Alarm limit value. The value is typically set by the instrument to match the value for the current calibration gas. It is expressed in parts per billion (ppb). **Note:** The default value depends on the measurement gas.

To change the High Alarm value:

1. Press [Y/+] to increase each digit's value.
2. Press [N/-] to advance to the next digit.
3. Again, use [Y/+] to increase the number.

Repeat this process until all numbers are entered.
When you have completed your selections, press [MODE]. You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

Press [Y/+] to save the changes.
Press [N/-] to undo the changes and revert to the previous settings.

Low Alarm

You can change the Low Alarm limit value. The value is typically set by the instrument to match the value for the current calibration gas. It is expressed in parts per billion (ppb). **Note:** The default value depends on the measurement gas.

To change the Low Alarm value:

1. Press [Y/+] to increase each digit's value.
2. Press [N/-] to advance to the next digit.
3. Again, use [Y/+] to increase the number.

Repeat this process until all numbers are entered.

When you have completed your selections, press [MODE]. You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

STEL Alarm

You can change the STEL Alarm limit value. The value is typically set by the instrument to match the value for the calibration gas. It is expressed in parts per billion (ppb). **Note:** The default value depends on the measurement gas.

To change the STEL Alarm value:

1. Press [Y/+] to increase each digit's value.
2. Press [N/-] to advance to the next digit.
3. Again, use [Y/+] to increase the number.

Repeat this process until all numbers are entered.

When you have completed your selections, press [MODE]. You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

TWA Alarm

You can change the TWA (time-weighted average) Alarm limit value. The value is typically set by the instrument to match the value for the calibration gas. It is expressed in parts per billion (ppb). **Note:** The default value depends on the measurement gas.

To change the TWA Alarm value:

1. Press [Y/+] to increase each digit's value.
2. Press [N/-] to advance to the next digit.
3. Again, use [Y/+] to increase the number.

Repeat this process until all numbers are entered.

When you have completed your selections, press [MODE]. You will see two choices:

- Save
- Undo

You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

Alarm Type

There are two selectable alarm types:

Latched	When the alarm is triggered, you can manually stop the alarm. The latched setting only controls alarms for High Alarm, Low Alarm, STEL Alarm, and TWA alarm. **Note:** To clear an alarm when the instrument is set to "Latched," press [Y/+] when the main (Reading) display is shown.
Automatic Reset	When the alarm condition is no longer present, the alarm stops and resets itself.

1. Press **[N/-]** to step from one alarm type to the other.
2. Press **[Y/+]** to select an alarm type.

When you have completed your selections, press [MODE].

You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

Buzzer & Light

The buzzer and light alarms can be programmed to be on or off individually or in combination. Your choices are:

- Both on
- Light only
- Buzzer only
- Both off

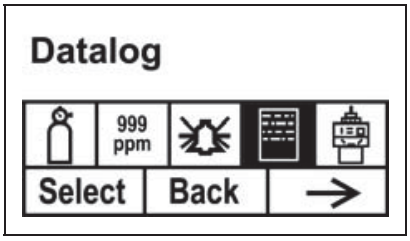
1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates your selection).
3. When you have completed your selections, press [MODE].

   You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

   - Press [Y/+] to save the changes.
   - Press [N/-] to undo the changes and revert to the previous settings.

Datalog

The instrument calculates and stores the concentration and ID of each sample taken. In the datalog sub-menu, a user can perform the tasks and functions shown below.



1. Scroll through the Datalog sub-menu using the [N/-] key until the display shows the desired parameter to be changed:

   Clear Datalog
   Interval
   Data Selection
   Datalog Type

2. Press [Y/+] to make your selection. Exit by pressing [MODE] for Back.

Clear Datalog

This erases all the data stored in the datalog.

Note: Once the datalog is cleared, the data cannot be recovered.

Press [Y/+] to clear the datalog. The display asks, "Are you sure?"

- Press [Y/+] if you want to clear the datalog. When it has been cleared, the display shows "Datalog Cleared!"
- Press [N/-] if you do not want to clear the datalog.

The display changes, and you are taken to the next sub-menu, Interval.

Interval

Intervals are shown in seconds. The default value is 60 seconds. The maximum interval is 3600 seconds.

1. Press [Y/+] to increase each digit's value.
2. Press [N/-] to advance to the next digit.
3. Again, use [Y/+] to increase the number.

Repeat this process until all numbers are entered.

When you have completed your selections, press [MODE].

You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

Data Selection

Data Selection allows you to select which types of data are stored and made available when you offload your datalog to a computer via ProRAE Studio software.

You can choose any or all of three types of data (you must choose at least one):

- Average
- Maximum
- Minimum

1. Press [N/-] to step from one option to the next. The highlighter indicates your choice.
2. Press [Y/+] to toggle your selection on or off (the check box indicates "on" with an "X").
3. When you have completed your selections, press [MODE].

You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

Datalog Type

The instrument has three datalog types:

Auto	Default mode. Collects datalog information when the instrument is sampling.
Manual	Datalogging occurs only when the instrument's datalogging is manually started (see below for details).
Snapshot	Datalogs only during single-event capture sampling.

Note: You can only choose one datalog type to be active at a time.

1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates "on").
3. When you have completed your selection, press [MODE].

You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.

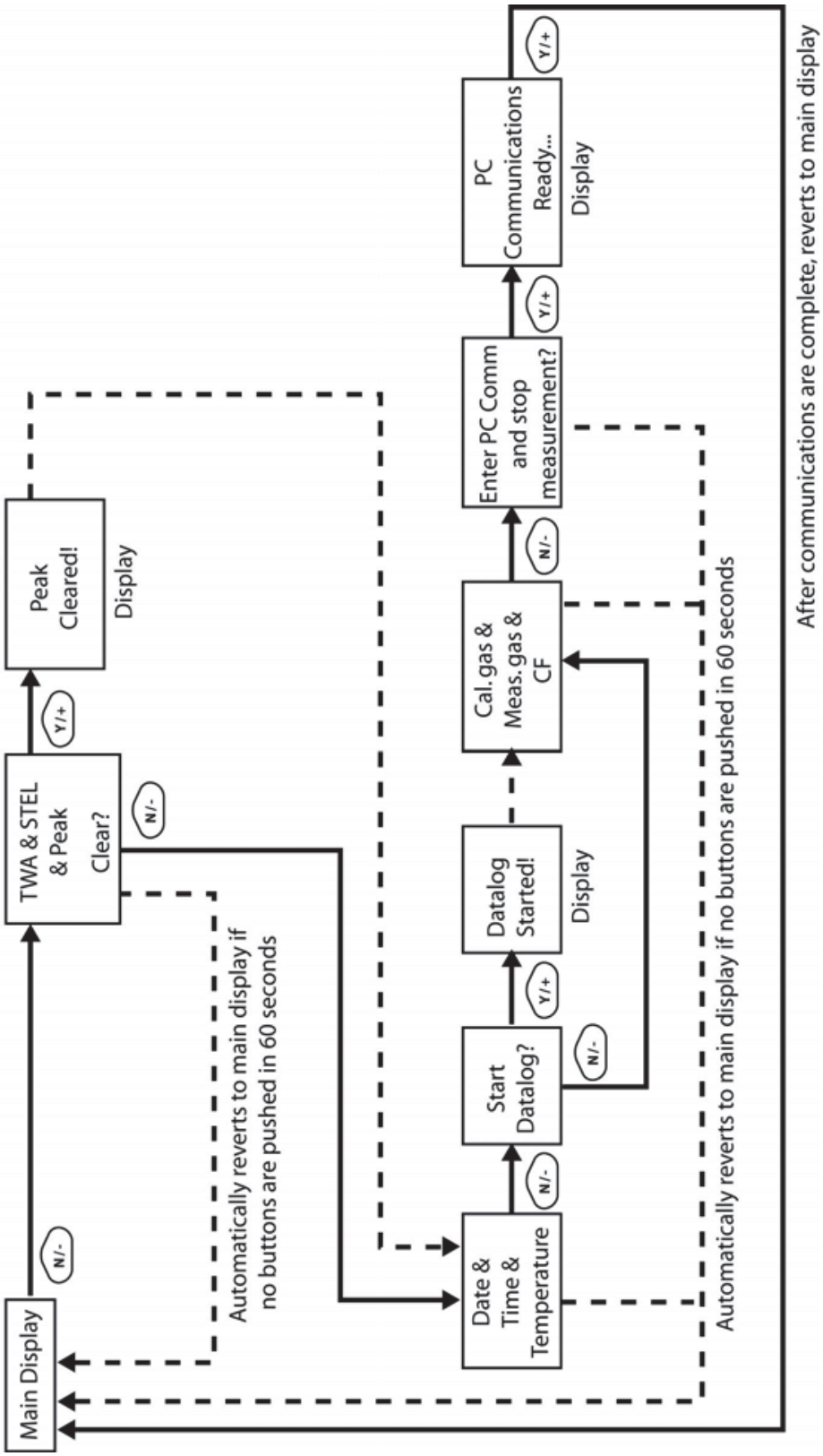
Press [N/-] to undo the changes and revert to the previous settings.

Manual Datalog

When the instrument is set to Manual Datalog, you turn datalogging on and off by stepping through the displays from the Main Display, and then pressing the keys to select datalog on/off functions.

- When you reach the screen that says "Start Datalog?" press [Y/+] to start it. You see "Datalog Started," confirming that datalogging is now on.

When you reach the screen that says "Stop Datalog?" press [Y/+] to stop it. You see "Datalog Stopped," confirming that datalogging is now off.



Note: Dashed line indicates automatic progression.

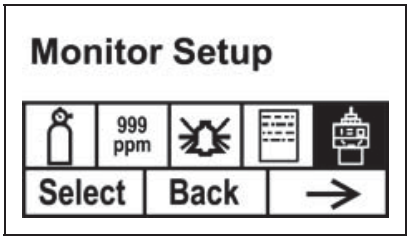
Snapshot Datalog

When the instrument is in Snapshot datalogging mode, it captures a single "snapshot" of the data at the moment of your choosing. Whenever the instrument is on and it is set to Snapshot, all you have to do is press [MODE] each time you want to capture a snapshot of the data at that instant.

When you send the data to a computer using ProRAE Studio, the data snapshots are uniquely identified by time and other parameters.

Monitor Setup

Many settings can be accessed in this menu, including setting the date and time and adjusting the pump's on/off duty cycle.



Op Mode

Under Monitor Setup is "Op Mode."

Press [Y/+] to select.

You see two options (one is highlighted):

Hygiene
Search

The current mode is indicated by a dark circle within the circle in front of either Hygiene or Search.

1. Select Hygiene or Search by pressing [N/-]. The highlighting changes from one to the other each time you press [N/-].
2. Press [Y/+] to select that mode for the instrument.
3. Press [MODE] when you want to register your selection to place the instrument in the selected mode.
4. Press [Y/+] to commit the change and exit to the Monitor Setup screen, or press [N/-] to Undo (exit to the Monitor Setup screen without changing the Mode).

Site ID

Enter an 8-digit alphanumeric/character Site ID in the programming mode. This Site ID is included in the datalog report.

1. Press [Y/+] and the display shows the current site ID. Example: "RAE00001." Note that the left-most digit flashes to indicate it is the selected one.
2. Press [Y/+] to step through all 26 letters (A to Z) and 10 numerals (0 to 9).
   Note: The last four digits must be numerals.
3. Press [N/-] to advance to the next digit. The next digit to the right flashes.

   Repeat this process until all eight digits of the new site ID are entered.

Press [MODE] to exit.

If there is any change to the existing site ID, the display shows "Save?" Press [Y/+] to accept the new site ID. Press [N/-] to discard the change and move to the next sub-menu.

User ID

Enter an 8-digit alphanumeric User ID in the programming mode. This User ID is included in the datalog report.

1. Press [Y/+] and the display shows the current User ID. Example: "RAE00001." Note that the left-most digit flashes to indicate it is the selected one.
2. Press [Y/+] to step through all 26 letters (A to Z) and 10 numerals (0 to 9).
3. Press [N/-] to advance to the next digit. The next digit to the right flashes.

   Repeat this process until all eight digits of the new User ID are entered.

Press [MODE] to exit.

If there is any change to the existing User ID, the display shows "Save" Press [Y/+] to accept the new site ID. Press [N/-] to discard (undo) the change and move to the next sub-menu.

User Mode

The instrument has two user modes:

Basic Basic users can only see and use a basic set of functions.
Advanced Advanced users can see all screens and perform all available functions.

Note: The default value for User Mode is Basic.

To change the User Mode:

1. Press [N/-] to step from one option to the next. The highlighting changes each time you press [N/-].
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates "on").
3. When you have completed your selection, press [MODE].
4. Press [Y/+] to accept the new User Mode. Press [N/-] to discard the change and move to the next sub-menu.

Date

The Date is expressed as Month/Day/Year, with two digits for each.

1. Press [Y/+] and the display shows the current date. Note that the left-most digit flashes to indicate it is selected.
2. Press [Y/+] to step through all 10 numerals (0 to 9).
3. Press [N/-] to advance to the next digit. The next digit to the right flashes.

   Repeat this process until all six digits of the new date are entered.

Press [MODE] to exit.

- Press [Y/+] to save the new date.
- Press [N/-] to undo the change and move to the next sub-menu.

Time

The Time is expressed as Hours/Minutes/Seconds, with two digits for each. The time is in 24-hour (military) format.

1. Press [Y/+] and the display shows the current time. Note that the left-most digit flashes to indicate it is selected.
2. Press [Y/+] to step through all 10 numerals (0 to 9).

3. Press [N/-] to advance to the next digit. The next digit to the right flashes.

   Repeat this process until all six digits of the new time are entered.

Press [MODE] to exit.

- Press [Y/+] to save the new date.
- Press [N/-] to undo the change and move to the next sub-menu.

Duty Cycle

The pump's duty cycle is the ratio of its on time to off time. The duty cycle ranges from 50% to 100% (always on), and the period is 10 seconds. Therefore, a duty cycle of 60% means that the pump is on for 6 seconds and off for four seconds. Duty cycling is employed by the instrument to clean the PID. A lower duty cycle has a greater effect on keeping the PID clean than a higher duty cycle.

Important! Pump duty cycling is interrupted when the instrument senses a gas. The pump's duty cycle is disabled when the measurement is greater than the 2ppm threshold and is re-enabled when the reading falls below 90% of the threshold (1.8 ppm).

1. Press [Y/+] to increase the value.
2. When you have completed your selection, press [MODE].
   - Press [Y/+] to save the new duty cycle value.
   - Press [N/-] to undo the change and move to the next sub-menu.

Temperature Unit

The temperature display can be switched between Fahrenheit and Celsius units.

1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates "on").
3. When you have completed your selection, press [MODE].
   - Press [Y/+] to save the new temperature unit.
   - Press [N/-] to undo the change and move to the next sub-menu.

Pump Speed

The pump can operate at two speeds, high and low. Running at low speed is quieter and conserves a small amount of power. There is almost no difference in sampling accuracy.

1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates "on").
3. When you have completed your selection, press [MODE].
   - Press [Y/+] to save the new temperature unit.
   - Press [N/-] to undo the change and move to the next sub-menu.

Language

English is the default language, but other languages can be selected for the instrument.

1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates "on").
3. When you have completed your selection, press [MODE].
   - Press [Y/+] to save your new language choice.
   - Press [N/-] to undo it and return to the previous language selection.

Radio Power

The radio connection can be turned on or off.

1. Press [N/-] to step from one option to the next (on or off).
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates that the option is selected).
3. When you have completed your selection, press [MODE].

   - Press [Y/+] to accept the new radio setting (on or off).
   - Press [N/-] to discard the change and move to the next sub-menu.

Real Time Protocol

Real Time Protocol is the setting for data transmission.

The choices are:

P2M (cable)	Point to multipoint. Data is transferred from the instrument to multiple locations using a wired connection. Default data rate: 19200 bps.
P2P (cable)	Point to point. Data is transferred only between the instrument and one other location, such as a computer. Default data rate: 9600 bps.
P2M (wireless)	Point to multipoint, wireless. Data is transferred wirelessly and can be received by multiple receivers.

1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates "on").
3. When you have completed your selection, press [MODE].
   - Press [Y/+] to save the new real-time communications protocol.
   - Press [N/-] to undo the change and move to the next sub-menu.

Power On Zero

When Power On Zero is on, the instrument performs a zero calibration when it is turned on.

1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates your selection).
3. When you have completed your selection, press [MODE].
   - Press [Y/+] to save the change.
   - Press [N/-] to discard the change and move to the next sub-menu.

Unit ID

This three-digit number keeps data separated by instrument when more than one instrument is used in a network. If multiple sensing units are attempting to communicate with the same Host, then the units must all have a different Unit ID.

1. Press [Y/+] to step through all 10 numerals (0 to 9). If you pass the numeral you want, keep pressing [Y/+]. After it counts up to 9, it starts counting up from 0 again.
2. Press [N/-] to advance to the next digit. The next digit to the right flashes.

Repeat this process until all three digits of the Unit ID are entered.

3. Press [MODE] when you are done.
   - Press [Y/+] to save the change.
   - Press [N/-] to discard the change and move to the next sub-menu.

LCD Contrast

The display's contrast can be increased or decreased from its default setting. You may not need to ever change the default setting, but sometimes you can optimize the display to suit extreme temperature and ambient brightness/darkness conditions.

- The minimum value is 20.
- The maximum value is 60.

1. Press [Y/+] to increase the value or [N/-] to decrease the value.
2. Press [MODE] to save your selection.
   - Press [Y/+] to save your new contrast value.
   - Press [N/-] to undo it and return to the previous value.

Hygiene Mode

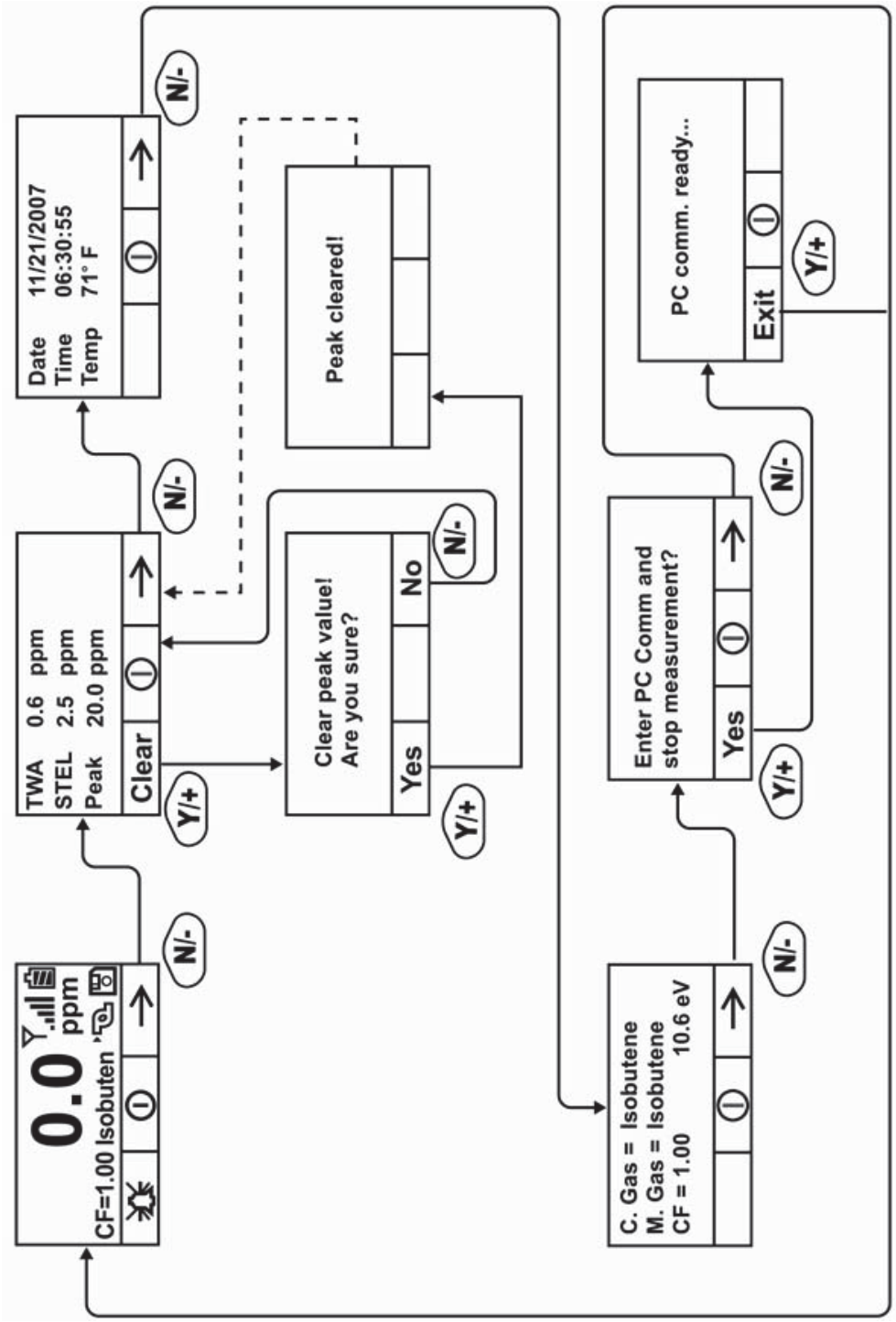
The instrument usually operates in Hygiene Mode, which provides basic functionality. However, it is possible to operate it in a second mode called Search Mode. Here are the primary differences:

Hygiene Mode: Automatic measurements, continuously running and datalogging, and calculates additional exposure values.

Search Mode: Manual start/stop of measurements and display of certain exposure values.

Basic User Level & Hygiene Mode

The default setting is navigated in the following way:



Note: Dashed line indicates automatic progression.

Pressing [N/-] steps you from screen to screen. Options include clearing the Peak value and turning on the instrument's PC Communications for data transfer to a PC.

Entering Search Mode From Hygiene Mode

In order to change the instrument's operational mode from Hygiene Mode to Search Mode, you must enter the password-protected Programming Mode:

1. Hold [MODE] and [N/-] until you see the password screen.
2. Use [Y/+] to increment to the number you want for the first digit. (If you pass by the desired number, press [Y/+] until it cycles through to 0 again. Then press [Y/+] until you reach the desired number.)
3. Press [N/-] to advance to the next digit.
4. Again press [Y/+] to increment the number.
5. Press [N/-] to advance to the next digit.

Continue the process until all four numbers of the password have been input. Then press [MODE] to proceed.

The screen changes to icons with the label "Calibration."

1. Press [N/-] to advance to "Monitor Setup."
2. Press [Y/+] to select Monitor Setup.

Under Monitor Setup, you will see "Op Mode."

Press [Y/+] to select.

You will see:

Hygiene
Search

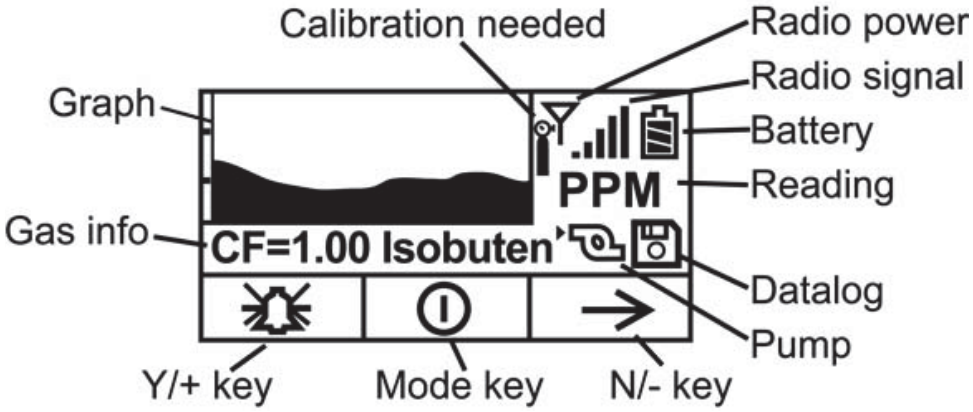
The current mode is indicated by a dark circle within the circle in front of either Hygiene or Search.

1. Select Hygiene or Search by pressing [N/-].
2. Press [Y/+] to place the instrument into the selected mode.

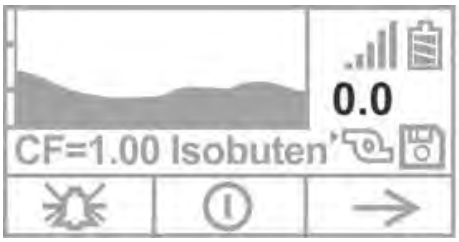
3. Press [MODE] when you want to register your selection to place the instrument in the selected mode.
4. Press [Y/+] to commit the change and exit to the Monitor Setup screen, or press [N/-] to Undo (exit to the Monitor Setup screen without changing the Mode).

Optional Graphic Screen In Search Mode

Using ProRAE Studio, you can set your instrument to show a graphic display instead of a numeric display of ongoing data. Consult your ProRAE Studio disc for information.



During sampling, the display's readings are shown numerically, plus the graph tracks the highest readings over time. The numeric reading alternates between the value and the measurement units, as well:



Advanced User Level (Hygiene Mode Or Search Mode)

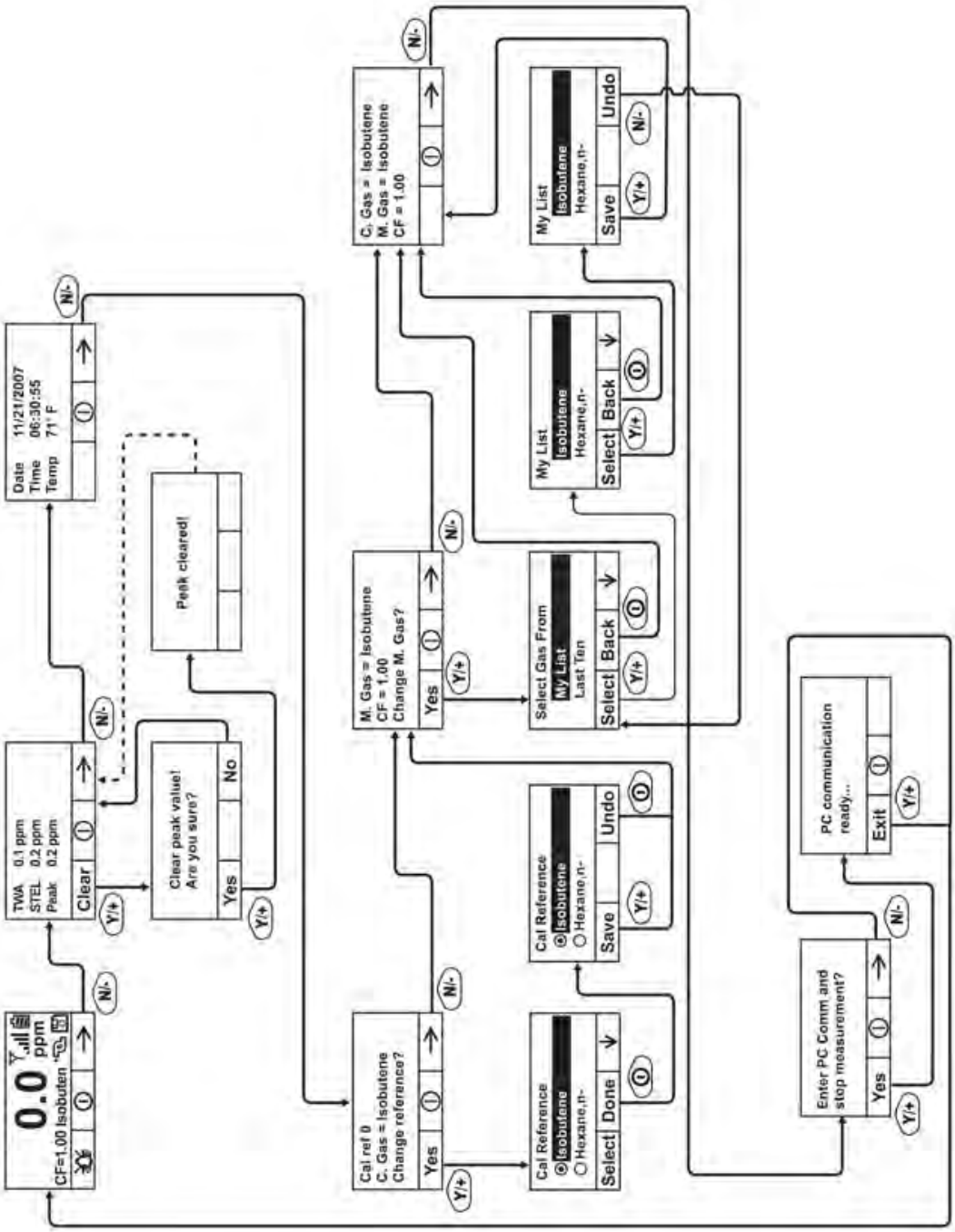
The User Mode called Advanced User Level allows a greater number of parameters to be changed than Basic User Level. It can be used with either of the Operation Modes, Hygiene Mode or Search Mode.

Advanced User Level & Hygiene Mode

With the instrument in Operation Mode: Hygiene Mode, enter User Mode: Advanced User Level (refer to the section called Monitor Mode for instructions).

Once you are in Advanced User Level and Hygiene Mode together, you can change the calibration reference and measurement gas, in addition to performing normal monitoring functions.

Pressing [N/-] progresses through the screens, while pressing [Y/+] selects options. Pressing [MODE] makes menu choices when it is shown for "Done" or "Back." Pressing and holding [Mode] whenever the circle with a vertical line in the middle is shown activates the countdown to shutoff.

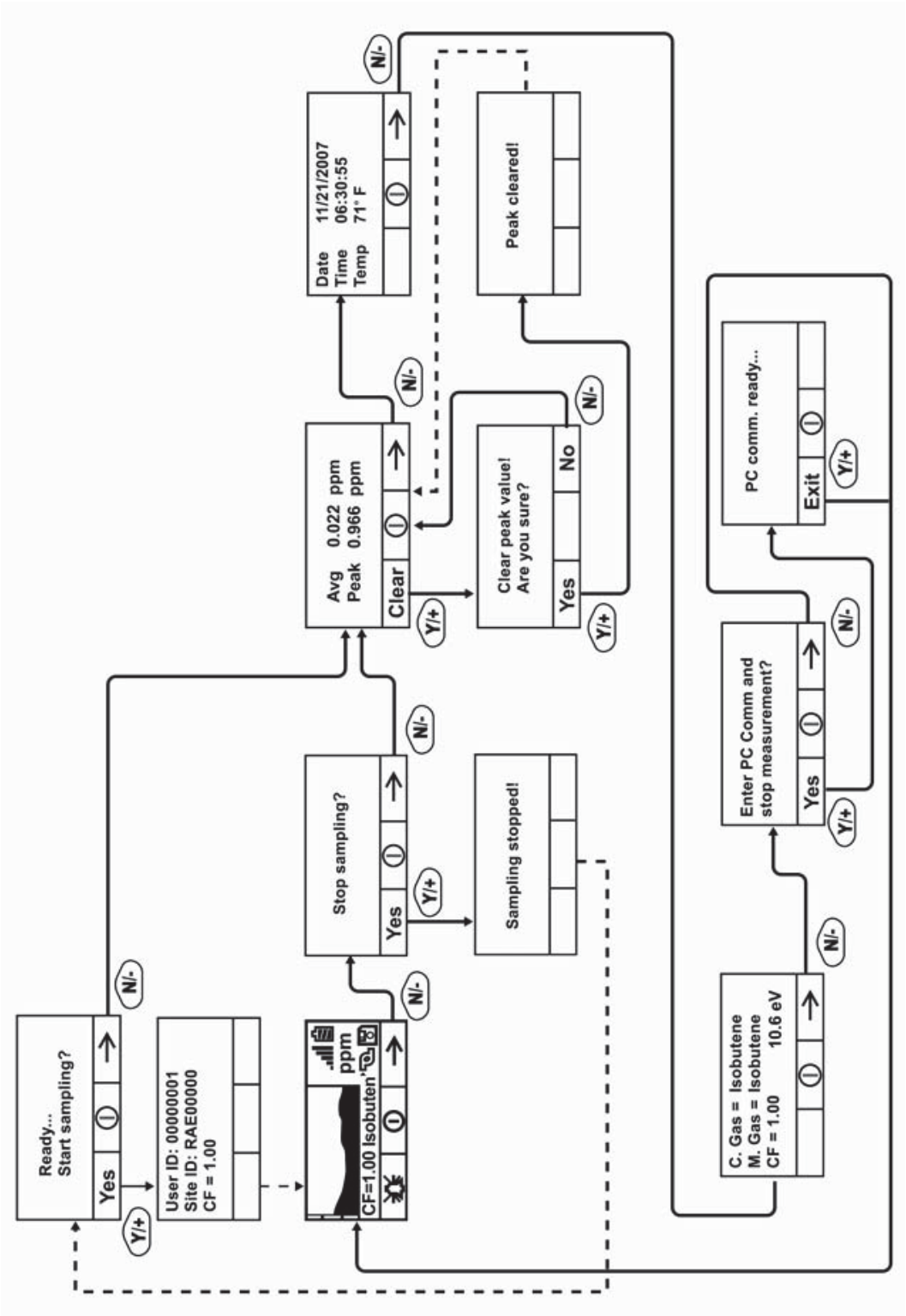


Note: Dashed line indicates automatic progression.

Basic User Level & Search Mode

With the instrument in Operation Mode: Search Mode, enter User Mode and select Basic User Level (refer to the section called User Mode for instructions).

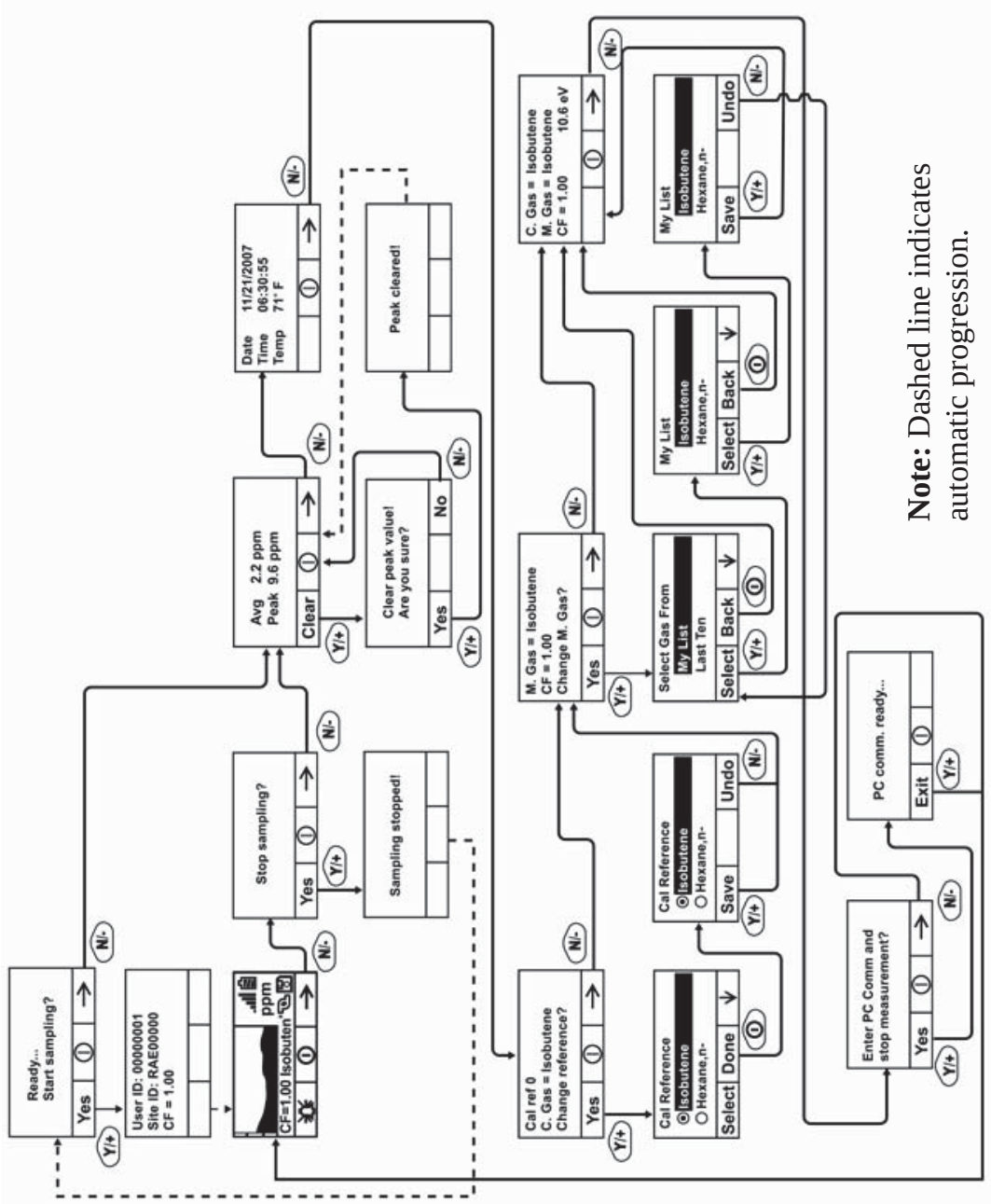
When the instrument is in Search Mode, it only samples when you activate sampling. When you see the display that says, "Ready…Start sampling?" press [Y/+] to start. The pump turns on and the instrument begins collecting data. To stop sampling, press [N/-] while the main display is showing. You will see a new screen that says, "Stop sampling?" Press [Y/+] to stop sampling. Press [N/-] if you want sampling to continue.



Note: Dashed line indicates automatic progression.

Advanced User Level & Search Mode

With the instrument in Operation Mode: Search Mode, enter User Mode and select Advanced User Level (refer to the section called Monitor Mode for instructions). Operation is similar to Basic User Level & Sampling Mode, but now allows you to change calibration and measurement reference gases. Refer to the section on measurement gases on page 52 for more details.



Note: Dashed line indicates automatic progression.

Diagnostic Mode

IMPORTANT! Diagnostic Mode is designed for servicing and manufacturing, and therefore is not intended for everyday use, even by advanced users. It provides raw data from sensors and about settings, but only allows adjustment of pump stall parameters, which should only be changed by qualified personnel.

Note: If the instrument is turned on in Diagnostic Mode and you switch to User Mode, datalog data remains in raw count form. To change to standard readings, you must restart the instrument.

Entering Diagnostic Mode

Note: To enter Diagnostic Mode, you must begin with the instrument turned off.

Press and hold [Y/+] and [MODE] until the instrument starts.

The instrument goes through a brief startup, and then displays raw data for the PID sensor. These numbers are raw sensor readings without calibration. The instrument is now in Diagnostic Mode.

Note: In Diagnostic Mode, the pump and lamp are normally on.

You can enter Programming Mode and calibrate the instrument as usual by pressing both [MODE] and [N/-] for three seconds.

You can enter Monitoring Mode by pressing [MODE] and [Y/+] together for three seconds.

Once the instrument is started up in Diagnostic Mode, you can switch between Diagnostic Mode and Monitoring Mode by pressing and holding [MODE] and [Y/+] simultaneously for two seconds.

In Diagnostic mode, you can step through parameter screens by pressing [MODE].

Adjusting The Pump Stall Threshold

If the gas inlet is blocked but the pump does not shut down, or the pump shuts down too easily with a slight blockage, the pump stall threshold value may be set too high or too low.

Use the following steps to adjust the pump stall threshold:

Pump High

In Diagnostic Mode, press the [MODE] key until "Pump High" is displayed. The display shows the maximum, minimum, and stall values for the pump at its high speed. Write down the "Max" reading.

Block the gas inlet and watch the pump current reading (labeled "I") increase. Write down its blocked reading. **Note:** If the pump current reading does not increase significantly (less than 10 counts), then there may be a leak in the gas inlet or the pump is weak or defective.

Add the two readings you wrote down. This is the average of the maximum block count and the maximum idle count. Divide that number by 2. Use the [Y/+] or [N/-] key to increase or decrease the stall value to equal that number.

Press the [MODE] key to exit this display.

Pump Low

In Diagnostic Mode, press the [MODE] key until "Pump Low" is displayed. The display shows the maximum, minimum, and stall values for the pump at its low speed. Write down the "Max" reading.

Block the gas inlet and watch the pump current reading (labeled "I") increase. Write down its blocked reading. **Note:** If the pump current reading does not increase significantly (less than 10 counts), then there may be a leak in the gas inlet or the pump is weak or defective.

Add the two readings you wrote down. This is the average of the maximum block count and the maximum idle count. Divide that

number by 2. Use the [Y/+] or [N/-] key to increase or decrease the stall value to equal that number.

Press the [MODE] key to exit this display.

Exiting Diagnostic Mode

You can exit Diagnostic Mode and go directly to Programming Mode or Monitor Mode as outlined above, or you can exit Diagnostic Mode completely.

To exit Diagnostic Mode so that it cannot be re-entered without a restart:

Shut down the instrument. When it is off, restart it by holding the [MODE] key. Diagnostic Mode cannot be entered until the instrument is restarted as outlined in "Entering Diagnostic Mode."

Transferring Data To & From A Computer

Once you have connected your instrument cradle to the PC, you can can transfer data, including a download of the datalog to the computer and updates of firmware to the instrument (should this ever be necessary).

Downloading The Datalog To A PC

1. Connect the data cable to the PC and the cradle.
2. Place the instrument into its cradle. The charging LED should be illuminated.
3. Start ProRAE Studio on your PC.
4. From ProRAE Studio, select "Operation" and select Setup Connection.
5. Select the COM port to establish a communication link between the PC and the instrument.
6. To receive the datalog in the PC, select "Downlog Datalog."
7. When you see "Unit Information," click OK.

During the data transfer, the display shows a progress bar.

When the transfer is done, you will see a screen with the datalog information. You can now export this datalog for other use or printing.

Uploading Firmware To The instrument From A PC

Uploading new firmware to your instrument requires connecting the instrument and PC. Follow these steps to make the connection:

1. Connect the data cable to the PC and the cradle.
2. Place the instrument into its cradle. The charging LED should be illuminated.
3. Start RAEProgrammer 7000 on your PC.
4. From RAEProgrammer 7000, select "Operation" and select Setup Connection.
5. Select the COM port to establish a communication link between the PC and the instrument.
6. Select Operation → Download Firmware.

Once communication is established, follow the instructions that accompany RAEProgrammer 7000 and the firmware to upload the new firmware to your instrument.

Note: Check for the latest updates to ProRAEProgrammer 7000 at www.raesystems.com.

Maintenance

The major maintenance items of the instrument are:

- Battery pack
- Sensor module
- PID lamp
- Sampling pump
- Inlet connectors and filters

Note: Maintenance should be performed by qualified personnel only.

NOTE: The printed circuit board of the instrument is connected to the battery pack even if the power is turned off. **Therefore, it is very important to disconnect the battery pack before servicing or replacing any components inside the instrument**. **Severe damage to the printed circuit board or battery may occur if the battery pack is not disconnected before servicing the unit.**

Battery Charging & Replacement

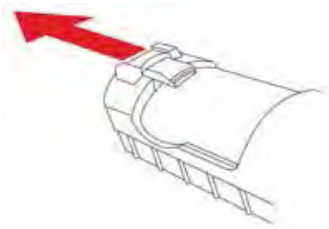
When the display shows a flashing empty battery icon, the battery requires recharging. It is recommended to recharge the instrument upon returning from fieldwork. A fully charged battery runs a instrument for 16 hours continuously. The charging time is less than 8 hours for a fully discharged battery. The battery may be replaced in the field (in areas known to be non-hazardous), if required.

WARNING!

To reduce the risk of ignition of hazardous atmospheres, recharge battery only in area known to be non-hazardous. **Remove and replace battery only in areas known to be non-hazardous.**

Replacing The Li-ion Battery

1. Turn off the instrument.
2. Located on the rear of the instrument is a battery tab. Slide it down to unlock the battery.



3. Remove the battery pack from the battery compartment by tilting it out.

4. Replace a fully charged spare battery pack inside the battery compartment. Make sure the battery pack is oriented properly inside the compartment.
5. Slide the capture tab back up to its locked position.

Replacing The Alkaline Battery Adapter

An alkaline battery adapter is supplied with each instrument. The adapter (part number 059-3052-000) accepts four AA alkaline batteries (use only Duracell MN1500) and provides approximately 12 hours of operation. The adapter is intended to be used in emergency situations when there is no time to charge the Li-ion battery pack.

To insert batteries into the adapter:

1. Remove the three Philips-head screws to open the compartment.
2. Insert four fresh AA batteries as indicated by the polarity (+/-) markings.
3. Replace the cover. Replace the three screws.

To install the adapter in the instrument:

1. Remove the Li-ion battery pack from the battery compartment by sliding the tab and tilting out the battery.
2. Replace it with the alkaline battery adapter
3. Slide the tab back into place to secure the battery adapter.

IMPORTANT!

Alkaline batteries cannot be recharged. The instrument's internal circuit detects alkaline batteries and will not allow recharging. If you place the instrument in its cradle, the alkaline battery will not be recharged. The internal charging circuit is designed to prevent damage to alkaline batteries and the charging circuit when alkaline batteries are installed inside the instrument.

Note: When replacing alkaline batteries, dispose of old ones properly.

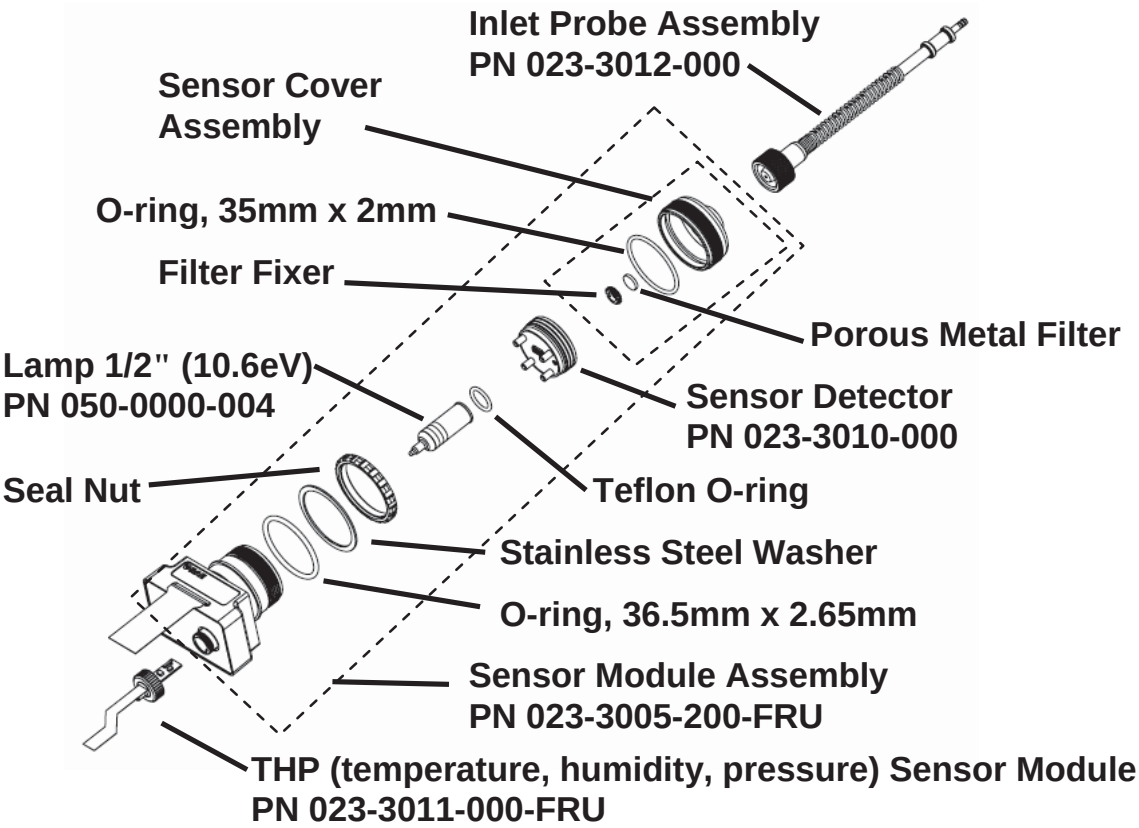
WARNING!

To reduce the risk of ignition of hazardous atmospheres, recharge the battery only in areas known to be non-hazardous. Remove and replace the battery only in areas known to be non-hazardous.

Note: The internal charging circuit is designed to prevent charging to alkaline batteries.

PID Sensor & Lamp Cleaning/Replacement

The sensor module is made of several components and is attached to the lamp-housing unit as shown below.



Sensor Components

Note: The cleaning procedure is not normally needed. Clean the PID sensor module, the lamp and the lamp housing only if:

1. The reading is inaccurate even after calibration.
2. The reading is very sensitive to air moisture.
3. A liquid has been sucked into the unit and damaged the unit.

Use of the external filter helps to prevent contamination of the sensor.

To access the sensor components and lamp, gently unscrew the lamp-housing cap, remove the sensor adapter with the gas inlet probe and the metal filter all together. Then hold the PID sensor and pull it straight out. A slight, gentle rocking motion helps release the sensor.

Cleaning The PID Sensor

Place the entire PID sensor module into GC grade methanol. It is highly recommended that an ultrasound bath to be used to clean the sensor for at least 15 minutes. Then dry the sensor thoroughly. Never touch the electrodes of the sensor by hand.
Also use a methanol-soaked cotton swab to wipe off the lamp housing where it contacts the sensor when the sensor is installed.

Turn over the sensor so that the pins point up and the sensor cavity is visible. Examine the sensor electrodes for any corrosion, damage, or bending out of alignment. The metal sensor electrode "fingers" should be flat and straight. If necessary, carefully bend the sensor fingers to ensure that they do not touch the Teflon portions and that they are parallel to each other. Make sure that the nuts on the sensor pins are snug but not overtight. If the sensor is corroded or otherwise damaged, it should be replaced.

Cleaning The Lamp Housing Or Changing The Lamp

If the lamp does not turn on, the instrument will display an error message to indicate replacement of the lamp may be required.

1. If the lamp is operational, clean the lamp window surface and the lamp housing by wiping it with GC grade methanol using a cotton swab using moderate pressure. After cleaning, hold the lamp up to the light at an angle to detect any remaining film. Repeat the process until the lamp window is clean. Never use water solutions to clean the lamp. Dry the lamp and the lamp housing thoroughly after cleaning.

   CAUTION: Never touch the window surface with the fingers or anything else that may leave a film. Never use acetone or aqueous solutions.

2. If the lamp does not turn on, remove the lamp from the lamp housing. Place the lamp O-ring onto the new lamp. Insert the new lamp, avoiding contact with the flat window surface.

3. Reinstall the PID sensor module.

4. Tighten the Lamp Housing Cap.

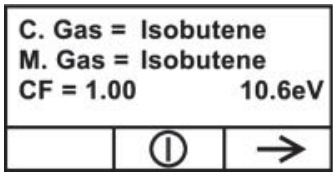
Determining The Lamp Type

The monitor can accommodate three lamp values: 10.6eV (standard), 9.8eV, and 11.7eV. The monitor automatically reads a marking on the side of the lamp to set the proper Correction Factor. There are two ways to determine the lamp type:

Remove the lamp and look for markings (bars) on the side:

- No bars: 10.6eV
- 1 bar: 11.7eV
- 2 bars: 9.8eV

Also, when the monitor is running, the lamp type is shown along with the calibration and measurement gas and Correction Factor:



Note: This screen can be accessed from the reading screen by pressing [N/-] four times.

Sampling Pump

When approaching the end of the specified lifetime of the pump, it will consume higher amount of energy and reduce its sample draw capability significantly. When this occurs, it is necessary to replace or rebuild the pump. When checking the pump flow, make sure that the inlet connector is tight and the inlet tubing is in good condition. Connect a flow meter to the gas inlet probe. The flow rate should be above 450 cc/min when there is no air leakage.

If the pump is not working properly, refer the instrument to qualified service personnel for further testing and, if necessary, pump repair or replacement.

Cleaning The Instrument

Occasional cleaning with a soft cloth is recommended. Do not use detergents or chemicals.

Visually inspect the contacts at the base of the instrument, on the battery, and on the charging cradle to make sure they are clean. If they are not, wipe them with a soft, dry cloth. Never use solvents or cleaners.

Ordering Replacement Parts

If you need replacement parts, contact your local RAE Systems distributor. A list is available online:

http://www.raesystems.com

In the U.S., you can order sensors, replacement batteries, and other accessories online at:

http://istore.raesystems.com/

Special Servicing Note

If the instrument needs to be serviced, contact either:

1. The RAE Systems distributor from whom the instrument was purchased; they will return the instrument on your behalf.

   or

2. The RAE Systems Technical Service Department. Before returning the instrument for service or repair, obtain a Returned Material Authorization (RMA) number for proper tracking of your equipment. This number needs to be on all documentation and posted on the outside of the box in which the instrument is returned for service or upgrade. Packages without RMA Numbers will be refused at the factory.

Troubleshooting

Problem	Possible Reasons & Solutions	
Cannot turn on power after charging the battery	**Reasons:**	Discharged battery. Defective battery.
	Solutions:	Charge or replace battery.
Lost password	**Solutions:**	Call Technical Support at +1 408-752-0723 or toll-free at +1 888-723-4800
Reading abnormally High	**Reasons:**	Dirty filter. Dirty sensor module. Excessive moisture and water condensation. Incorrect calibration.
	Solutions:	Replace filter. Blow-dry the sensor module. Calibrate the unit.
Reading abnormally Low	**Reasons:**	Dirty filter. Dirty sensor module. Weak or dirty lamp. Incorrect calibration.
	Solutions:	Replace filter. Remove Calibration Adapter. Calibrate the unit. Check for air leakage.
Buzzer Inoperative	**Reasons:**	Bad buzzer.
	Solutions:	Check that buzzer is not turned off. Call authorized service center.

Inlet flow too low	**Reasons:**	Pump diaphragm damaged or has debris. Flow path leaks.
	Solutions:	Check flow path for leaks; sensor module O-ring, tube connectors, Teflon tube compression fitting. Call Technical Support at +1 408-752-0723 or toll-free at +1 888-723-4800
"Lamp" message during operation	**Reasons:**	Lamp drive circuit. Weak or defective PID lamp, defective.
	Solutions:	Turn the unit off and back on. Replace UV lamp

Technical Support

To contact RAE Systems Technical Support Team:

Monday through Friday, 7:00AM to 5:00PM Pacific (US) Time
Phone (toll-free): +1 888-723-4800
Phone: +1 408-952-8461
Email: tech@raesystems.com

Life-critical after-hours support is available:

+1 408-952-8200 select option 8

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Fax: 82-32-328-7127
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Controlled Part of Manual

Intrinsic Safety:
US and Canada: Class I, Division 1, Groups A,B,C,D T4

Europe: ATEX (0575 Ex II 2G Ex ia IIC/IIB T4 Gb)
KEMA 07 ATEX 0127
Complies with EN60079-0:2009, EN60079-11:2007
IECEx CSA 10.0005 Ex ia IIC/IIB T4 Gb
Complies with IEC 60079-0:2007, IEC 60079-11:2006

Temperature: -20º C to 50º C (-4º to 122º F)

Humidity: 0% to 95% relative humidity (non-condensing)

Basic Operation

Turning The Instrument On

1. With the instrument turned off, press and hold [MODE].
2. When the display turns on, release the [MODE] key.

The instrument is now operating and performs self tests. Once the self tests are complete, the display shows a graph or numerical gas reading. This indicates that the instrument is fully functional and ready to use.

Turning The Instrument Off

1. Press and hold the Mode key for 3 seconds. A 5-second countdown to shutoff begins.
2. When you see "Unit off..." release your finger from the [MODE] key. The instrument is now off.

Note: You must hold your finger on the key for the entire shutoff process. If you remove your finger from the key during the countdown, the shutoff operation is canceled and the instrument continues normal operation.

Alarm Signals

During each measurement period, the gas concentration is compared with the programmed alarm limits (gas concentration alarm limit settings). If the concentration exceeds any of the preset limits, the loud buzzer and red flashing LED are activated immediately to warn you of the alarm condition.

In addition, the instrument alarms if one of the following conditions occurs: battery voltage falls below a preset voltage level, failure of the UV lamp, pump stall, or when the datalog memory is full.

Alarm Signal Summary

Message	Condition	Alarm Signal
HIGH	Gas exceeds "High Alarm" limit	3 beeps/flashes per second*
OVR	Gas exceeds measurement range	3 beeps/flashes per second*
MAX	Gas exceeds electronics' maximum range	3 beeps/flashes per second*
LOW	Gas exceeds "Low Alarm" limit	2 beeps/flashes per second*
TWA	Gas exceeds "TWA" limit	1 Beep/flash per second*
STEL	Gas exceeds "STEL" limit	1 Beep/flash per second*
Pump icon flashes	Pump failure	3 beeps/flashes per second
Lamp	PID lamp failure	3 beeps/flashes per second plus "Lamp" message on display

Battery icon flashes	Low battery	1 flash, 1 beep per minute plus battery icon flashes on display
CAL	Calibration failed, or needs calibration	1 beep/flash per second
NEG	Gas reading measures less than number stored in calibration	1 beep/flash per second

Preset Alarm Limits & Calibration

The instrument is factory calibrated with standard calibration gas, and is programmed with default alarm limits.

Cal Gas (Isobutylene)	Cal Span	unit	Low	High	TWA	STEL
ppbRAE 3000	10	ppm	10	25	10	25
MiniRAE 3000	100	ppm	50	100	10	25
MiniRAE Lite	100	ppm	50	100	10	25
UltraRAE 3000	100	ppm	50	100	10	25

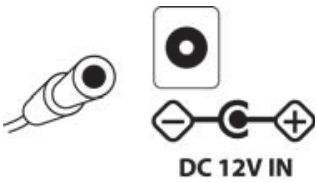
Charging The Battery

Always fully charge the battery before using the instrument. The instrument's Li-ion/NiMH battery is charged by placing the instrument in its cradle. Contacts on the bottom of the instrument meet the cradle's contacts, transferring power without other connections.

Note: Before setting the instrument into its charging cradle, visually inspect the contacts to make sure they are clean. If they are not, wipe them with a soft cloth. Do not use solvents or cleaners.

Follow this procedure to charge the instrument:

1. Plug the AC/DC adapter's barrel connector into the instrument's cradle.



2. Plug the AC/DC adapter into the wall outlet.
3. Place the instrument into the cradle, press down, and lean it back. It locks in place and the LED in the cradle glows.

Note: To release the instrument, press down and tilt the top out of the cradle and lift up.

The instrument begins charging automatically. The LED on the front of the cradle marked "Primary" blinks during charging. During charging, the diagonal lines in the battery icon on the instrument's display are animated and you see the message "Charging..."

When the instrument's battery is fully charged, the battery icon is no longer animated and shows a full battery. The message "Fully charged!" is shown and the Primary LED on the cradle glows continuously green.

Note: A spare Li-ion battery (059-3051-000) or NiMH(059-3054-000) can be charged by placing it directly in the charging port on the back of the cradle. It can be charged at the same time as the instrument. Press the battery in place, sliding it slightly toward the front of the cradle. This locks it in the cradle. To release the battery, slide it forward again and tilt it up.

Note: An Alkaline Battery Adapter (part number 059-3052-000), which uses four AA alkaline batteries (Duracell MN1500), may be substituted for the Li-Ion battery.

WARNING!

To reduce the risk of ignition of hazardous atmospheres, recharge and replace batteries only in areas known to be non-hazardous. **Remove and replace batteries only in areas known to be non-hazardous.**

Low Voltage Warning

When the battery's charge falls below a preset voltage, the instrument warns you by beeping once and flashing once every minute, and the battery icon blinks once per second. You should turn off the instrument within 10 minutes and either recharge the battery by placing the instrument in its cradle, or replace the battery with a fresh one with a full charge.

Clock Battery

An internal clock battery is mounted on one of the instrument's printed circuit boards. This long-life battery keeps settings in memory from being lost whenever the Li-ion, NiMH, or alkaline batteries are removed. This backup battery should last approximately five years, and must be replaced by an authorized RAE Systems service technician. It is not user-replaceable.

WARNING

To reduce the risk of ignition of hazardous atmospheres, recharge battery only in area known to be non-hazardous. Remove and replace battery only in an area known to be non-hazardous.

Replacing Rechargeable Li-Ion or NiMH Battery

Caution: Turn off the instrument before removing or replacing the battery.

Alkaline Battery Adapter

An alkaline battery adapter is supplied with each instrument. The adapter (part number 059-3052-000) accepts four AA alkaline batteries (use only Duracell MN1500).

Do not mix old and new batteries or different type batteries.

Troubleshooting

Problem	Possible Reasons & Solutions	
Cannot turn on power after charging the battery	**Reasons:**	Discharged battery. Defective battery.
	Solutions:	Charge or replace battery.
Lost password	**Solutions:**	Call Technical Support at +1 408-752-0723 or toll-free at +1 888-723-4800
Reading abnormally High	**Reasons:**	Dirty filter. Dirty sensor module. Excessive moisture and water condensation. Incorrect calibration.
	Solutions:	Replace filter. Blow-dry the sensor module. Calibrate the unit.
Reading abnormally Low	**Reasons:**	Dirty filter. Dirty sensor module. Weak or dirty lamp. Incorrect calibration.
	Solutions:	Replace filter. Remove Calibration Adapter. Calibrate the unit. Check for air leakage.
Buzzer Inoperative	**Reasons:**	Bad buzzer.
	Solutions:	Check that buzzer is not turned off. Call authorized service center.

Inlet flow too low	**Reasons:**	Pump diaphragm damaged or has debris. Flow path leaks.
	Solutions:	Check flow path for leaks; sensor module O-ring, tube connectors, Teflon tube compression fitting. Call Technical Support at +1 408-752-0723 or toll-free at +1 888-723-4800
"Lamp" message during operation	**Reasons:**	Lamp drive circuit. Weak or defective PID lamp, defective.
	Solutions:	Turn the unit off and back on. Replace UV lamp

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Rev. C
August 2010
P/N 059-4020-000

STANDARD OPERATING PROCEDURE

General Guidance for Monitoring Well Installation

I. Purpose

To provide site personnel with a review of the well installation procedures that will be performed. These procedures are to be considered general guidelines only and are in no way intended to supplement or replace the contractual specifications in the driller's subcontract.

II. Scope

Monitoring well installations are planned for shallow and/or deep unconsolidated aquifers and/or for bedrock aquifers. The SOPs *Installation of Shallow Monitoring Wells, Installation of Surface-Cased Monitoring Wells, Installation of Bedrock Monitoring Wells,* and *Installation of Monitoring Wells Using Sonic Drilling* provide more specifics.

III. Equipment and Materials

1. Drilling rig (hollow stem auger, sonic, air hammer, air rotary, or mud rotary)
2. Well-construction materials (i.e., surface casing, screens, riser, casing, caps, bottom plugs, centering guides, sand, bentonite, grout, and surface-finish materials)
3. Development equipment

IV. Procedures and Guidelines

1. Wells will be installed in accordance with standard EPA procedures. Note that USEPA Region III requires any well penetrating a confining layer to be double-cased.
2. The threaded connections will be water-tight.
3. Well screens generally will be constructed of 10-slot or 20-slot Schedule 40 PVC and will be 5 to 10 feet in length depending on saturated thickness of unconsolidated sediments. The exact slot size and length will be determined by the field team supervisor. Stainless steel may be required under certain contaminant conditions.
4. Stick-up wells will be surrounded by four concrete-filled guard posts at least 2 inches in diameter.

5. A record of the finished well construction will be compiled.

6. All soils and liquids generated during well installations will be drummed for proper disposal.

Monitoring Well Installation

- 2″ monitoring wells in unconsolidated materials will be installed in at least 6-inch-diameter boreholes to accommodate well completion materials in designated locations.
- All monitoring wells penetrating a confining layer will be surface-cased from the ground surface to approximately 5 feet into the confining layer. Exceptions to this may be allowed under certain circumstances (e.g., evidence of significant natural gaps in the confining layer).
- Monitoring wells in unconsolidated materials will be constructed of 2-inch-diameter, factory manufactured, flush-jointed, Schedule 40 PVC (or stainless steel) screen with threaded bottom plug and riser.
- Screens will be filter packed with a properly sized and graded, thoroughly washed, sound, durable, well-rounded basalt or siliceous sand. When using hollow-stem augers, the filter pack will be installed by slowly pouring the sand into the annular space while simultaneously raising the augers and using a weighted tape to sound for the sand surface. For rotary-drilled wells, the height of the sand pack also will be sounded with a weighted tape.
- The primary filter sand pack (typically Morie #00 or DSI #1 for a 10-slot screen) will extend from 1 to 2 feet below the base to 2 feet above the top of the screen; filter pack will be allowed to settle before final measurement is taken. For wells deeper than 30 feet, the filter pack will be placed using a tremie pipe and flowing water.
- A secondary filter sand pack (typically a fine sand seal) 1-foot thick may be placed above the primary sand pack.
- Annular well seals will consist of 2 feet of pelletized, chip, or granular bentonite clay placed above the filter pack. If necessary the pellets will be hydrated using potable water. For wells installed using hollow-stem augers, the bentonite will be poured into the annular space while slowly raising the augers and sounding for the top of the bentonite with a weighted tape. A high-solids bentonite slurry using powdered bentonite introduced with a side-discharging tremie pipe will be used for the bentonite seals in wells greater than 30 feet deep. For rotary-drilled wells, the height of the well seal also will be sounded with a weighted tape. High-solids slurries will have solids content of at least 20 percent.
- The top of the annular seal will be measured after the bentonite seal has been allowed to hydrate and before the grout is applied. The seal will be allowed to hydrate for at least 30 minutes before work in the well continues.

- The annular space above the bentonite seal will be filled to grade with a bentonite-cement slurry grout mixture.
- The grout mixture consists of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 6 pounds of bentonite added per bag of cement to reduce shrinkage.
- The grout mix will be carefully applied to avoid disturbing the bentonite seal; the method of grout placement must force grout from the top of the bentonite seal to ground surface.
- After allowing the grout to settle and set up overnight, additional grout will be added to maintain grade.
- A protective steel casing equipped with keyed alike locking caps will be grouted in place for each new well; the casing will extend at least 2 feet above grade and 3 feet below grade, and will be painted a bright color.

Well Development

- New monitoring wells will be developed after the well has been completely installed and the grout has hardened (at least 24 hours)
- The well will be developed by surging and pumping.
- Equipment placed in the well will be decontaminated before use.
- If information is available, begin developing in the least-contaminated well first.
- Development will include surging the well by either abruptly stopping flow and allowing water in the well column to fall back into the well or through the use of a surge block that is slightly smaller in diameter than the well casing inner diameter.
- Pipes and pumps must not be fitted with foot valves or other devices that might inhibit the return flow of water to the well.
- Surging should continue throughout the development process.
- The air-lift method may be used to pump materials out of the well. The air compressor will be fitted with filters to remove all oil and the air lift hose used will be made of inert materials.
- Well development will continue until the water produced is free of turbidity, sand, and silt. A Horiba-U22 meter, YSI meter with separate Hanna turbidity meter, or equivalent should be used to determine when the turbidity is low and parameters have stabilized.
- Development water will be considered hazardous and placed in sealed 55-gallon U.S. DOT approved steel drums. CH2M HILL will label and date the drums as pending analysis, and transport the drums to a designated site for storage.

V. Attachments

None.

VI. Key Check and Items

- Ensure that all equipment is properly decontaminated as needed.
- Only new, sealed materials (e.g., screens, risers, and sand) will be used in constructing the well.
- Care shall be taken when making downhole measurements to ensure that proper heights of sand, seal, and grout are achieved.

STANDARD OPERATING PROCEDURE

Groundwater Sampling from Monitoring Wells – EPA Region I and III

I. Purpose and Scope

This procedure presents general guidelines for collecting groundwater samples from monitoring wells. The procedure does not address purging and sampling using "low-flow" techniques (see SOP *Low-Flow Groundwater Sampling from Monitoring Wells – EPA Region I and III)*. Operations manuals should be consulted for specific calibration and operating procedures.

II. Equipment and Materials

- Peristaltic pump, pneumatic bladder pump, or electric submersible pump, pump shroud, tubing, support cables, air compressor, control box, and power supply
- Water quality meter, such as Horiba® U-22 or a combination of equivalent devices for monitoring pH, specific conductance, turbidity, dissolved oxygen, oxidation-reduction potential (ORP), and temperature
- Flow through cell with inlet/outlet ports for purged groundwater and watertight ports for each water quality probe
- Disposable 0.45µm filters (QED® FF8100 or equivalent), if applicable
- Bailer (Teflon or stainless steel) and nylon cord, if applicable

Note: bailers and peristaltic pumps should only be used when site access or other limitations prevent the use of sampling pumps

III. Procedures and Guidelines

A. Setup and Purging

1. Obtain information on well location, diameter(s), depth, and screened interval(s), and the method for disposal of purged water.
2. A pump will be used for well purging if the well yield is adequate; otherwise, a bailer may be used depending on project requirements.
3. Sampling equipment is cleaned and decontaminated prior to sampling in accordance with SOP *Decontamination of Personnel and Equipment*.
4. Instruments are calibrated according to manufacturer's instructions.

5. The well number, site, date, and condition are recorded in the field logbook.

6. Plastic sheeting is placed on the ground, and the well is unlocked and opened.

7. Water level measurements are collected in accordance with the *Water Level Measurement* SOP.

8. The volume (v) of water in a well casing is calculated as follows:

$$v = 7.48(\pi r^2 h)$$

where: $\pi = 3.14$
v=volume of water in well (gallons)
r = Radius of the well (feet)
h = height of water in well (feet)

The volume of water in common well casing diameters may be calculated as follows:

2-inch diameter well:
0.163 gal/ft x ___ (linear feet of water) = gallons

4-inch diameter well:
0.653 gal/ft x ___ (linear feet of water) = gallons

6-inch diameter well:
1.469 gal/ft x ___ (linear feet of water) = gallons

9. Attach tubing, support cable or rope, and air line (if applicable) to the pump. The support line should bear the weight of the pump. Set pump in the well at the desired sampling interval, typically mid-screen, and begin purging. If a bailer is being used, it is removed from its protective covering and attached to a cord compatible with constituents.

10. If a RediFlo or other similar electric submersible pump is to be used in a large diameter well (greater than 4 inches), a pump shroud should be used to direct the flow of water across the pump motor. Failure to use a shroud in this situation can lead to overheating of the motor and loss of volatiles from the pump discharge.

11. If a bailer is being used, it should be removed from its protective covering and attached to a cord compatible with the site contaminants. The bailer should be lowered into the top of the water column, allowed to fill, and removed. It is critical that bailers be slowly and gently immersed into the top of the water column, particularly during final stages of purging, to minimize turbidity and disturbance of volatile organic constituents. The use of bailers for purging and sampling is discouraged because the correct technique is highly operator dependent and improper use may result in an unrepresentative sample.

12. Field parameters including pH, ORP, turbidity, dissolved oxygen, specific conductance, and temperature are measured and recorded in the field logbook. The water quality probes are inserted into a flow-through cell. The purged groundwater is directed through the cell by connecting the pump discharge tubing to the bottom port on the flow through cell, allowing measurements to be collected before the water contacts the atmosphere.

13. During purging, the water quality parameters are measured at least once for each well volume. A minimum of three well volumes must be purged (up to 5 well volumes may be purged if water quality parameters do not stabilize) prior to sampling. In nonproductive wells, if the well is purged dry, it is <u>not necessary to remove a minimum of three well volumes</u>; however, the well should be allowed to recover sufficiently to allow collection of all samples.

14. Three to five well volumes are purged (more may be purged if parameters do not stabilize). Purging is stopped when field parameters have stabilized over three consecutive well volumes. Field Water quality parameters are considered stable when pH measurements agree within 0.1 units, specific conductance measurements agree within 3 percent, ORP measurements agree within 10 mV, dissolved oxygen measurements agree within 10 percent, and turbidity measurements agree within 10 percent or are as low as practicable given sampling conditions.

B. Sample Collection

Once purging is complete the well is ready to sample. The elapsed time between completion of purging and collection of the groundwater sample should be minimized. Typically, the sample is collected immediately after the well has been purged, but this is also dependent on well recovery.

Samples will be placed in sample containers that have been cleaned to laboratory standards and are preserved in accordance with the analytical method. The containers are typically pre-preserved, if required.

The steps to be followed for sample collection are as follows:

1. The cap is removed from the sample bottle, and the bottle is tilted slightly.

2. The sample is slowly poured from the bailer or discharged from the pump so that it runs down the inside of the sample bottle with a minimum of disturbance. The pumping rate should be reduced to approximately 100 ml per minute when sampling VOCs.

3. Inorganics, including metals, may be collected and preserved in the filtered form as well as the unfiltered form. Disposable in-line filters (0.45 micron filter), connected to the end of the sample tubing,, are typically used for field filtration. Samples are field filtered as the water

is being placed into the sample container. If a bailer is used, filtration may be driven by a peristaltic pump.

4. Adequate space is left in the bottle to allow for expansion, except for VOC vials, which are filled to the top with a positive meniscus.

5. The bottle is capped and clearly labeled.

6. Immediately upon collection, all samples for chemical analysis are to be placed in a closed container on ice unless it is not possible to do so. Although unusual and uncommon, there may be instances where it is not possible to have containers with ice at the sample location. In these instances, the samples should be placed on ice as soon as practical and during the time between collection and placing the samples on ice, the samples should be kept as cool as possible.

7. If the sample tubing or bailer is dedicated, it is returned to the well and the well is capped and locked. Nondedicated equipment is cleaned and decontaminated in accordance with the *Decontamination of Personnel and Equipment* SOP.

The following information, at a minimum, will be recorded in the log book:

1. Sample identification (site name, location, and project number; sample name/number and location; sample type and matrix; time and date; sampler's identity)

2. Sample source and source description

3. Field observations and measurements (appearance, volatile screening, field chemistry, sampling method), volume of water purged prior to sampling, number of well volumes purged, and field parameter measurements

4. Sample disposition (preservative; laboratory name, date and time sent; laboratory sample number, chain-of-custody number, sample bottle lot number)

Additional remarks

IV. Attachments

None.

V. Key Checks and Preventative Maintenance

- Use of peristaltic pumps and bailers should be avoided, if possible.
- Allow the field parameters to stabilize within the specified criteria as much as possible.
- Fill bottles for VOC samples first.

- Be sure the sample identification is properly specified.
- Maintain field equipment in accordance with the manufacturer's recommendations. This may include, but is not limited to:
  - Inspect sampling pump regularly and replace as warranted
  - Bring supplies for replacing the bladder and "O" rings if using a positive-displacement bladder pump
  - Inspect tubing regularly and replace as warranted
  - Inspect air/sample line quick-connects regularly and replace as warranted
  - Verify battery charge, calibration, and proper working order of field measurement equipment prior to initial mobilization and daily during field efforts

STANDARD OPERATING PROCEDURE

Installation of Shallow Monitoring Wells

I. Purpose and Scope

The purpose of this guideline is to describe methods for drilling and installation of shallow monitoring wells and piezometers in unconsolidated or poorly consolidated materials using hollow stem augers, air rotary, or mud rotary. Installing monitoring wells in unconsolidated materials using sonic drilling is discussed in SOP *Installation of Monitoring Wells Using Sonic Drilling.* Methods for drilling and installing bedrock monitoring wells and deep, surface-cased wells in unconsolidated materials are presented in SOPs *Installation of Bedrock Monitoring Wells* and *Installation of Surface-Cased Monitoring Wells,* respectively.

II. Equipment and Materials

Drilling

- Drilling rig (hollow stem auger, air rotary or mud rotary) and associated tools and equipment

Well Riser/Screen and Associated Materials

- Polyvinyl chloride (PVC), Schedule 40, minimum 2-inch ID, flush-threaded riser; alternatively, stainless-steel riser
- PVC, Schedule 40, minimum 2-inch ID, flush-threaded, factory slotted screen; alternatively, stainless-steel screen
- PVC bottom cap, threaded to match the well screen; alternatively, stainless steel
- PVC or stainless-steel centering guides (if used)
- Above-grade well completion: PVC well cap, threaded or push-on type, vented
- Flush-mount well completion: PVC well cap, locking, leak-proof seal
- Stainless steel to be used as appropriate

Sand

- Clean silica sand, provided in factory-sealed bags, well-rounded, containing no organic material, anhydrite, gypsum, mica, or calcareous material; primary (coarse – e.g., Morie #1) filter pack, and secondary (fine sand seal) filter pack. Grain size determined based on sediments observed during drilling.

Bentonite

- Pure, additive-free bentonite pellets or chips
- Pure, additive-free powdered bentonite
- Coated bentonite pellets; coating must biodegrade within 7 days

- Cement-Bentonite Grout: proportion of 6 to 8 gallons of water per 94-pound bag of Portland cement; 3 to 6 pounds of bentonite added per bag of cement to reduce shrinkage.

Protective Casing

- Above-grade well completion: 6-inch minimum ID black iron steel pipe with locking cover, diameter at least 2 inches greater than the well casing, painted with epoxy paint for rust protection; heavy duty lock; protective posts if appropriate
- Flush-mount well completion: Morrison 9-inch or 12-inch 519 manhole cover, or equivalent; rubber seal to prevent leakage; locking cover inside of road box

Well Development

- Surge block
- Well-development pump and associated equipment
- Calibrated meters to ensure pH, temperature, specific conductance, ORP, and dissolved oxygen of development water
- Containers (e.g., DOT-approved 55-gallon drums) for water produced from well.

III. Procedures and Guidelines

A. Drilling Method

Typically, continuous-flight hollow-stem augers with a minimum 4.25-inch inside diameter (ID) will be used to drill shallow monitoring well boreholes for 2-inch diameter monitoring wells. Alternatively, air or mud rotary may be used.

The bit of the auger is placed at the ground surface and then turned with the drilling rig. To collect split spoon samples, the auger is advanced to the top of the sampling depth, and the split-spoon sample is collected from below the auger head. The split spoon is advanced through repeated blows from a 140- or 300-pound hammer dropped from a height of 30 inches. Thin-walled tube samplers are advanced by pressing down on the rods with the weight of the drilling rig. Split-spoon samples may be collected at selected intervals for chemical analysis and/or lithologic classification. Soil sampling procedures are detailed in SOPs *Soil Boring Sampling – Split Spoons* and *Soil Sampling*.

The use of water to assist in hollow-stem auger drilling for monitoring well installation will be avoided, unless required for such conditions as running sands.

Hollow-stem augers, drilling bits, rods, split-spoon samplers, and other downhole drilling tools will be properly decontaminated prior to the initiation of drilling activities and between each borehole location. Split-spoon samplers and other downhole soil sampling equipment will also be

properly decontaminated before and after each use. SOP *Decontamination of Drill Rigs and Equipment* details proper decontamination procedures.

Drill cuttings and decontamination fluids generated during well drilling activities will be contained according to the procedures detailed in the SOP *Disposal of Waste Fluids and Solids* and the Investigation Derived Waste Management Plan (IDWMP).

Air or mud rotary drilling may be used instead of hollow-stem augers. The use of added mud should be kept to a minimum.

B. Monitoring-Well Installation

Shallow monitoring wells will be constructed inside the hollow-stem augers, once the borehole has been advanced to the desired depth, or in the mudded borehole once the drilling rods have been withdrawn. If the borehole has been drilled to a depth greater than that at which the well is to be set, the borehole will be backfilled with bentonite pellets or chips or a bentonite-cement slurry to a depth approximately 1 foot below the intended well depth. Approximately 1 foot of clean sand will be placed on top of the bentonite to return the borehole to the proper depth for well installation.

The appropriate lengths of well screen, nominally 10 feet (with bottom cap), and casing will be joined watertight and lowered inside the augers to the bottom of the borehole. Centering guides, if used, will be placed at the bottom of the screen and above the interval in which the bentonite seal is placed.

Selection of the filter pack and well screen intervals for the shallow monitoring wells shall be made in the field.

A primary sand pack consisting of clean Morie No. 00 (or DSI No.1) silica sand for 10-slot screen and Morie No. 01 (or DSI No.2) for 20-slot screen silica sand will be placed around the well screen. The sand will be placed into the borehole at a uniform rate, in a manner that will allow even placement of the sand pack. The augers will be raised gradually during sand pack installation to avoid caving of the borehole wall; at no time will the augers be raised higher than the top of the sand pack during installation. During placement of the sand, the position of the top of the sand will be continuously sounded. The primary sand pack will be extended from the bottom of the borehole to a minimum height of 2 feet above the top of the well screen. A secondary, finer-grained (fine sand seal), sand pack will be installed for a minimum of 1 foot above the coarse sand pack. Heights of the coarse and fine sand packs and bentonite seal may be modified in the field to account for a shallow water table and a small saturated thickness of the surficial aquifer.

A bentonite seal at least 2 feet thick will be placed above the sand pack. The seal will be placed into the borehole in a manner that will prevent bridging. The position of the top of the bentonite seal will be verified using a weighted tape measure. If all or a portion of the bentonite seal is above the water table,

clean water will be added to hydrate the bentonite. A hydration period of at least 30 minutes will be required following installation of the bentonite seal.

Above the bentonite seal, an annular seal of cement-bentonite grout will be placed. The cement-bentonite grout will be installed continuously in one operation from the bottom of the space to be grouted to the ground surface through a tremie pipe. The tremie pipe must be plugged at the bottom and have small openings along the sides of the bottom 1-foot length of pipe. This will allow the grout to diffuse laterally into the borehole and not disturb the bentonite pellet seal.

C. Well Completion

For monitoring wells that will be completed above-grade, a locking steel protective casing set in a concrete pad will be installed. The steel protective casing will extend at least 3 feet into the ground and 2 feet above ground but should not penetrate the bentonite seal. The concrete pad will be square, approximately 2 feet per side (unless otherwise specified in the project plans), and poured into wooden forms. The concrete will be sloped away from the protective casing.

Guard posts may be installed in high-traffic areas for additional protection. Four steel guard posts will be installed around the protective casing Guard posts would be concrete-filled, at least 2 inches in diameter, and would extend at least 2 feet into the ground and 3 feet above the ground. The protective casing and guard posts will be painted with an epoxy paint to prevent rust.

For monitoring wells with flush-mount completions, Morrison 9-inch or 12-inch 519 manhole cover or equivalent, with a rubber-sealed cover and drain will be installed. The top of the manhole cover will be positioned approximately 1 inch above grade. A square concrete pad, approximately 2 feet per side (unless otherwise specified in the project plans), will be installed as a concrete collar surrounding the road box cover, and will slope uniformly downward to the adjacent grade. The road box and installation thereof will be of sufficient strength to withstand normal vehicular traffic.

Concrete pads installed at all wells will be a minimum of 6 inches below grade. The concrete pad will be 12 inches thick at the center and taper to 6-inch thick at the edge. The surface of the pad should slope away from the protective casing to prevent water from pooling around the casing. Protective casing, guard posts, and flush mounts will be installed into this concrete.

Each well will be properly labeled on the exterior of the locking cap or protective casing with a metal stamp indicating the permanent well number.

D. Well Development

Well development will be accomplished using a combination of surging throughout the well screen and pumping, until the physical and chemical parameters of the discharge water that are measured in the field have

stabilized and the turbidity of the discharge water is substantially reduced. Fine-grained materials in the surficial aquifer at the site may not allow low turbidity results to be achieved.

The surging apparatus will include a surge block. Well development will begin by surging the well screen, starting at the bottom of the screen and proceeding upwards, throughout the screened zone. Following surging, the well will be pumped to remove the fine materials that have been drawn into the well. During pumping, measurements of pH, temperature, and specific conductance will be recorded.

Development will continue by alternately surging and pumping until the discharge water is free from sand and silt, the turbidity is substantially reduced, and the pH, temperature, and specific conductance have stabilized at regional background levels, based on historical data. Development will continue for a minimum of 30 minutes and until the water removed from the well is as clear of turbidity as practicable.

Well development equipment will be decontaminated prior to initial use and after the development of each well. Decontamination procedures are detailed in SOP *Decontamination of Personnel and Equipment*. Water generated during well development will be contained and managed as detailed in the SOP *Disposal of Waste Fluids and Solids* and the Investigation Derived Waste Management Plan.

IV. Attachments

Schematic diagram of shallow monitoring-well construction (MWSingleDiag.xls)

STANDARD OPERATING PROCEDURE

Logging of Soil Borings

I. Purpose and Scope

This SOP provides guidance to obtain accurate and consistent descriptions of soil characteristics during soil-sampling operations. The characterization is based on visual examination and manual tests, not on laboratory determinations.

II. Equipment and Materials

- Indelible pens
- Tape measure or ruler
- Field logbook
- Spatula
- HCL, 10 percent solution
- Squirt bottle with water
- Rock- or soil-color chart (e.g., Munsell)
- Grain-size chart
- Hand lens
- Unified Soil Classification System (USCS) index charts and tables to help with soil classification (attached)

III. Procedures and Guidelines

This section covers several aspects of soil characterization: instructions for completing the CH2M HILL soil boring log Form D1586 (attached), field classification of soil, and standard penetration test procedures.

A. Instructions for Completing Soil Boring Logs

Soil boring logs will be completed in the field log books or on separate soil boring log sheets. Information collected will be consistent with that required for Form D1586 (attached), a standard CH2M HILL form (attached), or an equivalent form that supplies the same information.

The information collected in the field to perform the soil characterization is described below.

Field personnel should review completed logs for accuracy, clarity, and thoroughness of detail. Samples also should be checked to see that information is correctly recorded on both jar lids and labels and on the log sheets.

B. Heading Information

Boring/Well Number. Enter the boring/well 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.

Location. If station, coordinates, mileposts, or similar project layout information is available, indicate the position of the boring to that system using modifiers such as "approximate" or "estimated" as appropriate.

Elevation. Elevation will be determined at the conclusion of field activities through a survey.

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 size and type, drilling fluid (if used), and method of drilling (e.g., rotary, hollow-stem auger). Information on the drilling equipment (e.g., CME 55, Mobile B61) also is noted.

Water Level and Date. Enter the depth below ground surface to the apparent water level in the borehole. The information should be recorded as a comment. If free water is not encountered during drilling or cannot be detected because of the drilling method, this information should be noted. Record date and time of day (for tides, river stage) of each water level measurement.

Date of Start and Finish. Enter the dates the boring was begun and completed. Time of day should be added if several borings are performed on the same day.

Logger. Enter the first and last name.

C. 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. Note the depth at the top and bottom of the sample interval.

Sample Type and Number. Enter the sample type and number. SS-1 = split spoon, first sample. 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 sampler. Often, there will be some wash or caved material above the sample; do not include the wash material in the measurement. Record soil recovery in feet.

Standard Penetration Test Results. In this column, enter the number of blows required for each 6 inches of sampler penetration and the "N" value, which is the sum of the blows in the middle two 6-inch penetration intervals. A typical standard penetration test involving successive blow counts of 2, 3, 4, and 5 is recorded as 2-3-4-5 and (7). The standard penetration test is terminated if the sampler encounters refusal. Refusal is a penetration of less than 6 inches with a blow count of 50. A

partial penetration of 50 blows for 4 inches is recorded as 50/4 inches. Penetration by the weight of the slide hammer only is recorded as "WOH."

Samples should be collected using a 140-pound hammer and 2-inch diameter split spoons. Samples may be collected using direct push sampling equipment. However, blow counts will not be available. A pocket penetrometer may be used instead to determine relative soil density of fine grained materials (silts and clays).

Sample also may be collected using a 300-pound hammer or 3-inch-diameter split-spoon samples at the site. However, use of either of these sample collection devices invalidates standard penetration test results and should be noted in the comments section of the log. The 300-pound hammer should only be used for collection of 3-inch-diameter split-spoon samples. Blow counts should be recorded for collection of samples using either a 3-inch split-spoon, or a 300-pound hammer. An "N" value need not be calculated.

Soil Description. The soil classification should follow the format described in the "Field Classification of Soil" subsection below.

Comments. Include all pertinent observations (changes in drilling fluid color, rod drops, drilling chatter, rod bounce as in driving on a cobble, damaged Shelby tubes, and equipment malfunctions). In addition, note if casing was used, the sizes and depths installed, and if drilling fluid was added or changed. You should instruct the driller to alert you to any significant changes in drilling (changes in material, occurrence of boulders, and loss of drilling fluid). Such information should be attributed to the driller and recorded 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 rod chatter
- Depth and percentage of drilling fluid loss
- Depth of hole caving or heaving
- Depth of change in material
- Health and safety monitoring data
- Drilling interval through a boulder

D. Field Classification of Soil

This section presents the format for the field classification of soil. In general, the approach and format for classifying soils should conform to ASTM D 2488, Visual-Manual Procedure for Description and Identification of Soils (attached).

The Unified Soil Classification System is based on numerical values of certain soil properties that are measured by laboratory tests. It is possible, however, to estimate these values in the field with reasonable accuracy using visual-manual procedures (ASTM D 2488). In addition, 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.

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 rather than differences between consecutive samples should be stressed.

Soil descriptions must be recorded 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. Soil name should be in all capitals in the log, for example "POORLY-GRADED SAND."
2. Group symbol, in parentheses, for example, "(SP)."
3. Color, using Munsell color designation
4. Moisture content
5. Relative density or consistency
6. Soil structure, mineralogy, or other descriptors

This order follows, in general, the format described in ASTM D 2488.

E. Soil Name

The basic name of a soil should be the ASTM D 2488 Group Name on the basis of visual estimates of gradation and plasticity. The soil name should be capitalized.

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).

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. There is no need to further document the gradation. However, the maximum size and angularity or roundness of gravel and sand-sized particles should be recorded. For fine-grained soil (50 percent or more passing the No. 200 sieve), the name is modified by the appropriate plasticity/elasticity term in accordance with ASTM D 2488.

Interlayered soil should each be described starting with the predominant type. An introductory name, such as "Interlayered Sand and Silt," should be used. In addition, the relative proportion of each soil type should be indicated (see Table 1 for example).

Where helpful, the evaluation of plasticity/elasticity can be justified 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.

F. Group Symbol

The appropriate group symbol from ASTM D 2488 must be given after each soil name. The group symbol should be placed in parentheses to indicate that the classification has been estimated.

In accordance with ASTM D 2488, dual symbols (e.g., GP-GM or SW-SC) can be used to indicate that a soil is estimated to have about 10 percent fines. Borderline symbols (e.g., 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. The use of a borderline symbol should not be used indiscriminately. Every effort should be made to first place the soil into a single group.

G. Color

The color of a soil must be given. The color description should be based on the Munsell system. The color name and the hue, value, and chroma should be given.

H. 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 on Table 2.

I. Relative Density or Consistency

Relative density of a coarse-grained (cohesionless) soil is based on N-values (ASTM D 1586 [attached]). If the presence of large gravel, disturbance of the sample, or non-standard sample collection makes determination of the in situ relative density or consistency difficult, then this item should be left out of the description and explained 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 3 and 4.

J. 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 such as cementation, abundant mica, or unusual mineralogy should be described.

Other descriptors may include particle size range or percentages, particle angularity or shape, maximum particle size, hardness of large particles, plasticity of fines, dry strength, dilatancy, toughness, reaction to HCl, and staining, as well as other information such as organic debris, odor, or presence of free product.

K. Equipment and Calibration

Before starting the testing, the equipment should be inspected for compliance with the requirements of ASTM D 1586. The split-barrel sampler should measure 2-inch or 3-inch O.D., and should have a split tube at least 18 inches long. The minimum size sampler rod allowed is "A" rod (1-5/8-inch O.D.). A stiffer rod, such as an "N" rod (2-5/8-inch O.D.), is required for depths greater than 50 feet. The drive weight assembly should consist of a 140-pound or 300-pound hammer weight, a drive head, and a hammer guide that permits a free fall of 30 inches.

IV. Attachments

Soil Boring Log (Sample Soil Boring Log.xls)

CH2M HILL Form D1586 and a completed example (Soil_Log_Examp.pdf)

ASTM D 2488 *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)* (ASTM D2488.pdf)

ASTM 1586 *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils* (ASTM D1586.pdf)

Tables 1 through 4 (Tables 1-4.pdf)

V. Key Checks and Preventive Maintenance

- Check entries to the soil-boring log and field logbook in the field; because the samples will be disposed of at the end of fieldwork, confirmation and corrections cannot be made later.
- Check that sample numbers and intervals are properly specified.
- Check that drilling and sampling equipment is decontaminated using the procedures defined in SOP *Decontamination of Drilling Rigs and Equipment*.

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PROJECT NUMBER	BORING NUMBER

SOIL BORING LOG

PROJECT : LOCATION :

ELEVATION : DRILLING CONTRACTOR :

DRILLING METHOD AND EQUIPMENT USED :

ATD WATER LEVEL : START : END : LOGGER :

DEPTH BELOW SURFACE (FT)	INTERVAL (FT)	RECOVERY (FT)	SAMPLE #/TYPE	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N')	SOIL DESCRIPTION SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY, OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY.	USCS	COMMENTS DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS, AND INSTRUMENTATION. DRILLING ACTIONS/DRILLER COMMENTS PID Readings: Breathing Zone: Above Hole:

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PROJECT NUMBER	BORING NUMBER SHEET OF

SOIL BORING LOG

PROJECT _____ LOCATION _____

ELEVATION _____ DRILLING CONTRACTOR _____

DRILLING METHOD AND EQUIPMENT _____

WATER LEVELS _____ START _____ FINISH _____ LOGGER _____

DEPTH BELOW SURFACE (FT)	SAMPLE			STANDARD PENETRATION TEST RESULTS	SOIL DESCRIPTION	COMMENTS
	INTERVAL	NUMBER AND TYPE	RECOVERY (FT)	6"-6"-6" (N)	SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION

Figure 1
SOIL BORING LOG, FORM D1586

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PROJECT NUMBER	BORING NUMBER	
DEN 22371.G5	BL-3	SHEET 1 OF 3

SOIL BORING LOG

PROJECT Howard Ave Landslide LOCATION Howard & 24th Ave, Centennial, CO

ELEVATION 5136 Feet DRILLING CONTRACTOR Kendall Explorations, Ashcan, Colorado

DRILLING METHOD AND EQUIPMENT 4"-inch H.S. Augers, Mobil B-61 rotary drill rig

WATER LEVELS 3.2 Feet, 8/5/89 START August 4, 1989 FINISH August 8, 1989 LOGGER J.A. Michner

DEPTH BELOW SURFACE (FT)	SAMPLE INTERVAL	SAMPLE NUMBER AND TYPE	SAMPLE RECOVERY (FT)	STANDARD PENETRATION TEST RESULTS 6"-6"-6" (N)	SOIL DESCRIPTION: SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	COMMENTS: DEPTH OF CASING, DRILLING RATE, DRILLING FLUID LOSS, TESTS AND INSTRUMENTATION
0					Surface material consist of 4 inches AC underlain by 6 inches of 3/4 inch minus base rock	Start Drilling @ 3:00
	2.5					
	4.0	1-S	1.5	2-3-4 (7)	POORLY-GRADED SAND WITH SILT, (SP-SM), fine, light brown, wet, loose	Driller notes water at 4 feet
	5.0					
5	6.5	2-S	0.9	WOH/12"-1	ORGANIC SILT, (OL), very dark, gray to black, wet, very soft, strong H_2S odor, many fine roots up to about 1/4 inch	Driller notes very soft drilling 4 ft. dark grey, wet silty cuttings.
	8.0					
	10.0	3-ST	1.3	—	ORGANIC SILT, similar to 2-S, except includes fewer roots (by volume)	
10	11.5	4-S	1.3	2-2-2 (4)	SILT, (ML), very dark gray to black, wet, soft	water level @ 3.2 feet on 8/5/89 @ 0730
						Driller notes rough drilling action and chatter @ 13 ft
	15.0					
15	15.5	5-S	0.5	60/6"	SILTY GRAVEL, (GM), rounded gravel up to about 1 inch maximum observed size, wet, very dense	
	20.0					Driller notes smoother, firm drilling @ 19 ft.
20	21.0	6-S	1.0	12-50/6"	LEAN CLAY WITH SAND, (CL), medium to light green, moist, very stiff	some angular rock chips @ bot. tip of 6-S, poss boulders or rock
	23.0					Driller notes very hard, slow grinding, smooth drilling action from 21 to 23 ft, possibly bedrock
	23.1	7-S	0	50/1"	NO RECOVERY	
					END SOIL BORING @ 23.1 FEET SEE ROCK CORE LOG FOR CONTINUATION OF BL-3	

Figure 2
EXAMPLE OF COMPLETED LOG FORM

Designation: D 2488 – 00

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as the standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2113 Practice for Diamond Core Drilling for Site Investigation[2]

D 2487 Classification of Soils for Engineering Purposes (Unified Soil Classification System)[2]

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and rock as Used in Engineering Design and Construction[3]

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)[2]

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D 653.

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:
Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and
Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.1 *clay*—soil passing a No. 200 (75-μm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid

[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

*A Summary of Changes section appears at the end of this standard.

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limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).

3.1.2 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.3 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.4 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.6 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-µm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-µm) sieve.

fine—passes a No. 40 (425-µm) sieve and is retained on a No. 200 (75-µm) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-µm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols*.

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means for evaluating some of those factors.

6. Apparatus

6.1 *Required Apparatus*:

6.1.1 *Pocket Knife or Small Spatula.*

6.2 *Useful Auxiliary Apparatus*:

6.2.1 *Small Test Tube and Stopper* (or jar with a lid).

6.2.2 *Small Hand Lens.*

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water

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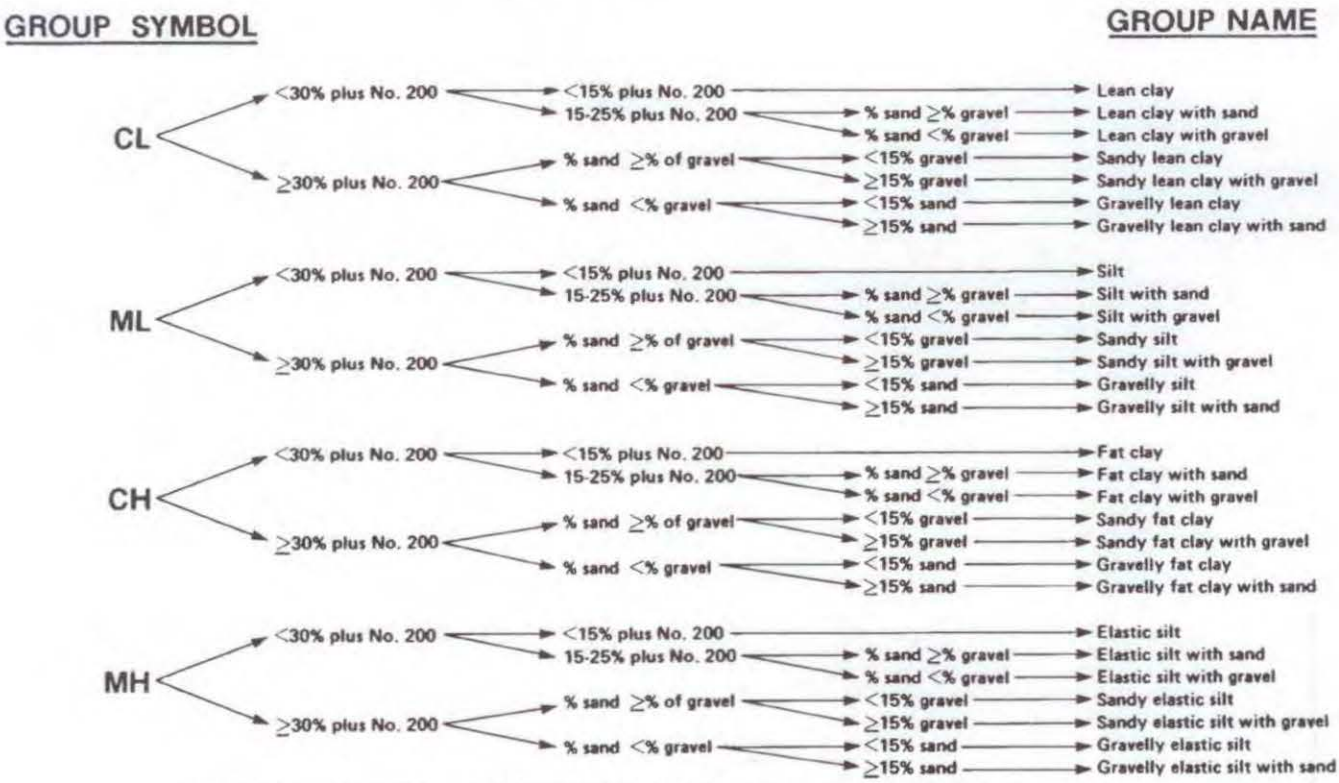
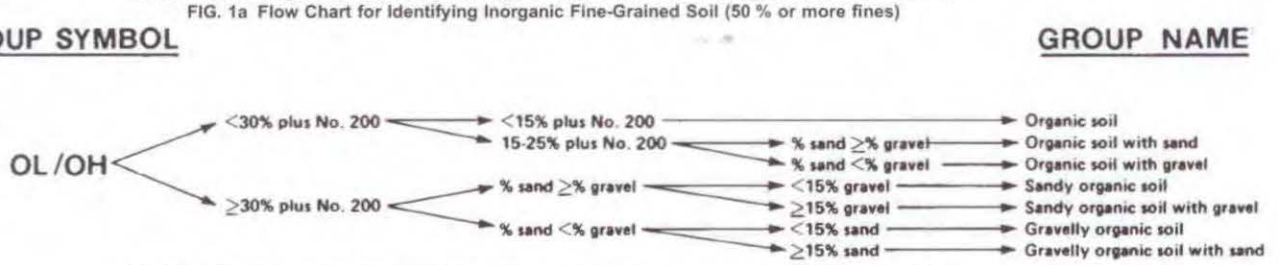


NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

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)

supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 6—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Test Method D 1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

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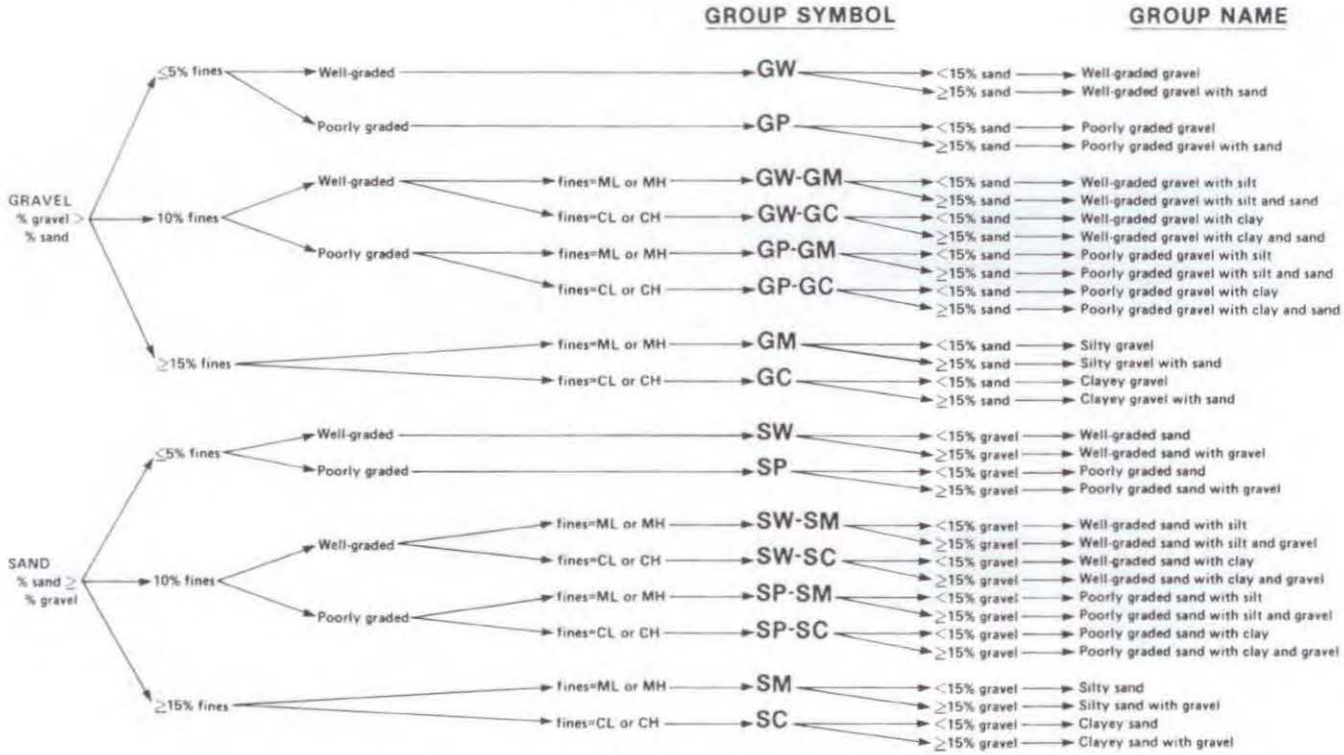

NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

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

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

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FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

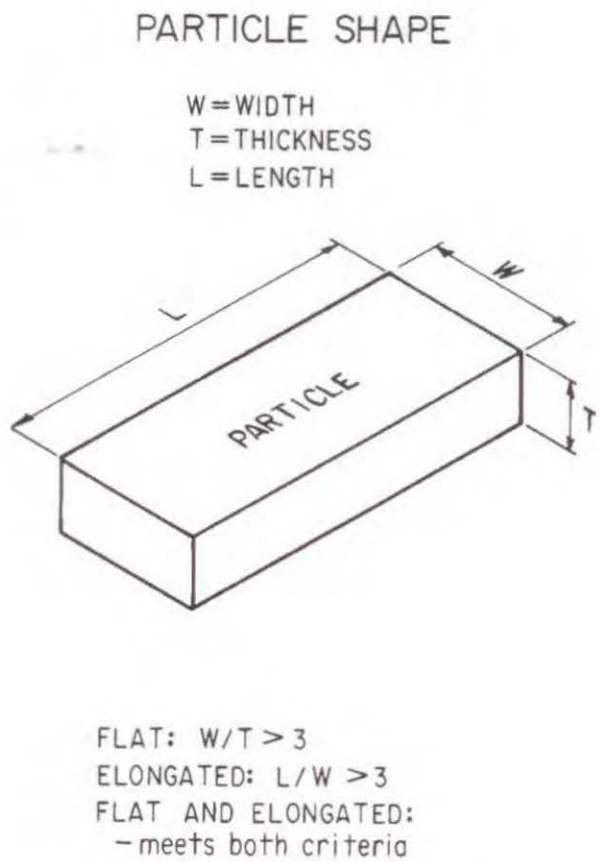

FIG. 4 Criteria for Particle Shape

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering

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TABLE 3 Criteria for Describing Moisture Condition

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

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Dilatancy

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Toughness

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Dilatancy

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength*:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½ in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low,

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medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 *Dilatancy*:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness*:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

TABLE 8 Criteria for Describing Toughness

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

TABLE 9 Criteria for Describing Dilatancy

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

TABLE 10 Criteria for Describing Toughness

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

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.7 *Identification of Inorganic Fine-Grained Soils*:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

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14.8 *Identification of Organic Fine-Grained Soils*:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils

(Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

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16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—About 60 % gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % fines; "Poorly Graded Gravel with Sand (GP)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard,

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angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix: Suffix:

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s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (1993$^{\epsilon 1}$) that may impact the use of this standard.

(1) Added Practice D 3740 to Section 2.

(2) Added Note 5 under 5.7 and renumbered subsequent notes.

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Designation: D 1586 – 08

Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative disturbed soil sample for identification purposes, and measure the resistance of the soil to penetration of the sampler. Another method (Test Method D 3550) to drive a split-barrel sampler to obtain a representative soil sample is available but the hammer energy is not standardized.

1.2 Practice D 6066 gives a guide to determining the normalized penetration resistance of sands for energy adjustments of N-value to a constant energy level for evaluating liquefaction potential.

1.3 Test results and identification information are used to estimate subsurface conditions for foundation design.

1.4 Penetration resistance testing is typically performed at 5-foot depth intervals or when a significant change of materials is observed during drilling, unless otherwise specified.

1.5 This test method is limited to use in nonlithified soils and soils whose maximum particle size is approximately less than one-half of the sampler diameter.

1.6 This test method involves use of rotary drilling equipment (Guide D 5783, Practice D 6151). Other drilling and sampling procedures (Guide D 6286, Guide D 6169) are available and may be more appropriate. Considerations for hand driving or shallow sampling without boreholes are not addressed. Subsurface investigations should be recorded in accordance with Practice D 5434. Samples should be preserved and transported in accordance with Practice D 4220 using Group B. Soil samples should be identified by group name and symbol in accordance with Practice D 2488.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026, unless superseded by this test method.

1.8 The values stated in inch-pound units are to be regarded as standard, except as noted below. The values given in parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.8.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.9 Penetration resistance measurements often will involve safety planning, administration, and documentation. This test method does not purport to address all aspects of exploration and site safety. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Performance of the test usually involves use of a drill rig; therefore, safety requirements as outlined in applicable safety standards (for example, OSHA regulations,[2] NDA Drilling Safety Guide,[3] drilling safety manuals, and other applicable state and local regulations) must be observed.

2. Referenced Documents

2.1 *ASTM Standards:* [4]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D 2488 Practice for Description and Identification of Soils

[1] This method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

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[2] Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, http://www.osha.gov.

[3] Available from the National Drilling Association, 3511 Center Rd., Suite 8, Brunswick, OH 44212, http://www.nda4u.com.

[4] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

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(Visual-Manual Procedure)

D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D 4220 Practices for Preserving and Transporting Soil Samples

D 4633 Test Method for Energy Measurement for Dynamic Penetrometers

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock

D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices

D 6026 Practice for Using Significant Digits in Geotechnical Data

D 6066 Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential

D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling

D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations

D 6286 Guide for Selection of Drilling Methods for Environmental Site Characterization

D 6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

3. Terminology

3.1 *Definitions:* Definitions of terms included in Terminology D 653 specific to this practice are:

3.1.1 *cathead, n*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.2 *drill rods, n*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.3 *N-value, n*—the blow count representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows (*N*) required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.4 *Standard Penetration Test (SPT), n*—a test process in the bottom of the borehole where a split-barrel sampler having an inside diameter of either 1-1/2-in. (38.1 mm) or 1-3/8-in. (34.9 mm) (see Note 2) is driven a given distance of 1.0 ft (0.30 m) after a seating interval of 0.5 ft (0.15 m) using a hammer weighing approximately 140-lbf (623-N) falling 30 ± 1.0 in. (0.76 m ± 0.030 m) for each hammer blow.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anvil, n*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2.2 *drive weight assembly, n*—an assembly that consists of the hammer, anvil, hammer fall guide system, drill rod attachment system, and any hammer drop system hoisting attachments.

3.2.3 *hammer, n*—that portion of the drive-weight assembly consisting of the 140 ± 2 lbf (623 ± 9 N) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.2.4 *hammer drop system, n*—that portion of the drive-weight assembly by which the operator or automatic system accomplishes the lifting and dropping of the hammer to produce the blow.

3.2.5 *hammer fall guide, n*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.2.6 *number of rope turns, n*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.2.7 *sampling rods, n*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

4. Significance and Use

4.1 This test method provides a disturbed soil sample for moisture content determination, for identification and classification (Practices D 2487 and D 2488) purposes, and for laboratory tests appropriate for soil obtained from a sampler that will produce large shear strain disturbance in the sample such as Test Methods D 854, D 2216, and D 6913. Soil deposits containing gravels, cobbles, or boulders typically result in penetration refusal and damage to the equipment.

4.2 This test method provides a disturbed soil sample for moisture content determination and laboratory identification. Sample quality is generally not suitable for advanced laboratory testing for engineering properties. The process of driving the sampler will cause disturbance of the soil and change the engineering properties. Use of the thin wall tube sampler (Practice D 1587) may result in less disturbance in soft soils. Coring techniques may result in less disturbance than SPT sampling for harder soils, but it is not always the case, that is, some cemented soils may become loosened by water action during coring; see Practice D 6151, and Guide D 6169.

4.3 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate blow count, or *N*-value, and the engineering behavior of earthworks and foundations are available. For evaluating the liquefaction potential of sands during an earthquake event, the *N*-value should be normalized to a standard overburden stress level. Practice D 6066 provides methods to obtain a record of normalized resistance of sands to the penetration of a standard sampler driven by a standard energy. The penetration resistance is adjusted to drill rod energy ratio of 60 % by using a hammer system with either an estimated energy delivery or directly measuring drill rod stress wave energy using Test Method D 4633.

NOTE 1—The reliability of data and interpretations generated by this practice is dependent on the competence of the personnel performing it

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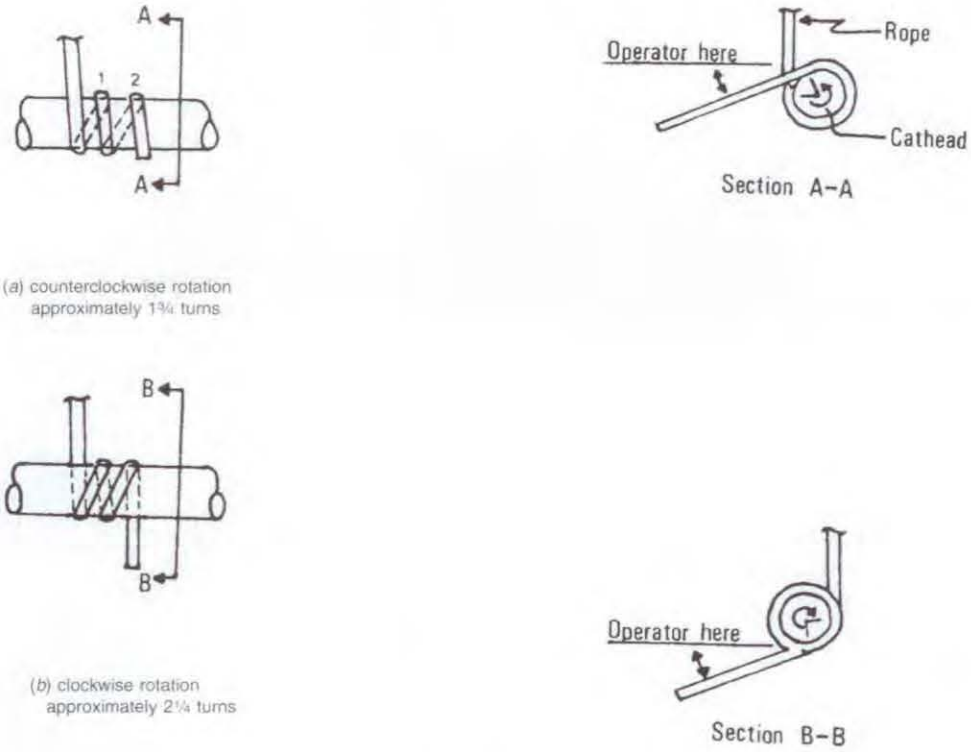

(*a*) counterclockwise rotation approximately 1¾ turns

(*b*) clockwise rotation approximately 2¼ turns

FIG. 1 Definitions of the Number of Rope Turns and the Angle for (*a*) Counterclockwise Rotation and (*b*) Clockwise Rotation of the Cathead

and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 generally are considered capable of competent testing. Users of this practice are cautioned that compliance with Practice D 3740 does not assure reliable testing. Reliable testing depends on several factors and Practice D 3740 provides a means of evaluating some of these factors. Practice D 3740 was developed for agencies engaged in the testing, inspection, or both, of soils and rock. As such, it is not totally applicable to agencies performing this practice. Users of this test method should recognize that the framework of Practice D 3740 is appropriate for evaluating the quality of an agency performing this test method. Currently, there is no known qualifying national authority that inspects agencies that perform this test method.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitable borehole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions:

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

5.1.2 *Roller-Cone Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the borehole. The inside diameter of the hollow-stem augers shall be less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm) in diameter may be used if the soil on the side of the borehole does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod that has an outside diameter of 1-5/8 in. (41.3 mm) and an inside diameter of 1-1/8 in. (28.5 mm).

5.3 *Split-Barrel Sampler*—The standard sampler dimensions are shown in Fig. 2. The sampler has an outside diameter of 2.00 in. (50.8 mm). The inside diameter of the of the split-barrel (dimension D in Fig. 2) can be either 1½-in. (38.1

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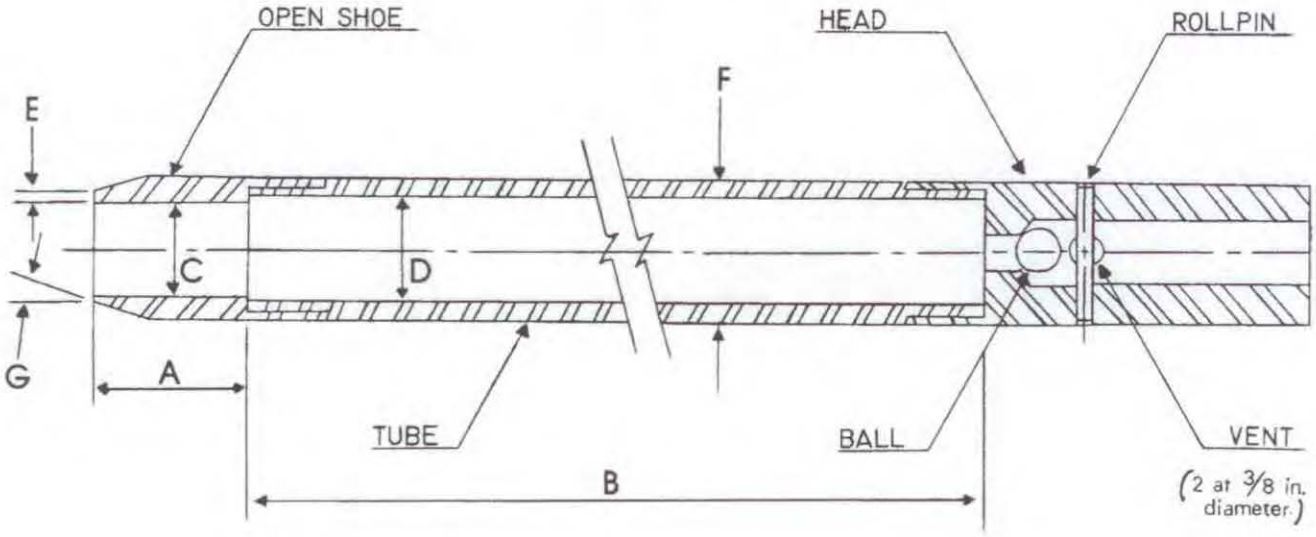

A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)
G = 16.0° to 23.0°

FIG. 2 Split-Barrel Sampler

mm) or 1⅜-in. (34.9 mm) (see Note 2). A 16-gauge liner can be used inside the 1½-in. (38.1 mm) split barrel sampler. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The penetrating end of the drive shoe may be slightly rounded. The split-barrel sampler must be equipped with a ball check and vent. Metal or plastic baskets may be used to retain soil samples.

NOTE 2—Both theory and available test data suggest that *N*-values may differ as much as 10 to 30 % between a constant inside diameter sampler and upset wall sampler. If it is necessary to correct for the upset wall sampler refer to Practice D 6066. In North America, it is now common practice to use an upset wall sampler with an inside diameter of 1½ in. At one time, liners were used but practice evolved to use the upset wall sampler without liners. Use of an upset wall sampler allows for use of retainers if needed, reduces inside friction, and improves recovery. Many other countries still use a constant ID split-barrel sampler, which was the original standard and still acceptable within this standard.

5.4 *Drive-Weight Assembly:*

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lbf (623 ± 9 N) and shall be a rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting an unimpeded fall shall be used. Fig. 3 shows a schematic of such hammers. Hammers used with the cathead and rope method shall have an unimpeded over lift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged as shown in Fig. 3. The total mass of the hammer assembly bearing on the drill rods should not be more than 250 ± 10 lbm (113 ± 5 kg).

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic or automatic hammer drop systems, as shown in Fig. 4 may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The borehole shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata. Record the depth of drilling to the nearest 0.1 ft (0.030 m).

6.2 Any drilling procedure that provides a suitably clean and stable borehole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures has proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable boreholes. The process of jetting through an open tube sampler and

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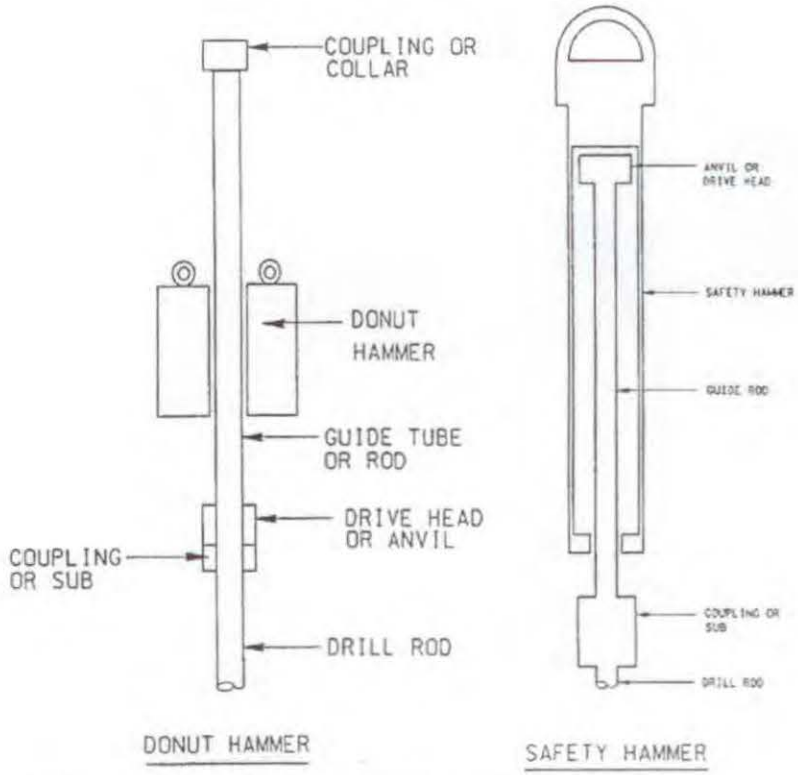

FIG. 3 Schematic Drawing of the Donut Hammer and Safety Hammer

then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the borehole below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a borehole with bottom discharge bits is not permissible. It is not permissible to advance the borehole for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the borehole or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the borehole has been advanced to the desired sampling elevation and excessive cuttings have been removed, record the cleanout depth to the nearest 0.1 ft (0.030 m), and prepare for the test with the following sequence of operations:

7.1.1 Attach either split-barrel sampler Type A or B to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the borehole. Record the sampling start depth to the nearest 0.1 ft (0.030 m). Compare the sampling start depth to the cleanout depth in 7.1. If excessive cuttings are encountered at the bottom of the borehole, remove the sampler and sampling rods from the borehole and remove the cuttings.

7.1.4 Mark the drill rods in three successive 0.5-foot (0.15 m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 0.5-foot (0.15 m) increment.

7.2 Drive the sampler with blows from the 140-lbf (623-N) hammer and count the number of blows applied in each 0.5-foot (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 0.5-foot (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 1.5 ft. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.2.5 If the sampler sinks under the weight of the hammer, weight of rods, or both, record the length of travel to the nearest 0.1 ft (0.030 m), and drive the sampler through the remainder of the test interval. If the sampler sinks the complete interval, stop the penetration, remove the sampler and sampling rods from the borehole, and advance the borehole through the very soft or very loose materials to the next desired sampling elevation. Record the *N*-value as either weight of hammer, weight of rods, or both.

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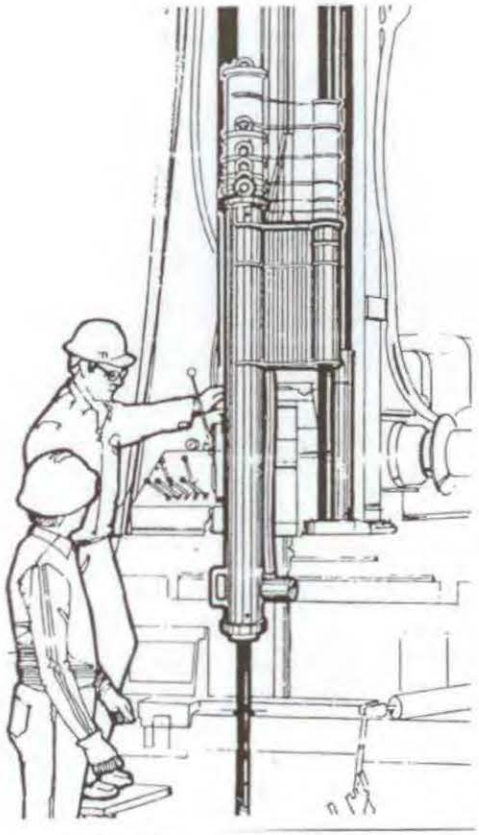

FIG. 4 Automatic Trip Hammer

7.3 Record the number of blows (*N*) required to advance the sampler each 0.5-foot (0.15 m) of penetration or fraction thereof. The first 0.5-foot (0.15 m) is considered to be a seating drive. The sum of the number of blows required for the second and third 0.5-foot (0.15 m) of penetration is termed the "standard penetration resistance," or the "*N*-value." If the sampler is driven less than 1.5 ft (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 0.5-foot (0.15 m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 0.1 ft (0.030 m) in addition to the number of blows. If the sampler advances below the bottom of the borehole under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lbf (623-N) hammer shall be accomplished using either of the following two methods. Energy delivered to the drill rod by either method can be measured according to procedures in Test Method D 4633.

7.4.1 *Method A*—By using a trip, automatic, or semi-automatic hammer drop system that lifts the 140-lbf (623-N) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 0.030 m) with limited unimpedence. Drop heights adjustments for automatic and trip hammers should be checked daily and at first indication of variations in performance. Operation of automatic hammers shall be in strict accordance with operations manuals.

7.4.2 *Method B*—By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM.

7.4.2.3 The operator should generally use either 1-3/4 or 2-1/4 rope turns on the cathead, depending upon whether or not the rope comes off the top (1-3/4 turns for counterclockwise rotation) or the bottom (2-1/4 turns for clockwise rotation) of the cathead during the performance of the penetration test, as shown in Fig. 1. It is generally known and accepted that 2-3/4 or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be stiff, relatively dry, clean, and should be replaced when it becomes excessively frayed, oily, limp, or burned.

7.4.2.4 For each hammer blow, a 30 ± 1.0 in. (0.76 m ± 0.030 m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

NOTE 4—If the hammer drop height is something other than 30 ± 1.0 in. (0.76 m ± 0.030 m), then record the new drop height. For soils other than sands, there is no known data or research that relates to adjusting the *N*-value obtained from different drop heights. Test method D 4633 provides information on making energy measurement for variable drop

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heights and Practice D 6066 provides information on adjustment of *N*-value to a constant energy level (60 % of theoretical, N60). Practice D 6066 allows the hammer drop height to be adjusted to provide 60 % energy.

7.5 Bring the sampler to the surface and open. Record the percent recovery to the nearest 1 % or the length of sample recovered to the nearest 0.01 ft (5 mm). Classify the soil samples recovered as to, in accordance with Practice D 2488, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 0.5-foot (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel. Samples should be preserved and transported in accordance with Practice D 4220 using Group B.

8. Data Sheet(s)/Form(s)

8.1 Data obtained in each borehole shall be recorded in accordance with the Subsurface Logging Guide D 5434 as required by the exploration program. An example of a sample data sheet is included in Appendix X1.

8.2 Drilling information shall be recorded in the field and shall include the following:

8.2.1 Name and location of job,

8.2.2 Names of crew,

8.2.3 Type and make of drilling machine,

8.2.4 Weather conditions,

8.2.5 Date and time of start and finish of borehole,

8.2.6 Boring number and location (station and coordinates, if available and applicable),

8.2.7 Surface elevation, if available,

8.2.8 Method of advancing and cleaning the borehole,

8.2.9 Method of keeping borehole open,

8.2.10 Depth of water surface to the nearest 0.1 ft (0.030 m) and drilling depth to the nearest 0.1 ft (0.030 m) at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.2.11 Location of strata changes, to the nearest 0.5 ft (15 cm),

8.2.12 Size of casing, depth of cased portion of borehole to the nearest 0.1 ft (0.030 m),

8.2.13 Equipment and Method A or B of driving sampler,

8.2.14 Sampler length and inside diameter of barrel, and if a sample basket retainer is used,

8.2.15 Size, type, and section length of the sampling rods, and

8.2.16 Remarks.

8.3 Data obtained for each sample shall be recorded in the field and shall include the following:

8.3.1 Top of sample depth to the nearest 0.1 ft (0.030 m) and, if utilized, the sample number,

8.3.2 Description of soil,

8.3.3 Strata changes within sample,

8.3.4 Sampler penetration and recovery lengths to the nearest 0.1 ft (0.030 m), and

8.3.5 Number of blows per 0.5 foot (0.015 m) or partial increment.

9. Precision and Bias

9.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

9.1.1 The Subcommittee 18.02 is seeking additional data from the users of this test method that might be used to make a limited statement on precision. Present knowledge indicates the following:

9.1.1.1 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent boreholes in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.1.1.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; soil; split-barrel sampling; standard penetration test

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APPENDIX

(Nonmandatory Information)

X1. Example Data Sheet

X1.1 See Fig. 5.

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DRILLERS BORING LOG

Project _____ Project No _____ Boring No _____

Location _____ Sheet _____ of _____

Date Started _____ Date Completed _____

Drill Crew:

Boring Location
Station _____ Offset _____

Elevation

Strata Depth		Soil Description and Remarks	Sample Type	No.	Depth		Recovery	N-Values		
From	To				From	To		6"	6"	6"

Drill Rig Type _____

Method Of Drilling:

Auger _____ Size _____

Wash _____ Water _____ Mud _____

Hammer Type

Auto _____ Manual _____

Split-Spoon Type

Length _____ Liner Used _____

Boring Size _____ Bit Used _____

Casing Size _____ Length _____

Weather _____

Non-Drilling Time (Hrs.)

Boring Layout _____ Moving _____

Hauling Water _____ Standby _____

Water Level @ _____ Date _____ Time _____

@ _____ Date _____ Time _____

@ _____ Date _____ Time _____

Cave-in Depth

@ _____ Date _____ Time _____

FIG. 5 Example Data Sheet

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SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D 1586 – 99) that may impact the use of this standard. (Approved February 1, 2008.)

(*1*) There have been numerous changes to this standard to list them separately. From the most recent main ballot process, additional changes were requested and incorporated into this newest revision. Stated below is a highlight of some of the changes.

(*2*) Scope was completely revised.

(*3*) Referenced Documents updated to include new standards.

(*4*) Terminology: added section on Definitions.

(*5*) Significance and Use: clarified use of the SPT test.

(*6*) Apparatus: general editorial changes.

(*7*) Sampling and Testing Procedure: general editorial changes.

(*8*) Data Sheets/Forms: general editorial changes.

(*9*) Precision and Bias: added Sections 9.1.1.1 and 9.1.1.2.

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Table 1
EXAMPLE SOIL DESCRIPTIONS

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, lacustrine

WELL-GRADED SAND WITH GRAVEL (SM), reddish brown, moist, dense, subangular gravel to 0.6 inches 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, subrounded gravel to 1.2 inches max

INTERLAYERED SILT (60 percent) AND CLAY (40 percent): SILT WITH SAND (ML), medium greenish gray, nonplastic, 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 (SM), light yellowish brown, moist, medium dense, weak gravel to 1.0 inches max, very few small particles of coal, fill

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 inches max

Table 2
CRITERIA FOR DESCRIBING MOISTURE CONDITION

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

Table 3
RELATIVE DENSITY OF COARSE-GRAINED SOIL
(Developed from Sowers, 1979)

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 ½-in. steel rod driven with 5-lb hammer

Table 4
CONSISTENCY OF FINE-GRAINED SOIL
(Developed from Sowers, 1979)

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

STANDARD OPERATING PROCEDURE

Shallow Soil Sampling

I. Purpose

To provide general guidelines for the collection and handling of surface soil samples during field operations.

II. Scope

The method described for surface soil sampling is applicable for loosely packed earth and is used to collect disturbed-soil samples.

III. Equipment and Materials

- Sample jars.
- A hand auger or other device that can be used to remove the soil from the ground. Only stainless steel, Teflon, or glass materials should be used. The only exception is split spoons, which are most commonly available in carbon steel; these are acceptable for use only if they are not rusty.
- A stainless steel spatula or disposable plastic scoop should be used to remove material from the sampling device.
- Unpainted wooden stakes or pin flags
- Fiberglass measuring tape (at least 200 feet in length)
- GPS Unit (if available)

IV. Procedures and Guidelines

A. Wear protective gear, as specified in the Health and Safety Plan.

B. To locate samples, identify the correct location using the pin flags or stakes. Proceed to collect a sample from the undisturbed soil adjacent to the marker following steps C and D. If markers are not present, the following procedures will be used.

1. For samples on a grid:

   a. Use measuring tape to locate each sampling point on the first grid line as prescribed in the sampling plan. As each point is located, drive a numbered stake in the ground and record its location on the site map and in the logbook.

b. Proceed to sample the points on the grid line.

c. Measure to location where next grid line is to start and stake first sample. For subsequent samples on the line take two orthogonal measurements: one to the previous grid line, and one to the previous sample on the same grid line.

d. Proceed to sample the points on the grid line as described in Section C below.

e. Repeat 1c and 1d above until all samples are collected from the area.

f. Or, a GPS unit can be used to identify each location based on map coordinated, if available.

2. For non-grid samples:

a. Use steel measuring tape to position sampling point at location described in the sampling plan by taking two measurements from fixed landmarks (e.g., corner of house and fence post).

b. Note measurements, landmarks, and sampling point on a sketch in the field notebook, and on a site location map.

c. Proceed to sample as described in Section C below.

d. Repeat 2a through 2c above until all samples are collected from the area.

e. Or, a GPS unit can be used to identify each location based on map coordinated, if available.

C. To the extent possible, differentiate between fill and natural soil. If both are encountered at a boring location, sample both as prescribed in the field sampling plan. Do not locate samples in debris, tree roots, or standing water. In residential areas, do not sample in areas where residents' activities may impact the sample (e.g., barbecue areas, beneath eaves of roofs, driveways, garbage areas). If an obstacle prevents sampling at a measured grid point, move as close as possible, but up to a distance of one half the grid spacing in any direction to locate an appropriate sample. If an appropriate location cannot be found, consult with the Field Team Leader (FTL). If the FTL concurs, the sampling point will be deleted from the program. The FTL will contact the CH2M HILL project manager (PM) immediately. The PM and Navy Technical Representative (NTR) will discuss whether the point should be deleted from the program. If it is deleted, the PM will follow-up with the NTR in writing.

D. To collect samples:

1. Use a decontaminated stainless steel scoop/trowel or disposable plastic scoop to scrape away surficial organic material (grass, leaves, etc.) adjacent to

the stake. New disposable scoops or trowels may also be used to reduce the need for equipment blanks.

2. If sampling:

   a. Surface soil: Obtain soil sample by scooping soil using the augering scoop/trowel, starting from the surface and digging down to a depth of about 6 inches, or the depth specified in the workplan.

   b. Subsurface soil: Obtain the subsurface soil sample using an auger down to the depths prescribed in the field sampling plan.

3. Take a photo ionization detector (PID) reading of the sampled soil if organics are anticipated to be present and record the response in the field notebook. Also record lithologic description and any pertinent observations (such as discoloration) in the logbook.

4. Empty the contents of the scoop/trowel into a decontaminated stainless steel pan or dedicated sealable bag.

5. Repeat this procedure until sufficient soil is collected to meet volume requirements.

6. For TCL VOC and field GC aliquots, fill sample jars directly with the trowel or scoop or specialized sampling equipment (i.e. Encore® or Terra Core® sampler) and cap immediately upon filling. DO NOT HOMOGENIZE.

7. For TCL pesticides/PCBs and SVOCs, TAL metals, and field XRF aliquots, homogenize cuttings in the pan using a decontaminated stainless steel utensil in accordance with SOP *Decontamination of Drilling Rigs and Equipment*.

8. Transfer sample for analysis into appropriate containers with a decontaminated utensil.

9. Immediately upon collection, all samples for chemical analysis are to be placed in a closed container on ice unless it is not possible to do so. Although unusual and uncommon, there may be instances where it is not possible to have containers with ice at the sample location. In these instances, the samples should be placed on ice as soon as practical and during the time between collection and placing the samples on ice, the samples should be kept as cool as possible

10. Backfill the hole with soil removed from the borehole. To the extent possible, replace topsoil and grass and attempt to return appearance of sampling area to its pre-sampled condition. For samples in non-residential, unmowed areas, mark the sample number on the stake and leave stake in place. In mowed areas, remove stake.

V. Attachments

None.

VI. Key Checks and Items

- Use phthalate-free latex or surgical gloves and other personal protective equipment.
- Transfer volatiles first, avoid mixing.
- Decontaminate utensils before reuse, or use dedicated, disposable utensils.

STANDARD OPERATING PROCEDURE

Packaging and Shipping Procedures for Low-Concentration Samples

I. Purpose and Scope

The purpose of this guideline is to describe the packaging and shipping of low-concentration samples of various media to a laboratory for analysis.

II. Scope

The guideline only discusses the packaging and shipping of samples that are anticipated to have low concentrations of chemical constituents. Whether or not samples should be classified as low-concentration or otherwise will depend upon the site history, observation of the samples in the field, odor, and photoionization-detector readings.

If the site is known to have produced high-concentration samples in the past or the sampler suspects that high concentrations of contaminants might be present in the samples, then the sampler should conservatively assume that the samples cannot be classified as low-concentration. Samples that are anticipated to have medium to high concentrations of constituents should be packaged and shipped accordingly.

If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result only employees who are trained under CH2M HILL Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should utilize the HAZMAT ShipRight tool on the Virtual Office and/or contact a designated CH2M HILL HazMat advisor with questions.

III. Equipment and Materials

- Coolers
- Clear tape
- “This Side Up” labels
- “Fragile” labels
- Vermiculite
- Ziplock bags or bubble wrap
- Ice
- Chain-of-Custody form (completed)
- Custody seals

IV. Procedures and Guidelines

Low-Concentration Samples

A. Prepare coolers for shipment:

- Tape drains shut.
- Affix "This Side Up" labels on all four sides and "Fragile" labels on at least two sides of each cooler.
- Place mailing label with laboratory address on top of coolers.
- Fill bottom of coolers with about 3 inches of vermiculite or absorbent pads.

B. Arrange decontaminated sample containers in groups by sample number. Consolidate VOC samples into one cooler to minimize the need for trip blanks.

C. Affix appropriate adhesive sample labels to each container. Protect with clear label protection tape.

D. Seal each sample bottle within a separate ziplock plastic bag or bubble wrap, if available. Tape the bag around bottle. Sample label should be visible through the bag.

E. Arrange sample bottles in coolers so that they do not touch.

F. If ice is required to preserve the samples, cubes should be repackaged in zip-lock bags and placed on and around the containers.

G. Fill remaining spaces with vermiculite or absorbent pads.

H. Complete and sign chain-of-custody form (or obtain signature) and indicate the time and date it was relinquished to Federal Express or the courier.

J Close lid and latch.

K. Carefully peel custody seals from backings and place intact over lid openings (right front and left back). Cover seals with clear protection tape.

L. Tape cooler shut on both ends, making several complete revolutions with strapping tape. Cover custody seals with tape to avoid seals being able to be peeled from the cooler.

M. Relinquish to Federal Express or to a courier arranged with the laboratory. Place airbill receipt inside the mailing envelope and send to the sample documentation coordinator along with the other documentation.

Medium- and High-Concentration Samples:

Medium- and high-concentration samples are packaged using the same techniques used to package low-concentration samples, with potential additional restrictions. If applicable, the sample handler must refer to instructions associated with the shipping of dangerous goods for the necessary procedures for shipping by Federal Express or other overnight carrier. If warranted, procedures for dangerous-goods shipping may be implemented. Dangerous goods and hazardous materials pose an unreasonable risk to health, safety, or property during transportation without special handling. As a result only employees who are trained under CH2M HILL Dangerous Goods Shipping course may ship or transport dangerous goods. Employees should utilize the HAZMAT ShipRight tool on the Virtual Office and/or contact a designated CH2M HILL HazMat advisor with questions.

V. Attachments

None.

VI. Key Checks and Items

- Be sure laboratory address is correct on the mailing label
- Pack sample bottles carefully, with adequate vermiculite or other packaging and without allowing bottles to touch
- Be sure there is adequate ice
- Include chain-of-custody form
- Include custody seals

STANDARD OPERATING PROCEDURE

Aquifer Slug Testing

I. Purpose and Scope

The purpose of this procedure is to outline the equipment and methods that will be used to perform variable-head tests ("slug" tests) on piezometers and monitoring wells. The guidance covers use of both air and solid displacement methods.

II. Equipment and Materials

- In-Situ data loggers or equivalent
- Well-testing assembly
  - packer
  - fittings for pressure transducers
  - fittings for air supply
  - release valve
- Compressed air
- Computer and associated equipment
- Solid displacement device with rope

III. Procedures and Guidelines

The tests to be performed are rising head tests. The tests are accomplished by lowering the head of water in the well and monitoring the recovery of the water level to the static water level. The water level will be lowered by one of two methods. One method is the use of an air displacement device. Alternatively, a solid displacement device removed from the well will be used.

The air displacement apparatus consists of a packer assembly, fittings to accommodate transducers and air pressurization, and a pressure-release valve. The packer is lowered into the upper portion of the monitoring well, secured in place and inflated, providing a seal between the apparatus and the inside of the well. Two fittings are provided for pressure transducers: one transducer is fed through the inside of the device and positioned below the water surface and the other is inserted to measure the air pressure inside the assembly. A third fitting is connected to the pressurized air supply, a compressed air tank.

The datalogger will be programmed to display the air pressure in units of head, the head measured by the submerged transducer, and the difference between the two. The difference between the two pressure transducers is the height of the water column on the submerged transducer. The readings are recorded in a field notebook, and then the assembly is pressurized. The air pressure applied will be equivalent to 3 to 7 feet of

head. The pressures are allowed to stabilize. The pressure of the air should not lower the water level to below the base of the bentonite seal installed in the well.

Each test is started by releasing the air pressure inside the assembly and allowing the water level to rise to the static water level. When the datalogger perceives a change in water level in the well above a preset trigger amount, it automatically begins to record the water levels and elapsed time. Alternatively, the datalogger can be started manually just prior to injection of air. Each test will be terminated when the water level has recovered to at least 90 percent of the original equilibrium level before pressurization. Note that the test method cannot be used if the well is screened across or near the water table.

An alternate method of lowering the water level is to use a solid displacement device. A single transducer will be installed in the well below the water table. A weighted solid displacement device is added to the well and the water level allowed to stabilize at the original static water level. The test is started by rapidly removing the displacement device, which causes a drop in the water level. The data logger begins recording the water level and elapsed time when the preset trigger amount is reached. Readings are taken as above, and the test stopped when the well has recovered to 90 percent of the original level.

At least two valid tests will be performed in each well. Additional tests will be required if there is some evidence that any of the tests were unacceptable.

At the end of each test, the test results will be transferred to a laptop and the data downloaded and checked for preliminary completeness.

IV. Attachments

None.

V. Key Checks and Preventive Maintenance

- Check that the packer assembly is in good condition and not leaking. Provide a repair kit including tape and clamps. Take additional packer assembly and other spare parts.
- Check the batteries for the datalogger and computer. Check that the computer disks containing the programs for the datalogger are packed.
- Check the datalogger calculation of the well hydraulic conductivity at the end of each test to determine if these are consistent with expectations.

STANDARD OPERATING PROCEDURE

Soil Sampling

I. Purpose and Scope

The purpose of this procedure is to provide guidelines for obtaining samples of surface and subsurface soils using hand and drilling-rig mounted equipment.

II. Equipment and Materials

- Stainless-steel trowel, shovel, scoop, coring device, hand auger, or other appropriate hand tool
- Stainless-steel, split-spoon samplers
- Thin-walled sampling tubes
- Drilling rig or soil-coring rig
- Stainless-steel pan/bowl or disposable sealable bags
- Sample bottles

III. Procedures and Guidelines

Before sampling begins, equipment will be decontaminated using the procedures described in SOP *Decontamination of Drilling Rigs and Equipment*. The sampling point is located and recorded in the field logbook. Debris should be cleared from the sampling location.

A. Surface and Shallow Subsurface Sampling

A shovel, post-hole digger, or other tool can be used to remove soil to a point just above the interval to be sampled. A decontaminated sampling tool will be used to collect the sample when the desired sampling depth has been reached. Soil for semivolatile organic and inorganic analyses is placed in the bowl and mixed; soil for volatile organic analysis is not mixed or composited but is placed directly into the appropriate sample bottles. A stainless-steel or dedicated wooden tongue depressor is used to transfer the sample from the bowl to the container.

The soils removed from the borehole should be visually described in the field log book, including approximated depths.

When sampling is completed, photo-ionization device (PID) readings should be taken directly above the hole, and the hole is then backfilled.

More details are provided in the SOP *Shallow Soil Sampling.*

B. Split-Spoon Sampling

Using a drilling rig, a hole is advanced to the desired depth. For split-spoon sampling, the samples are then collected following the ASTM D 1586 standard (attached). The sampler is lowered into the hole and driven to a depth equal to the total length of the sampler; typically this is 24 inches. The sampler is driven in 6-inch increments using a 140-pound weight ("hammer") dropped from a height of 30 inches. The number of hammer blows for each 6-inch interval is counted and recorded. To obtain enough volume of sample for subsequent laboratory analysis, use of a 3-inch ID sampler may be required. Blow counts obtained with a 3-inch ID spoon would not conform to ASTM D 1586 and would therefore not be used for geotechnical evaluations.

Once retrieved from the hole, the sampler is carefully split open. Care should be taken not to allow material in the sampler to fall out of the open end of the sampler. To collect the sample, the surface of the sample should be removed with a clean tool and disposed of. Samples collected for volatiles analysis should be placed directly into the sample containers from the desired depth in the split spoon. Material for samples for all other parameters should be removed to a decontaminated stainless steel tray or disposable sealable bag. The sample for semivolatile organic and inorganic analyses should be homogenized in the field by breaking the sample into small pieces and removing gravel. The homogenized sample should be placed in the sample containers. If sample volume requirements are not met by a single sample collection, additional sample volume may be obtained by collecting a sample from below the sample and compositing the sample for non-volatile parameters only.

Split-spoon samples also will be collected using a tripod rig. When using a tripod rig the soil samples are collected using an assembly similar to that used by the drilling rig.

C. Thin-Walled Tube Sampling

Undisturbed fine grained samples may be collected for analysis for geotechnical parameters such as vertical hydraulic conductivity. These samples will be collected using thin-walled sampling tubes (sometimes called Shelby tubes) according to ASTM D 1587 (attached). 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 will be sealed with bees wax and then sealed with end caps and heavy tape. The sample designation, data and time of sampling, and the up direction will be noted on the sampling tube. The tube shall be kept upright as much as possible and will be protected from freezing, which could disrupt the undisturbed nature of the sample. Samples for geochemical analysis normally are not collected from thin-walled tube samples.

IV. Attachments

ASTM D 1586 *Standard Penetration Test Method for Penetration Test and Split-Barrel Sampling of Soils* (ASTM D1586.pdf)

ASTM D 1587 *Standard Practice for Thin-Walled Tube Sampling of Soils* (ASTM D1587.pdf)

V. Key Checks and Preventative Maintenance

- Check that decontamination of equipment is thorough.
- Check that sample collection is swift to avoid loss of volatile organics during sampling.

Designation: D 1586 – 08

Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative disturbed soil sample for identification purposes, and measure the resistance of the soil to penetration of the sampler. Another method (Test Method D 3550) to drive a split-barrel sampler to obtain a representative soil sample is available but the hammer energy is not standardized.

1.2 Practice D 6066 gives a guide to determining the normalized penetration resistance of sands for energy adjustments of N-value to a constant energy level for evaluating liquefaction potential.

1.3 Test results and identification information are used to estimate subsurface conditions for foundation design.

1.4 Penetration resistance testing is typically performed at 5-foot depth intervals or when a significant change of materials is observed during drilling, unless otherwise specified.

1.5 This test method is limited to use in nonlithified soils and soils whose maximum particle size is approximately less than one-half of the sampler diameter.

1.6 This test method involves use of rotary drilling equipment (Guide D 5783, Practice D 6151). Other drilling and sampling procedures (Guide D 6286, Guide D 6169) are available and may be more appropriate. Considerations for hand driving or shallow sampling without boreholes are not addressed. Subsurface investigations should be recorded in accordance with Practice D 5434. Samples should be preserved and transported in accordance with Practice D 4220 using Group B. Soil samples should be identified by group name and symbol in accordance with Practice D 2488.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D 6026, unless superseded by this test method.

1.8 The values stated in inch-pound units are to be regarded as standard, except as noted below. The values given in parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.8.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.9 Penetration resistance measurements often will involve safety planning, administration, and documentation. This test method does not purport to address all aspects of exploration and site safety. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Performance of the test usually involves use of a drill rig; therefore, safety requirements as outlined in applicable safety standards (for example, OSHA regulations,[2] NDA Drilling Safety Guide,[3] drilling safety manuals, and other applicable state and local regulations) must be observed.

2. Referenced Documents

2.1 *ASTM Standards:* [4]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D 2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D 2488 Practice for Description and Identification of Soils

[1] This method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved Feb. 1, 2008. Published March 2008. Originally approved in 1958. Last previous edition approved in 1999 as D 1586 – 99.

[2] Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, http://www.osha.gov.

[3] Available from the National Drilling Association, 3511 Center Rd., Suite 8, Brunswick, OH 44212, http://www.nda4u.com.

[4] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

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(Visual-Manual Procedure)

D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D 4220 Practices for Preserving and Transporting Soil Samples

D 4633 Test Method for Energy Measurement for Dynamic Penetrometers

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock

D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices

D 6026 Practice for Using Significant Digits in Geotechnical Data

D 6066 Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential

D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling

D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations

D 6286 Guide for Selection of Drilling Methods for Environmental Site Characterization

D 6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

3. Terminology

3.1 *Definitions:* Definitions of terms included in Terminology D 653 specific to this practice are:

3.1.1 *cathead, n*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.2 *drill rods, n*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.3 *N-value, n*—the blow count representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows (*N*) required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.4 *Standard Penetration Test (SPT), n*—a test process in the bottom of the borehole where a split-barrel sampler having an inside diameter of either 1-1/2-in. (38.1 mm) or 1-3/8-in. (34.9 mm) (see Note 2) is driven a given distance of 1.0 ft (0.30 m) after a seating interval of 0.5 ft (0.15 m) using a hammer weighing approximately 140-lbf (623-N) falling 30 ± 1.0 in. (0.76 m ± 0.030 m) for each hammer blow.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anvil, n*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2.2 *drive weight assembly, n*—an assembly that consists of the hammer, anvil, hammer fall guide system, drill rod attachment system, and any hammer drop system hoisting attachments.

3.2.3 *hammer, n*—that portion of the drive-weight assembly consisting of the 140 ± 2 lbf (623 ± 9 N) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.2.4 *hammer drop system, n*—that portion of the drive-weight assembly by which the operator or automatic system accomplishes the lifting and dropping of the hammer to produce the blow.

3.2.5 *hammer fall guide, n*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.2.6 *number of rope turns, n*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.2.7 *sampling rods, n*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

4. Significance and Use

4.1 This test method provides a disturbed soil sample for moisture content determination, for identification and classification (Practices D 2487 and D 2488) purposes, and for laboratory tests appropriate for soil obtained from a sampler that will produce large shear strain disturbance in the sample such as Test Methods D 854, D 2216, and D 6913. Soil deposits containing gravels, cobbles, or boulders typically result in penetration refusal and damage to the equipment.

4.2 This test method provides a disturbed soil sample for moisture content determination and laboratory identification. Sample quality is generally not suitable for advanced laboratory testing for engineering properties. The process of driving the sampler will cause disturbance of the soil and change the engineering properties. Use of the thin wall tube sampler (Practice D 1587) may result in less disturbance in soft soils. Coring techniques may result in less disturbance than SPT sampling for harder soils, but it is not always the case, that is, some cemented soils may become loosened by water action during coring; see Practice D 6151, and Guide D 6169.

4.3 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate blow count, or *N*-value, and the engineering behavior of earthworks and foundations are available. For evaluating the liquefaction potential of sands during an earthquake event, the *N*-value should be normalized to a standard overburden stress level. Practice D 6066 provides methods to obtain a record of normalized resistance of sands to the penetration of a standard sampler driven by a standard energy. The penetration resistance is adjusted to drill rod energy ratio of 60 % by using a hammer system with either an estimated energy delivery or directly measuring drill rod stress wave energy using Test Method D 4633.

NOTE 1—The reliability of data and interpretations generated by this practice is dependent on the competence of the personnel performing it

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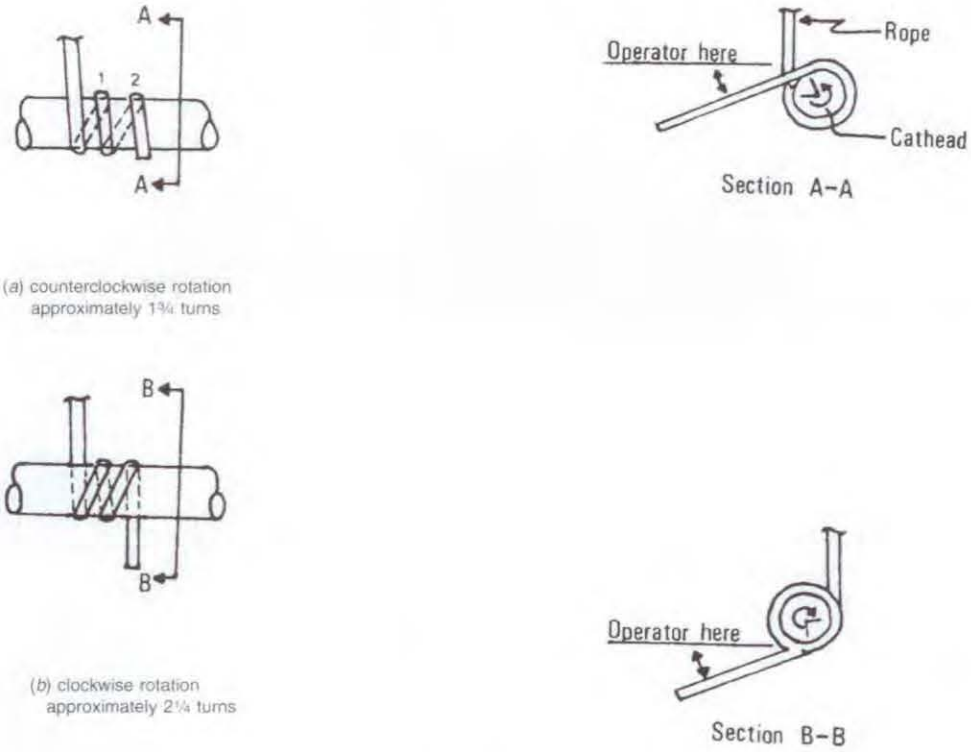

(*a*) counterclockwise rotation approximately 1¾ turns

(*b*) clockwise rotation approximately 2¼ turns

FIG. 1 Definitions of the Number of Rope Turns and the Angle for (*a*) Counterclockwise Rotation and (*b*) Clockwise Rotation of the Cathead

and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 generally are considered capable of competent testing. Users of this practice are cautioned that compliance with Practice D 3740 does not assure reliable testing. Reliable testing depends on several factors and Practice D 3740 provides a means of evaluating some of these factors. Practice D 3740 was developed for agencies engaged in the testing, inspection, or both, of soils and rock. As such, it is not totally applicable to agencies performing this practice. Users of this test method should recognize that the framework of Practice D 3740 is appropriate for evaluating the quality of an agency performing this test method. Currently, there is no known qualifying national authority that inspects agencies that perform this test method.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitable borehole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions:

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

5.1.2 *Roller-Cone Bits*, less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the borehole. The inside diameter of the hollow-stem augers shall be less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm) in diameter may be used if the soil on the side of the borehole does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod that has an outside diameter of 1-5/8 in. (41.3 mm) and an inside diameter of 1-1/8 in. (28.5 mm).

5.3 *Split-Barrel Sampler*—The standard sampler dimensions are shown in Fig. 2. The sampler has an outside diameter of 2.00 in. (50.8 mm). The inside diameter of the of the split-barrel (dimension D in Fig. 2) can be either 1½-in. (38.1

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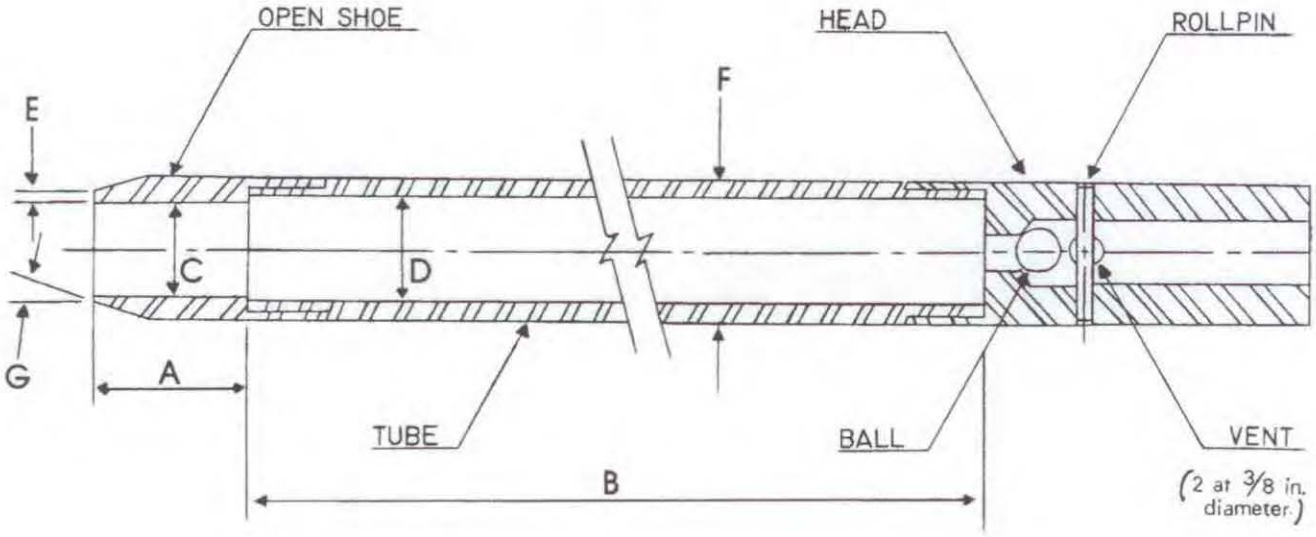

A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)
G = 16.0° to 23.0°

FIG. 2 Split-Barrel Sampler

mm) or 1⅜-in. (34.9 mm) (see Note 2). A 16-gauge liner can be used inside the 1½-in. (38.1 mm) split barrel sampler. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The penetrating end of the drive shoe may be slightly rounded. The split-barrel sampler must be equipped with a ball check and vent. Metal or plastic baskets may be used to retain soil samples.

NOTE 2—Both theory and available test data suggest that *N*-values may differ as much as 10 to 30 % between a constant inside diameter sampler and upset wall sampler. If it is necessary to correct for the upset wall sampler refer to Practice D 6066. In North America, it is now common practice to use an upset wall sampler with an inside diameter of 1½ in. At one time, liners were used but practice evolved to use the upset wall sampler without liners. Use of an upset wall sampler allows for use of retainers if needed, reduces inside friction, and improves recovery. Many other countries still use a constant ID split-barrel sampler, which was the original standard and still acceptable within this standard.

5.4 *Drive-Weight Assembly:*

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lbf (623 ± 9 N) and shall be a rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting an unimpeded fall shall be used. Fig. 3 shows a schematic of such hammers. Hammers used with the cathead and rope method shall have an unimpeded over lift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged as shown in Fig. 3. The total mass of the hammer assembly bearing on the drill rods should not be more than 250 ± 10 lbm (113 ± 5 kg).

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic or automatic hammer drop systems, as shown in Fig. 4 may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The borehole shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata. Record the depth of drilling to the nearest 0.1 ft (0.030 m).

6.2 Any drilling procedure that provides a suitably clean and stable borehole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures has proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable boreholes. The process of jetting through an open tube sampler and

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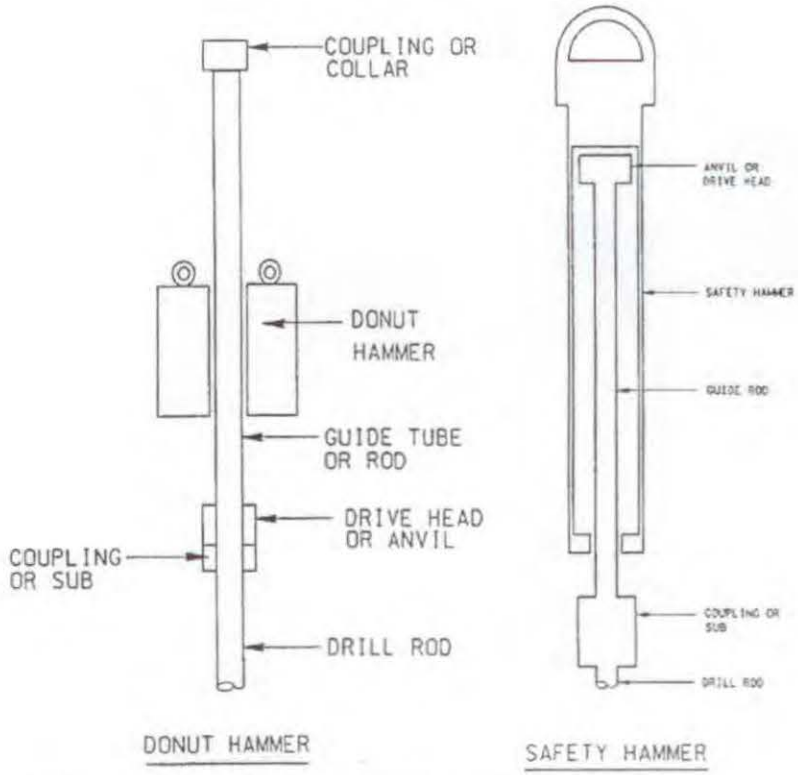

FIG. 3 Schematic Drawing of the Donut Hammer and Safety Hammer

then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the borehole below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a borehole with bottom discharge bits is not permissible. It is not permissible to advance the borehole for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the borehole or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the borehole has been advanced to the desired sampling elevation and excessive cuttings have been removed, record the cleanout depth to the nearest 0.1 ft (0.030 m), and prepare for the test with the following sequence of operations:

7.1.1 Attach either split-barrel sampler Type A or B to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the borehole. Record the sampling start depth to the nearest 0.1 ft (0.030 m). Compare the sampling start depth to the cleanout depth in 7.1. If excessive cuttings are encountered at the bottom of the borehole, remove the sampler and sampling rods from the borehole and remove the cuttings.

7.1.4 Mark the drill rods in three successive 0.5-foot (0.15 m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 0.5-foot (0.15 m) increment.

7.2 Drive the sampler with blows from the 140-lbf (623-N) hammer and count the number of blows applied in each 0.5-foot (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 0.5-foot (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 1.5 ft. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.2.5 If the sampler sinks under the weight of the hammer, weight of rods, or both, record the length of travel to the nearest 0.1 ft (0.030 m), and drive the sampler through the remainder of the test interval. If the sampler sinks the complete interval, stop the penetration, remove the sampler and sampling rods from the borehole, and advance the borehole through the very soft or very loose materials to the next desired sampling elevation. Record the *N*-value as either weight of hammer, weight of rods, or both.

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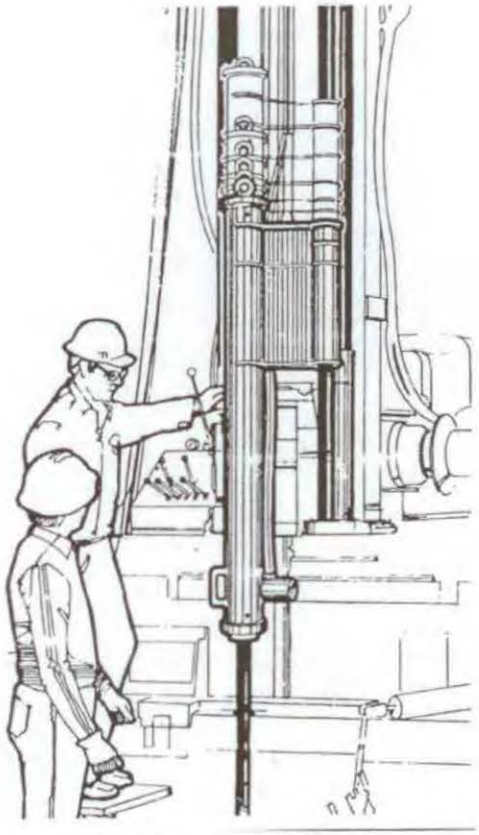

FIG. 4 Automatic Trip Hammer

7.3 Record the number of blows (*N*) required to advance the sampler each 0.5-foot (0.15 m) of penetration or fraction thereof. The first 0.5-foot (0.15 m) is considered to be a seating drive. The sum of the number of blows required for the second and third 0.5-foot (0.15 m) of penetration is termed the "standard penetration resistance," or the "*N*-value." If the sampler is driven less than 1.5 ft (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 0.5-foot (0.15 m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 0.1 ft (0.030 m) in addition to the number of blows. If the sampler advances below the bottom of the borehole under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lbf (623-N) hammer shall be accomplished using either of the following two methods. Energy delivered to the drill rod by either method can be measured according to procedures in Test Method D 4633.

7.4.1 *Method A*—By using a trip, automatic, or semi-automatic hammer drop system that lifts the 140-lbf (623-N) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 0.030 m) with limited unimpedence. Drop heights adjustments for automatic and trip hammers should be checked daily and at first indication of variations in performance. Operation of automatic hammers shall be in strict accordance with operations manuals.

7.4.2 *Method B*—By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM.

7.4.2.3 The operator should generally use either 1-3/4 or 2-1/4 rope turns on the cathead, depending upon whether or not the rope comes off the top (1-3/4 turns for counterclockwise rotation) or the bottom (2-1/4 turns for clockwise rotation) of the cathead during the performance of the penetration test, as shown in Fig. 1. It is generally known and accepted that 2-3/4 or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be stiff, relatively dry, clean, and should be replaced when it becomes excessively frayed, oily, limp, or burned.

7.4.2.4 For each hammer blow, a 30 ± 1.0 in. (0.76 m ± 0.030 m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

NOTE 4—If the hammer drop height is something other than 30 ± 1.0 in. (0.76 m ± 0.030 m), then record the new drop height. For soils other than sands, there is no known data or research that relates to adjusting the *N*-value obtained from different drop heights. Test method D 4633 provides information on making energy measurement for variable drop

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heights and Practice D 6066 provides information on adjustment of *N*-value to a constant energy level (60 % of theoretical, N60). Practice D 6066 allows the hammer drop height to be adjusted to provide 60 % energy.

7.5 Bring the sampler to the surface and open. Record the percent recovery to the nearest 1 % or the length of sample recovered to the nearest 0.01 ft (5 mm). Classify the soil samples recovered as to, in accordance with Practice D 2488, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 0.5-foot (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel. Samples should be preserved and transported in accordance with Practice D 4220 using Group B.

8. Data Sheet(s)/Form(s)

8.1 Data obtained in each borehole shall be recorded in accordance with the Subsurface Logging Guide D 5434 as required by the exploration program. An example of a sample data sheet is included in Appendix X1.

8.2 Drilling information shall be recorded in the field and shall include the following:

8.2.1 Name and location of job,

8.2.2 Names of crew,

8.2.3 Type and make of drilling machine,

8.2.4 Weather conditions,

8.2.5 Date and time of start and finish of borehole,

8.2.6 Boring number and location (station and coordinates, if available and applicable),

8.2.7 Surface elevation, if available,

8.2.8 Method of advancing and cleaning the borehole,

8.2.9 Method of keeping borehole open,

8.2.10 Depth of water surface to the nearest 0.1 ft (0.030 m) and drilling depth to the nearest 0.1 ft (0.030 m) at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.2.11 Location of strata changes, to the nearest 0.5 ft (15 cm),

8.2.12 Size of casing, depth of cased portion of borehole to the nearest 0.1 ft (0.030 m),

8.2.13 Equipment and Method A or B of driving sampler,

8.2.14 Sampler length and inside diameter of barrel, and if a sample basket retainer is used,

8.2.15 Size, type, and section length of the sampling rods, and

8.2.16 Remarks.

8.3 Data obtained for each sample shall be recorded in the field and shall include the following:

8.3.1 Top of sample depth to the nearest 0.1 ft (0.030 m) and, if utilized, the sample number,

8.3.2 Description of soil,

8.3.3 Strata changes within sample,

8.3.4 Sampler penetration and recovery lengths to the nearest 0.1 ft (0.030 m), and

8.3.5 Number of blows per 0.5 foot (0.015 m) or partial increment.

9. Precision and Bias

9.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

9.1.1 The Subcommittee 18.02 is seeking additional data from the users of this test method that might be used to make a limited statement on precision. Present knowledge indicates the following:

9.1.1.1 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent boreholes in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.1.1.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; soil; split-barrel sampling; standard penetration test

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APPENDIX

(Nonmandatory Information)

X1. Example Data Sheet

X1.1 See Fig. 5.

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DRILLERS BORING LOG

Project _____ Project No _____ Boring No _____

Location _____ Sheet _____ of _____

Date Started _____ Date Completed _____

Drill Crew:

Boring Location
Station _____ Offset _____

Elevation

Strata Depth		Soil Description and Remarks	Sample Type	No.	Depth		Recovery	N-Values		
From	To				From	To		6"	6"	6"

Drill Rig Type _____

Method Of Drilling:

Auger _____ Size _____

Wash _____ Water _____ Mud _____

Hammer Type

Auto _____ Manual _____

Split-Spoon Type

Length _____ Liner Used _____

Boring Size _____ Bit Used _____

Casing Size _____ Length _____

Weather _____

Non-Drilling Time (Hrs.)

Boring Layout _____ Moving _____

Hauling Water _____ Standby _____

Water Level @ _____ Date _____ Time _____

@ _____ Date _____ Time _____

@ _____ Date _____ Time _____

Cave-in Depth

@ _____ Date _____ Time _____

FIG. 5 Example Data Sheet

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SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D 1586 – 99) that may impact the use of this standard. (Approved February 1, 2008.)

(*1*) There have been numerous changes to this standard to list them separately. From the most recent main ballot process, additional changes were requested and incorporated into this newest revision. Stated below is a highlight of some of the changes.

(*2*) Scope was completely revised.

(*3*) Referenced Documents updated to include new standards.

(*4*) Terminology: added section on Definitions.

(*5*) Significance and Use: clarified use of the SPT test.

(*6*) Apparatus: general editorial changes.

(*7*) Sampling and Testing Procedure: general editorial changes.

(*8*) Data Sheets/Forms: general editorial changes.

(*9*) Precision and Bias: added Sections 9.1.1.1 and 9.1.1.2.

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Designation: D 1587 – 00 (Reapproved 2007)$^{\epsilon 1}$

Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes[1]

This standard is issued under the fixed designation D 1587; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

ϵ^1 NOTE—Editorial changes were made in June 2007.

1. Scope*

1.1 This practice covers a procedure for using a thin-walled metal tube to recover relatively undisturbed soil samples suitable for laboratory tests of engineering properties, such as strength, compressibility, permeability, and density. Thin-walled tubes used in piston, plug, or rotary-type samplers should comply with Section 6.3 of this practice which describes the thin-walled tubes.

NOTE 1—This practice does not apply to liners used within the samplers.

1.2 This Practice is limited to soils that can be penetrated by the thin-walled tube. This sampling method is not recommended for sampling soils containing gravel or larger size soil particles cemented or very hard soils. Other soil samplers may be used for sampling these soil types. Such samplers include driven split barrel samplers and soil coring devices (D 1586, D 3550, and D 6151). For information on appropriate use of other soil samplers refer to D 6169.

1.3 This practice is often used in conjunction with fluid rotary drilling (D 1452, D 5783) or hollow-stem augers (D 6151). Subsurface geotechnical explorations should be reported in accordance with practice (D 5434). This practice discusses some aspects of sample preservation after the sampling event. For information on preservation and transportation process of soil samples, consult Practice D 4220. This practice does not address environmental sampling; consult D 6169 and D 6232for information on sampling for environmental investigations.

1.4 The values stated in inch-pound units are to be regarded as the standard. The SI values given in parentheses are provided for information purposes only. The tubing tolerances presented in Table 1 are from sources available in North America. Use of metric equivalent is acceptable as long as thickness and proportions are similar to those required in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.6 This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 1452 Practice for Soil Investigation and Sampling by Auger Borings

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

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)

D 3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved May 1, 2007. Published July 2007. Originally approved in 1958. Last previous edition approved in 2003 as D 1587 – 03.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

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TABLE 1 Dimensional Tolerances for Thin-Walled Tubes

	Nominal Tube Diameters from Table 2[A] Tolerances					
Size Outside Diameter	2 in.	50.8 mm	3 in.	76.2 mm	5 in.	127 mm
Outside diameter, D_o	+0.007 -0.000	+0.179 -0.000	+0.010 -0.000	+0.254 -0.000	+0.015 -0.000	0.381 -0.000
Inside diameter, D_i	+0.000 -0.007	+0.000 -0.179	+0.000 -0.010	+0.000 -0.254	+0.000 -0.015	+0.000 -0.381
Wall thickness	±0.007	±0.179	±0.010	±0.254	±0.015	±0.381
Ovality	0.015	0.381	0.020	0.508	0.030	0.762
Straightness	0.030/ft	2.50/m	0.030/ft	2.50/m	0.030/ft	2.50/m

[A] Intermediate or larger diameters should be proportional. Specify only two of the first three tolerances; that is, D_o and D_i, or D_o and Wall thickness, or D_i and Wall thickness.

as Used in Engineering Design and Construction

D 4220 Practices for Preserving and Transporting Soil Samples

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock

D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices

D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling

D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations

D 6232 Guide for Selection of Sampling Equipment for Waste and Contaminated Media Data Collection Activities

3. Terminology

3.1 *Definitions:*

3.1.1 For common definitions of terms in this standard, refer to Terminology D 653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *inside clearance ratio, %, n*—the ratio of the difference in the inside diameter of the tube, D_i, minus the inside diameter of the cutting edge, D_e, to the inside diameter of the tube, D_i expressed as a percentage (see Fig. 1).

3.2.2 *ovality, n*—the cross section of the tube that deviates from a perfect circle.

4. Summary of Practice

4.1 A relatively undisturbed sample is obtained by pressing a thin-walled metal tube into the in-situ soil at the bottom of a boring, removing the soil-filled tube, and applying seals to the soil surfaces to prevent soil movement and moisture gain or loss.

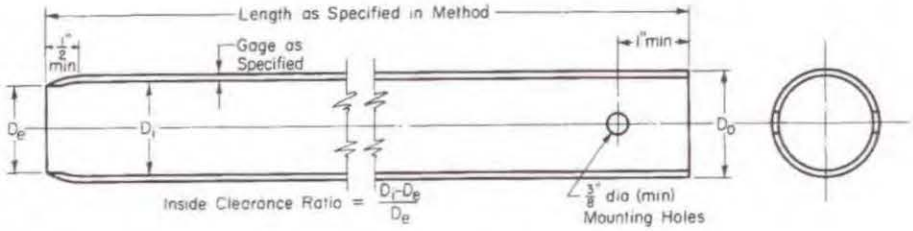
5. Significance and Use

5.1 This practice, or Practice D 3550 with thin wall shoe, is used when it is necessary to obtain a relatively undisturbed specimen suitable for laboratory tests of engineering properties or other tests that might be influenced by soil disturbance.

NOTE 2—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective sampling. Users of this practice, are cautioned that compliance with Practice D 3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D 3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Drilling Equipment*—When sampling in a boring, any drilling equipment may be used that provides a reasonably



NOTE 1—Minimum of two mounting holes on opposite sides for D_o smaller than 4 in. (101.6 mm).

NOTE 2—Minimum of four mounting holes equally spaced for D_o 4 in. (101.6 mm) and larger.

NOTE 3—Tube held with hardened screws or other suitable means.

NOTE 4—2-in (50.8 mm) outside-diameter tubes are specified with an 18-gage wall thickness to comply with area ratio criteria accepted for "undisturbed samples." Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-gage tubes are generally readily available.

Metric Equivalent Conversions

in.	mm
3/8	9.53
1/2	12.7
1	25.4
2	50.8
3	76.2
4	101.6
5	127

FIG. 1 Thin-Walled Tube for Sampling

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TABLE 2 Suitable Thin-Walled Steel Sample Tubes[A]

Outside diameter (D_o):			
in.	2	3	5
mm	50.8	76.2	127
Wall thickness:			
Bwg	18	16	11
in.	0.049	0.065	0.120
mm	1.24	1.65	3.05
Tube length:			
in.	36	36	54
m	0.91	0.91	1.45
Inside clearance ratio, %	<1	<1	<1

[A] The three diameters recommended in Table 2 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions.

clean hole; that minimizes disturbance of the soil to be sampled; and that does not hinder the penetration of the thin-walled sampler. Open borehole diameter and the inside diameter of driven casing or hollow stem auger shall not exceed 3.5 times the outside diameter of the thin-walled tube.

6.2 *Sampler Insertion Equipment*, shall be adequate to provide a relatively rapid continuous penetration force. For hard formations it may be necessary, although not recommended, to drive the thin-walled tube sampler.

6.3 *Thin-Walled Tubes*, should be manufactured to the dimensions as shown in Fig. 1. They should have an outside diameter of 2 to 5 in. (50 to 130 mm) and be made of metal having adequate strength for the type of soil to be sampled. Tubes shall be clean and free of all surface irregularities including projecting weld seams. Other diameters may be used but the tube dimensions should be proportional to the tube designs presented here.

6.3.1 *Length of Tubes*—See Table 2 and 7.4.1.

6.3.2 *Tolerances*, shall be within the limits shown in Table 1.

6.3.3 *Inside Clearance Ratio*, should be not greater than 1 % unless specified otherwise for the type of soil to be sampled. Generally, the inside clearance ratio used should increase with the increase in plasticity of the soil being sampled, except for sensitive soils or where local experience indicates otherwise. See 3.2.1 and Fig. 1 for definition of inside clearance ratio.

6.3.4 *Corrosion Protection*—Corrosion, whether from galvanic or chemical reaction, can damage or destroy both the thin-walled tube and the sample. Severity of damage is a function of time as well as interaction between the sample and the tube. Thin-walled tubes should have some form of protective coating, unless the soil is to be extruded less than 3 days. The type of coating to be used may vary depending upon the material to be sampled. Plating of the tubes or alternate base metals may be specified. Galvanized tubes are often used when long term storage is required. Coatings may include a light coat of lubricating oil, lacquer, epoxy, Teflon, zinc oxide, and others.

NOTE 3—Most coating materials are not resistant to scratching by soils that contain sands. Consideration should be given for prompt testing of the sample because chemical reactions between the metal and the soil sample con occur with time.

6.4 *Sampler Head*, serves to couple the thin-walled tube to the insertion equipment and, together with the thin-walled tube, comprises the thin-walled tube sampler. The sampler head shall contain a venting area and suitable check valve with the venting area to the outside equal to or greater than the area through the check valve. In some special cases, a check valve may not be required but venting is required to avoid sample compression. Attachment of the head to the tube shall be concentric and coaxial to assure uniform application of force to the tube by the sampler insertion equipment.

7. Procedure

7.1 Remove loose material from the center of a casing or hollow stem auger as carefully as possible to avoid disturbance of the material to be sampled. If groundwater is encountered, maintain the liquid level in the borehole at or above ground water level during the drilling and sampling operation.

7.2 Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted.

NOTE 4—Roller bits are available in downward-jetting and diffused-jet configurations. Downward-jetting configuration rock bits are not acceptable. Diffuse-jet configurations are generally acceptable.

7.3 Lower the sampling apparatus so that the sample tube's bottom rests on the bottom of the hole and record depth to the bottom of the sample tube to the nearest 0.1-ft (.03 m)

7.3.1 Keep the sampling apparatus plumb during lowering, thereby preventing the cutting edge of the tube from scraping the wall of the borehole.

7.4 Advance the sampler without rotation by a continuous relatively rapid downward motion and record length of advancement to the nearest 1 in. (25 mm).

7.4.1 Determine the length of advance by the resistance and condition of the soil formation, but the length shall never exceed 5 to 10 diameters of the tube in sands and 10 to 15 diameters of the tube in clays. In no case shall a length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3-in. (75 mm) for sludge and end cuttings.

NOTE 5—The mass of sample, laboratory handling capabilities, transportation problems, and commercial availability of tubes will generally limit maximum practical lengths to those shown in Table 2.

7.5 When the soil formation is too hard for push-type insertion, the tube may be driven or Practice D 3550 may be used. If driving methods are used, the data regarding weight and fall of the hammer and penetration achieved must be shown in the report. Additionally, that tube must be prominently labeled a "driven sample."

7.6 Withdraw the sampler from the soil formation as carefully as possible in order to minimize disturbance of the sample. The tube can be slowly rotated to shear the material at the end of the tube, and to relieve water and/or suction pressures and improve recovery. Where the soil formation is soft, a delay before withdraw of the sampler (typically 5 to 30 minutes) may improve sample recovery.

8. Sample Measurement, Sealing and Labeling

8.1 Upon removal of the tube, remove the drill cuttings in the upper end of the tube and measure the length of the soil

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sample recovered to the nearest 0.25 in. (5 mm) in the tube. Seal the upper end of the tube. Remove at least 1 in. (25 mm) of material from the lower end of the tube. Use this material for soil description in accordance with Practice D 2488. Measure the overall sample length. Seal the lower end of the tube. Alternatively, after measurement, the tube may be sealed without removal of soil from the ends of the tube.

8.1.1 Tubes sealed over the ends, as opposed to those sealed with expanding packers, should be provided with spacers or appropriate packing materials, or both prior to sealing the tube ends to provide proper confinement. Packing materials must be nonabsorbent and must maintain their properties to provide the same degree of sample support with time.

8.1.2 Depending on the requirements of the investigation, field extrusion and packaging of extruded soil samples can be performed. This allows for physical examination and classification of the sample. Samples are extruded in special hydraulic jacks equipped with properly sized platens to extrude the core in a continuous smooth speed. In some cases, further extrusion may cause sample disturbance reducing suitability for testing of engineering properties. In other cases, if damage is not significant, cores can be extruded and preserved for testing (D 4220). Bent or damaged tubes should be cut off before extruding.

8.2 Prepare and immediately affix labels or apply markings as necessary to identify the sample (see Section 9). Assure that the markings or labels are adequate to survive transportation and storage.

NOTE 6—Top end of the tube should be labeled "top".

9. Field Log

9.1 Record the information that may be required for preparing field logs in general accordance to ASTM D 5434 "Guide for Field Logging of Subsurface Explorations of Soil and Rock". This guide is used for logging explorations by drilling and sampling. Some examples of the information required include;

9.1.1 Name and location of the project,

9.1.2 Boring number,

9.1.3 Log of the soil conditions,

9.1.4 Surface elevation or reference to a datum to the nearest foot (0.5 m) or better,

9.1.5 Location of the boring,

9.1.6 Method of making the borehole,

9.1.7 Name of the drilling foreman and company, and

9.1.8 Name of the drilling inspector(s),

9.1.9 Date and time of boring-start and finish,

9.1.10 Depth to groundwater level: date and time measured.

9.2 Recording the appropriate sampling information is required as follows:

9.2.1 Depth to top of sample to the nearest 0.1 ft. (.03 m) and number of sample,

9.2.2 Description of thin-walled tube sampler: size, type of metal, type of coating,

9.2.3 Method of sampler insertion: push or drive,

9.2.4 Method of drilling, size of hole, casing, and drilling fluid used,

9.2.5 Soil description in accordance with Practice D 2488,

9.2.6 Length of sampler advance (push), and

9.2.7 Recovery: length of sample obtained.

10. Keywords

10.1 geologic investigations; sampling; soil exploration; soil investigations; subsurface investigations; undisturbed

SUMMARY OF CHANGES

In accordance with committee D18 policy, this section identifies the location of changes to this standard since the last edition, 200, which may impact the use of this standard.

(1) Added parts of speech to terms.

(2) Corrected reference in Note 2 from D 5740 to D 3740.

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STANDARD OPERATING PROCEDURE

Soil Boring Sampling–Split Spoon

I. Purpose

To provide a general procedure for sampling subsurface soil produced from a split spoon.

II. Scope

The scope of this procedure is to cover the sample team's responsibility beginning with the opening of the split spoon.

III. Equipment and Materials

- Latex or surgical gloves
- Stainless steel tray or pan or disposable sealable bags
- Field notebook
- Stainless steel spoon or spatula or disposable plastic scoop
- Sampling jars
- Decontamination solutions and equipment

IV. Procedures and Guidelines

1. Field team personnel will wear latex or surgical inner gloves and nitrile or neoprene outer gloves to protect from potential dermal contact with hazardous substances.

2. After the split spoon is removed from the borehole and opened by the driller or driller's assistant, it will be turned over to field team personnel.

3. The sample description, depth, time, and date will be logged in the field notebook.

4. Samples for laboratory analysis will be separated and transferred from the split spoon half into the sample jars by a decontaminated stainless steel utensil or plastic disposable scoop. Samples for VOC analysis will be separated and transferred first, followed by semivolatile samples. For volatile samples, avoid mixing soil before or during transfer. Homogenize the rest of the sample according to SOP *Homogenization of Soil and Sediment Samples.*

5. Immediately upon collection, all samples for chemical analysis are to be placed in a closed container on ice unless it is not possible to do so. Although

unusual and uncommon, there may be instances where it is not possible to have containers with ice at the sample location. In these instances, the samples should be placed on ice as soon as practical and during the time between collection and placing the samples on ice, the samples should be kept as cool as possible.

6. Split spoon and media transfer tools will be decontaminated before being used again.

V. Attachments

None.

VI. Key Checks and Items

- Latex or surgical gloves.
- Decontaminate split spoon and transfer tools before next sample.
- Sample volatiles first, then semivolatiles.
- Avoid mixing for volatiles samples.

Standard Operating Procedure

Locating and Clearing Underground Utilities

I. Purpose

The purpose of this SOP is to provide general guidelines and specific procedures that must be followed on Navy CLEAN projects for locating underground utilities and clearing dig locations in order to maximize our ability to avoid hitting underground utilities and to minimize liabilities to CH2M HILL and its subcontractors and health and safety risks to our project staff.

This SOP shall be used by Activity Managers and Project Managers to, in-turn, develop Activity-specific and project-specific utility location procedures. The activity and project-specific procedures will become part of work plans and project instructions and will be used to prepare scopes of work (SOWs) for the procurement of utility location subcontractors to meet the needs of individual projects.

This SOP also identifies the types of utility locating services that are available from subcontractors and the various tools that are used to locate utilities, and discusses when each type of service and tool may or may not be applicable.

II. Scope

Depending on the Navy/Marine Activity we typically find ourselves in one of two scenarios:

Scenario 1

The Activity provides utility locating (or dig clearance) services through the public works department or similar organization, or has a contract with an outside utility clearance service. Some of these services are provided in the form of dig permits which are required before you can dig or drill. In other cases no official permit is required and the process is somewhat vague.

Scenario 2

The Activity does not get involved in any utility locating processes aside from possibly providing the most recent utility maps, and relies on CH2M HILL to clear the dig locations.

Table 1 provides an up to date summary of which scenarios apply to the various primary Activities served under the Navy CLEAN program.

Scenario 1 is preferred because under this scenario the Navy tends to assume the responsibility if the location is improperly cleared, a utility is struck, and property damage results. However, our experience has been that the clearance services provided

by the Navy do not meet the standards that we consider to be adequate, in that they often simply rely on available base maps to mark utilities and do not verify locations using field geophysics. And if they do use locating tools, they do not provide adequate documentation or marking to confirm that a location has been cleared. So while the Navy's process may protect us from liability for property damage, it does not adequately protect our staff and subcontractors from health risks nor does it compensate us for down time, should a utility be hit.

Therefore, regardless of what services the Navy provides, in most cases we still need to supplement this effort with clearance services from our own third party utility location subcontractor following the procedures and guideline outlined in Section IV of this SOP. The cost implications of providing this service will range from $500 to several $1,000 depending on the size of the project.

The scope of services that we ask our subcontractors to provide can involve utility marking/mapping or the clearing of individual dig locations. In the former we ask our subs to mark all utilities within a "site" and often ask them to prepare a map based on their work. In the later, we ask them to clear (identify if there are any utilities within) a certain radius of a proposed dig/drill location.

The appropriate requested scope of services for a project will depend on the project. Clearing individual boreholes is often less expensive and allows the sub to concentrate their efforts on a limited area. However if the scope of the investigation is fluid (all borehole locations are not predetermined) it may be best to mark and map an entire site or keep the subcontractor on call.

Clearance of individual dig locations should be done to a minimum 20 foot radius around the location.

An example SOW for a utility subcontractor procurement is provided in Attachment A.

III. Services and Equipment

This section provides a general description of the services available to help us locate subsurface utilities and describes the types of equipment that these services may (or may not) use to perform their work. It identifies the capabilities of each type of equipment to help the PM specify what they should require from our utility location subs.

Services

The services that are available to us for identifying and marking underground utilities are:

- The local public/private utility-run service such as Miss Utility
- Utility location subcontractors (hired by us)

Attachment B provides a detailed description of each type of organization. It also provides contact numbers and web sites for the various Miss-Utility-type organizations in the areas where we do work for the Navy and contacts and services provided by several subcontractors that we have used or spoken to in the past.

Equipment

Attachment C provides a summary of the various types of equipment used for subsurface utility location. It describes the capabilities and limitations of each in order to help the PM determine if the equipment being used by a subcontractor is adequate.

It is important to make the potential subcontractors aware of the possible types of utilities (and utility materials) that are at the site, and to have them explain in their bid what types of equipment they will use to locate utilities /clear dig locations, and what the limitations of these equipment are.

A list of in-house experts that can be used to help you evaluate bids or answer questions you may have is provided in **Appendix C.**

IV. Procedures and Guidelines

This section presents specific procedures to be followed for the utility location work to be conducted by CH2M HILL and our subcontractors. In addition, a PM will have to follow the procedures required by the Activity to obtain their approvals, clearances and dig permits where necessary. These "dig permit" requirements vary by Activity and must be added to the project-specific SOP, or project instructions. It is preferable that the Activity perform their clearance processes before we follow up with our clearance work.

Activity Notification and Dig Permit Procedures

Identify Activity-specific permit and/or procedural requirements for excavation and drilling activities. Contact the Base Civil Engineer and obtain the appropriate form to begin the clearance process.

Activity Specific: To be provided by Activity or Project Manager

CH2M HILL Utility Clearance Procedures

Do not begin subsurface construction activities (e.g., trenching, excavation, drilling, etc.) until a check for underground utilities and similar obstructions has been conducted by CH2M HILL as a follow-up to the services provided by the Navy. The use of as-built drawings and utility company searches must be supplemented with a geophysical or other survey by a qualified, independent survey contractor (subcontracted to CH2M HILL) to identify additional and undiscovered buried utilities.

Examples of the type of geophysical technologies include (these are further described in Attachment C):

- **Ground Penetrating Radar (GPR),** which can detect pipes, including gas pipes, tanks, conduits, cables etc, both metallic and non-metallic at depths up to 30 feet depending on equipment. Sensitivity for both minimum object size and maximum depth detectable depends on equipment selected, soil conditions, etc.
- **Radio Frequency (RF),** involves inducing an RF signal in the pipe or cable and using a receiver to trace it. Some electric and telephone lines emit RF naturally and can be

detected without an induced signal. This method requires knowing where the conductive utility can be accessed to induce RF field if necessary.

- **Dual RF**, a modified version of RF detection using multiple frequencies to enhance sensitivity but with similar limitations to RF
- **Ferromagnetic Detectors**, are metal detectors that will detect ferrous and non-ferrous utilities. Sensitivity is limited, e.g. a 100 mm iron disk to a depth of about one meter or a 25 mm steel paper clip to a depth of about 20 cm.
- **Electronic markers,** are emerging technologies that impart a unique electronic signature to materials such as polyethylene pipe to facilitate location and tracing after installation. Promising for future installations but not of help for most existing utilities already in place.

The following procedures shall be used to identify and mark underground utilities during subsurface construction activities on the project:

- Contact utility companies or the state/regional utility protection service (such as Miss Utility) at least two (2) working days prior to intrusive activities to advise of the proposed work, and ask them to establish the location of the utility underground installations prior to the start of actual excavation: this is a law. These services will only mark the location of public-utility-owned lines and not Navy-owned utilities. In many cases there will not be any public-utility-owned lines on the Activity. There may also be Base-access issues to overcome.
- Procure and schedule the independent survey.
- The survey contractor shall determine the most appropriate geophysical technique or combinations of techniques to identify the buried utilities on the project site, based on the survey contractor's experience and expertise, types of utilities anticipated to be present and specific site conditions. ***The types of utilities must be provided to the bidding subcontractors in the SOW and procedures to be used must be specified by the bidder in their bid. It is extremely helpful to provide the sub with utility maps, with the caveat that all utilities are not necessarily depicted.***
- The survey subcontractor shall employ the same geophysical techniques used to identify the buried utilities, to survey the proposed path of subsurface investigation/construction work to confirm no buried utilities are present.
- Obtain utility clearances for subsurface work on both public and private property.
- Clearances provided by both the "Miss Utility" service and the CH2M HILL-subcontracted service are to be in writing, signed by the party conducting the clearance. The Miss Utility service will have standard notification forms/letters which typically simply state that they have been to the site and have done their work. The CH2M HILL subcontractor shall be required to fill out the form provided in Attachment D (this can be modified for a particular project) indicating that each dig/drill location has been addressed. ***This documentation requirement (with a copy of the form) needs to be provided in the subcontractor SOW.***

- Marking shall be done using the color coding presented in Attachment E. The type of material used for marking must be approved by the Activity prior to marking. Some base commanders have particular issues with persistent spray paint on their sidewalks and streets. ***Any particular marking requirements need to be provided in the subcontractor SOW.***
- Protect and preserve the markings of approximate locations of facilities until the markings are no longer required for safe and proper excavations. If the markings of utility locations are destroyed or removed before excavation commences or is completed, the Project Manager must notify the utility company or utility protection service to inform them that the markings have been destroyed.
- Perform a field check prior to drilling/digging (preferably while the utility location sub is still at the site) to see if field utility markings coincide with locations on utility maps. Look for fire hydrants, valves, manholes, light poles, lighted signs, etc to see if they coincide with utilities identified by the subcontractor.
- Underground utility locations must be physically verified (or dig locations must be physically cleared) by hand digging using wood or fiberglass-handled tools, air knifing, or by some other acceptable means approved by CH2M HILL, when the dig location (e.g. mechanical drilling, excavating) is expected to be within 5 feet of a marked underground system. Hand clearance shall be done to a depth of four feet unless a utility cross-section is available that indicates the utility is at a greater depth. In that event, the hand clearance shall proceed until the documented depth of the utility is reached.
- Conduct a site briefing for employees at the start of the intrusive work regarding the hazards associated with working near the utilities and the means by which the operation will maintain a safe working environment. Detail the method used to isolate the utility and the hazards presented by breaching the isolation.
- Monitor for signs of utilities during advancement of intrusive work (e.g., sudden change in advancement of auger or split spoon during drilling or change in color, texture or density during excavation that could indicate the ground has been previously disturbed).

IV. Attachments

A- Example SOW for Utility Location Subcontractor Procurement
B - Services Available for Identifying and Marking Underground Utilities
C – Equipment Used for Identifying Underground Utilities
D – Utility Clearance Documentation Form
E – Utility Marking Color Codes

Attachment A – Example SOW for Subcontracting Underground Utilities Locating Services

CTO-XXX

Scope of Work

Subsurface Utility Locating

Site XX

Navy Activity

City, State

A licensed and insured utility locator will be subcontracted to identify and mark out subsurface utilities for an environmental investigation/remediation project at Site XX of <<insert name of base, city, and state>>. The subcontractor will need to be available beginning at <<insert time>> on <<insert date>>. It is estimated that the work can be completed within XX days.

Proposed Scope of Work

The subcontractor will identify and mark all subsurface utilities (CHOOSE 1) that lie within a radius of 20 feet of each of XX sampling locations at Site XX shown on the attached Figure 1; (OR) that lie within the bounds of Site XX as delineated on the attached Figure 1. (If multiple sites are to be cleared, provide maps of each site with sample locations or clearance boundaries clearly delineated and a scale provided.)

Utilities will be identified using all reasonably available as-built drawings, electronic locating devices, and any other means necessary to maintain the safety of drilling and sampling personnel and the protection of the base infrastructure. The location of utilities identified from as-built drawings or other maps must be verified in the field prior to marking.

Base utility drawings for the Site(s) (CHOOSE 1) can be found at <<insert specific department and address or phone number on the base>> and should be reviewed by the subcontractor and referenced as part of the utility locating. (OR), will be provided to the subcontractor by CH2M HILL upon the award of the subcontract. (OR), are not available. Utility drawings shall not be considered definitive and must be field verified.

Field verification will include detection using nonintrusive subsurface detection equipment (magnetometers, GPR, etc) as well as opening manhole covers to verify pipe directions. As part of the bid, the Subcontractor shall provide a list of the various subsurface investigation tools they propose to have available and use at the site and what the limitations are of each tool.

A CH2M HILL representative shall be present to coordinate utility clearance activities and identify points and features to be cleared.

Field Marking and Documentation

All utilities located within **(CHOOSE 1)** ***a 20-ft radius of the XX proposed soil boring locations*** **(OR)** ***within the boundary of the site(s)*** as identified on the attached figure(s) will be marked using **paint** ***(some Bases such as the WNY may have restrictions on the use of permanent paint)*** and/or pin flags color coded to indicate electricity, gas, water, steam, telephone, TV cable, fiber optic, sewer, etc. The color coding shall match the industry standard as described on the attached form. In addition, the ***Buried Utility Location Tracking Form*** (attached) will be completed by the Subcontractor based upon what is identified in the field during the utility locating and submitted back to CH2M HILL (field staff or project manager) within 24 hours of completing the utility locating activities.

(OPTIONAL) ***The subcontractor shall also provide a map (or hand sketch) of the identified utilities to the Engineer within XX days of field demobilization. The map shall include coordinates or ties from fixed surface features to each identified subsurface utility.***

Bid Sheet/Payment Units

The subcontractor will bid on a time and materials basis for time spent on site and researching utility maps. Mobilization (including daily travel to the site) should be bid as a lump sum, as well as the preparation of the AHA and any required mapping. The per diem line item should be used if the field crew will require overnight accommodations at the project site.

Health and Safety Requirements

The utility locating subcontractor is to provide and assume responsibility for an adequate corporate Health and Safety Plan for onsite personnel. Standard personal safety equipment including: hard hat, safety glasses, steel-toed boots, gloves are recommended for all project activities. Specific health and safety requirements will be established by the Subcontractor for each project. The health and safety requirements will be subject to the review of CH2M HILL.

The subcontractor shall also prepare and provide to the Engineer, at least 48 hours prior to mobilization, an acceptable Activity Hazard Analysis (AHA) using the attached AHA form or similar.

It is also required that all subcontractor personnel who will be on site attend the daily 15-minute health and safety tailgate meeting at the start of each day in the field.

Subcontractor personnel showing indications of being under the influence of alcohol or illegal drugs will be sent off the job site and their employers will be notified. Subcontractor personnel under the influence of prescription or over-the-counter medication that may impair their ability to operate equipment will not be permitted to do so. It is expected that the subcontractor will assign them other work and provide a capable replacement (if necessary) to operate the equipment to continue work.

Security

The work will be performed on US Navy property. CH2M HILL will identify the Subcontractor personnel who will perform the work to the appropriate Navy facility point-of-contact, and will identify the Navy point-of-contact to the Subcontractor crew. The Subcontractor bears final responsibility for coordinating access of his personnel onto Navy property to perform required work. This responsibility includes arranging logistics and providing to CH2M HILL, in advance or at time of entry as specified, any required identification information for the Subcontractor personnel. Specifically, the following information should be submitted with the bid package for all personnel that will perform the work in question (this information is required to obtain a base pass):

- Name
- Birth Place
- Birth Date
- Social Security Number
- Drivers License State and Number
- Citizenship

Please be advised that no weapons, alcohol, or drugs will be permitted on the Navy facility at any time. If any such items are found, they will be confiscated, and the Subcontractor will be dismissed.

Quality Assurance

The Subcontractor will be licensed and insured to operate in the State of <<state>> and will comply with all applicable federal, state, county and local laws and regulations. The subcontractor will maintain, calibrate, and operate all electronic locating instruments in accordance with the manufacturer's recommendations. Additionally, the Subcontractor shall make all reasonable efforts to review as-built engineering drawings maintained by Base personnel, and shall notify the CH2M HILL Project Manager in writing (email is acceptable) whenever such documentation was not available or could not be reviewed.

Subcontractor Standby Time

At certain periods during the utility locating activities, the Subcontractor's personnel may be asked to stop work and standby when work may normally occur. During such times, the Subcontractor will cease activities until directed by the CH2M HILL representative to resume operations. Subcontractor standby time also will include potential delays caused by the CH2M HILL representative not arriving at the site by the agreed-upon meeting time for start of the work day. Standby will be paid to the

Subcontractor at the hourly rate specified in the Subcontractor's Bid Form attached to these specifications.

Cumulative Subcontractor standby will be accrued in increments no shorter than 15 minutes (i.e., an individual standby episode of less than 15 minutes is not chargeable).

During periods for which standby time is paid, the surveying equipment will not be demobilized and the team will remain at the site. At the conclusion of each day, the daily logs for the Subcontractor and CH2M HILL representative will indicate the amount of standby time incurred by the Subcontractor, if any. Payment will be made only for standby time recorded on CH2M HILL's daily logs.

Down Time

Should equipment furnished by the Subcontractor malfunction, preventing the effective and efficient prosecution of the work, or inclement weather conditions prevent safe and effective work from occurring, down time will be indicated in the Subcontractor's and CH2M Hill representative's daily logs. No payment will be made for down time.

Schedule

It is anticipated that the subsurface utility locating activities will occur on <<insert date>>. It is estimated that the above scope will be completed within XXX days.

Attachment B - Services Available for Identifying and Marking Underground Utilities

The services that are available to us for identifying and marking underground utilities are:

- The Activity's PWC (or similar organization)
- The local public/private utility -run service such as Miss Utility
- Utility location subcontractors (hired by CH2M HILL)

Each are discussed below.

Navy Public Works Department

A Public Works Department (PWD) is usually present at each Activity. The PWD is responsible for maintaining the public works at the base including management of utilities. In many cases, the PWD has a written permit process in place to identify and mark-out the locations of Navy-owned utilities [Note: The PWD is usually NOT responsible for the locations/mark-outs of non-Navy owned, public utilities (e.g., Washington Gas, Virginia Power, municipal water and sewer, etc.). Therefore, it is likely that we will have to contact other organizations besides the PWD in order to identify non-Navy owned, public utilities].

At some Activities, there may not be a PWD, the PWD may not have a written permit process in place, or the PWD may not take responsibility for utility locating and mark-outs. In these cases, the PWD should still be contacted since it is likely that they will have the best understanding of the utility locations at the Activity (i.e., engineering drawings, institutional knowledge, etc.). Subsequently, the PWD should be brought into a cooperative arrangement (if possible) with the other services employed in utility locating and mark-out in order to have the most comprehensive assessment performed.

At all Activities we should have a contact (name and phone number), and preferably an established relationship, with PWD, either directly or through the NAVFAC Atlantic, Midlant, or Washington NTR or Activity Environmental Office that we can work with and contact in the event of problems.

Miss Utility or "One Call" Services for Public Utility Mark-outs

Miss Utility or "One Call" service centers are information exchange centers for excavators, contractors and property owners planning any kind of excavation or digging. The "One Call" center notifies participating public utilities of the upcoming excavation work so they can locate and mark their underground utilities in advance to prevent possible damage to underground utility lines, injury, property damage and service outages. In some instances, such with southeastern Virginia bases, the Navy has entered into agreement with Ms. Utilities and is part of the response process for Miss

Utilities. Generally, a minimum of 48 hours is required for the public utility mark-outs to be performed. The "One Call" services are free to the public. Note that the "One Call" centers only coordinate with participating public utilities. There may be some public utilities that do NOT participate in the "One Call" center which may need to be contacted separately. For example, in Washington, DC, the Miss Utility "One Call" center does not locate and mark public sewer and water lines. Therefore, the municipal water and sewer authority must be contacted separately to have the sewer and water lines marked out. The AM should contact the appropriate one-call center to determine their scope of services.

For the Mid-Atlantic region, the following "One Call" service centers are available.

Name	Phone	Website	Comments
Miss Utility of DELMARVA	800-257-7777	www.missutility.net	Public utility mark-outs in Delaware, Maryland, Washington, DC, and Northern Virginia
Miss Utility of Southern Virginia (One Call)	800-552-7001	not available	Public utility mark-outs in Southern Virginia
Miss Utility of Virginia	800-257-7777 800-552-7007	www.missutilityofvirginia.com	General information on public utility mark-outs in Virginia, with links to Miss Utility of DELMARVA and Miss Utility of Southern Virginia (One Call)
Miss Utility of West Virginia, Inc	800-245-4848	none	Call to determine what utilities they work with in West Virginia
North Carolina One Call Center	800-632-4949	www.ncocc.org/ncocc/default.htm	Public Utility Markouts in North Carolina

Private Subcontractors

1. Utility-locating support is required at some level for most all CH2M HILL field projects in "clearing" proposed subsurface boring locations on the project site. Utility location and sample clearance can include a comprehensive effort of GIS map interpretation, professional land surveying, field locating, and geophysical surveying. Since we can usually provide our own GIS-related services for projects and our professional land surveying services are normally procured separately, utility-locating subcontractors will normally only be required for some level of geophysical surveying support in the field. This level of geophysical surveying support can range widely from a simple electromagnetic (EM) survey over a known utility line, to a blind geophysical effort, including a ground-penetrating radar (GPR) survey and/or a comprehensive EM survey to delineate and characterize all unknown subsurface anomalies.

   The level of service required from the subcontractor will vary depending on the nature of the site. At sites where utility locations are well defined on the maps and recent construction is limited, CH2M HILL may be confident with a limited effort from a traditional utility-locating subcontractor providing a simple EM survey. At sites where utility locations are not well defined, where recent constructions may have altered utility locations, or the nature of the site makes utility location difficult,

CH2M HILL will require the services of a comprehensive geophysical surveying subcontractor, with a wide range of GPR and EM services available for use on an "as-needed" basis. Typical costs for geophysical surveying subcontractors will range from approximately $200 per day for a simple EM effort (usually one crew member and one instrument) to approximately $1,500 per day for a comprehensive geophysical surveying effort (usually a two-person crew and multiple instruments). Comprehensive geophysical surveying efforts may also include field data interpretation (and subsequent report preparation) and non-destructive excavation to field-verify utility depths and locations.

The following table provides a list of recommended geophysical surveying support subcontractors that can be used for utility-locating services:

Company Name and Address	Contact Name and Phone Number	Equipment[1]					Other Services[2]		
		1	2	3	4	5	A	B	C
US Radar, Inc.* PO Box 319 Matawan, NJ 07747	Ron LaBarca 732-566-2035			4					
Utilities Search, Inc.*	Jim Davis 703-369-5758	4				4	4	4	4
So Deep, Inc.* 8397 Euclid Avenue Manassas Park, VA 20111	703-361-6005	4					4	4	4
Accurate Locating, Inc. 1327 Ashton Rd., Suite 101 Hanover, MD 21076	Ken Shipley 410-850-0280	4	4						
NAEVA Geophysics, Inc. P.O. Box 7325 Charlottesville, VA 22906	Alan Mazurowski 434-978-3187	4	4	4	4	4	4	4	4
Earth Resources Technology. Inc. 8106 Stayton Rd. Jessup, MD 20794	Peter Li 240-554-0161	4	4	4	4	4	4	4	
Geophex, Ltd 605 Mercury Street Raleigh, NC 27603	I. J. Won 919-839-8515	4	4	4	4	4	4	4	4

Notes:

*Companies denoted with an asterisk have demonstrated reluctance to assume responsibility for damage to underground utilities or an inability to accommodate the insurance requirements that CH2M HILL requests for this type of work at many Navy sites.

[1]Equipment types are:

1. Simple electromagnetic instruments, usually hand-held
2. Other, more innovative, electromagnetic instruments, including larger instruments for more area coverage
3. Ground-penetrating radar systems of all kinds
4. Audio-frequency detectors of all kinds
5. Radio-frequency detectors of all kinds

[2]Other services include:

A. Data interpretation and/or report preparation to provide a permanent record of the geophysical survey results and a professional interpretation of the findings, including expected accuracy and precision.

B. Non-destructive excavation to field-verify the depths, locations, and types of subsurface utilities.

C. Concrete/asphalt coring and pavement/surface restoration.

Attachment C – Equipment Used for Identifying Underground Utilities

This attachment provides a summary of the various types of equipment used for subsurface utility location. It describes the capabilities and limitations of each in order to help the AM and PM determine if the equipment being proposed by a subcontractor or Navy is adequate. A list of in-house experts that can be used to answer questions you may have is provided below.

CH2M HILL In-house Utility Location Experts

Tamir Klaff/WDC

Home Office Phone – 703-669-9611

Electromagnetic Induction (EMI) Methods

EMI instruments, in general, induce an electromagnetic field into the ground (the primary field) and then record the response (the secondary field), if any. Lateral changes in subsurface conductivity, such as caused by the presence of buried metal or by significant soil variations, cause changes in the secondary field recorded by the instrument and thus enable detection and mapping of the subsurface features. It should be noted that EMI only works for electrically conductive materials--plastic or PVC pipes are generally not detected with EMI. Water and gas lines are commonly plastic, although most new lines include a copper "locator" strip on the top of the PVC to allow for detection with EMI.

EMI technology encompasses a wide range of instruments, each with inherent strengths and weaknesses for particular applications. One major division of EMI is between "time-domain" and "frequency-domain" instruments that differ in the aspect of the secondary field they detect. Another difference in EMI instruments is the operating frequency they use to transmit the primary field. Audio- and radio-frequencies are often used for utility detection, although other frequencies are also used. Consideration of the type of utility expected, surface features that could interfere with detection, and the "congestion" of utilities in an area, should be made when choosing a particular EMI instrument for a particular site.

One common EMI tool used for utility location is a handheld unit that can be used to quickly scan an area for utilities and allows for marking locations in "real time". This method is most commonly used by "dig-safe" contractors marking out known utilities prior to excavation. It should be noted that this method works best when a signal (the primary field) can be placed directly onto the line (i.e., by clamping or otherwise connecting to the end of the line visible at the surface, or for larger utilities such as sewers, by running a transmitter through the utility). These types of tools also have a limited capability to scan an area for unknown utilities. Usually this requires having enough area to separate a hand held transmitter at least a hundred feet from the

receiver. Whether hunting for unknown, or confirming known, utilities, this method will only detect continuous lengths of metallic conductors.

In addition to the handheld EMI units, larger, more powerful EMI tools are available that provide more comprehensive detection and mapping of subsurface features. Generally, data with these methods are collected on a regular grid in the investigation area, and are then analyzed to locate linear anomalies that can be interpreted as utilities. These methods will usually detect *all* subsurface metal (above a minimum size), including pieces of abandoned utilities. In addition, in some situations, backfill can be detected against native soils giving information on trenching and possible utility location. Drawbacks to these methods are that the secondary signals from utilities are often swamped (i.e., undetectable) close to buildings and other cultural features, and that the subsurface at heavily built-up sites may be too complicated to confidently interpret completely.

Hand-held metal detectors (treasure-finders) are usually based on EMI technology. They can be used to locate shallow buried metal associated with utilities (e.g., junctions, manholes, metallic locators). Advantages of these tools is the ease of use and real-time marking of anomalies. Drawbacks include limited depths of investigations and no data storage capacity.

Ground Penetrating Radar (GPR)

GPR systems transmit radio and microwave frequency (e.g., 80 megaHertz to 1,000 megaHertz) waves into the ground and then record reflections of those waves coming back to the surface. Reflections of the radar waves typically occur at lithologic changes, subsurface discontinuities, and subsurface structures. Plastic and PVC pipes can sometimes be detected in GPR data, especially if they are shallow, large, and full of a contrasting material such as air in a wet soil, or water in a dry soil. GPR data are usually collected in regular patterns over an area and then analyzed for linear anomalies that can be interpreted as utilities. GPR is usually very accurate in x-y location of utilities, and can be calibrated at a site to give very accurate depth information as well. A significant drawback to GPR is that depth of investigation is highly dependant on background soil conductivity, and it will not work on all sites. It is not uncommon to get only 1-2 feet of penetration with the signal in damp, clayey environments. Another drawback to GPR is that sites containing significant fill material (e.g., concrete rubble, scrap metal, garbage) will result in complicated anomalies that are difficult or impossible to interpret.

Magnetic Field Methods

Magnetic field methods rely on detecting changes to the earth's magnetic field caused by ferrous metal objects. This method is usually more sensitive to magnetic metal (i.e., deeper detection) than EMI methods. A drawback to this method is it is more susceptible to being swamped by surface features such as fences and cars. In addition, procedures must usually be implemented that account for natural variations in the earth's background field as it changes throughout the day. One common use of the method is to measure and analyze the gradient of the magnetic field, which eliminates most of the drawbacks to the method. It should be noted this method only detects

ferrous metal, primarily iron and steel for utility location applications. Some utility detector combine magnetic and EMI methods into a single hand-held unit.

Optical Methods

Down the hole cameras may be useful in visually reviewing a pipe for empty conduits and/or vaults.

Attachment D – Utility Clearance Documentation Form

Attachment E – Utility Marking Color Codes

The following is the standard color code used by industry to mark various types of utilities and other features at a construction site.

White – Proposed excavations and borings

Pink – Temporary survey markings

Red – Electrical power lines, cables, conduits and lighting cables

Yellow – Gas, oil, steam, petroleum or gaseous materials

Orange – Communication, alarm or signal lines, cables, or conduits

Blue – Potable water

Purple – Reclaimed water, irrigation and slurry lines

Green – Sewer and storm drain lines

PMS 219

PMS 1795*

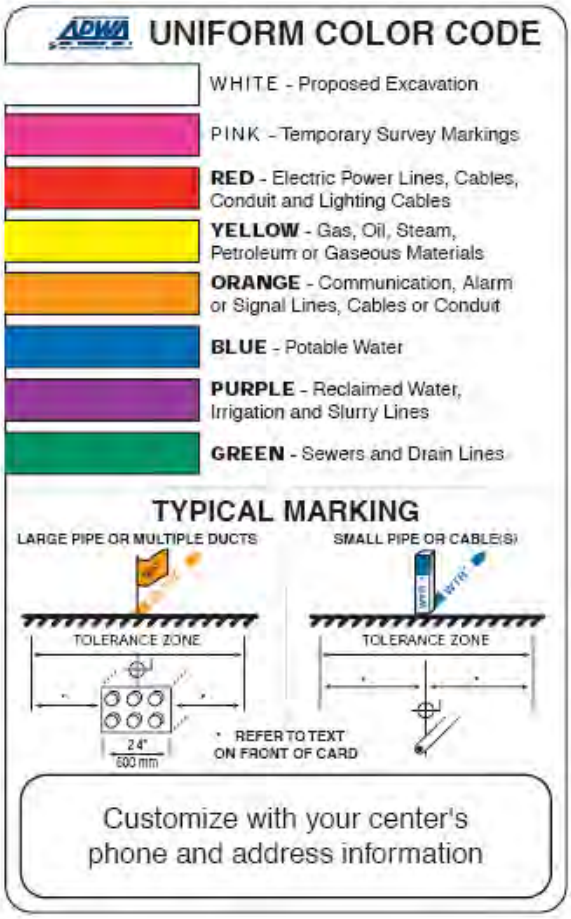
PMS 108

PMS 144*

13.5 parts process
2.5 parts reflex

PMS 253

PMS 3415



GUIDELINES FOR UNIFORM TEMPORARY MARKING OF UNDERGROUND FACILITIES

This marking guide provides for universal use and understanding of the temporary marking of subsurface facilities to prevent accidents and damage or service interruption by contractors, excavators, utility companies, municipalities or any others working on or near underground facilities.

ONE-CALL SYSTEMS
The One-Call damage prevention system shall be contacted prior to excavation.

PROPOSED EXCAVATION
Use white marks to show the location, route or boundary of proposed excavation. Surface marks on roadways do not exceed 1.5" by 18" (40 mm by 450 mm). The facility color and facility owner identity may be added to white flags or stakes.

USE OF TEMPORARY MARKING
Use color-coded surface marks (i.e., paint or chalk) to indicate the location or route of active and out-of-service buried lines. To increase visibility, color coded vertical markers (i.e., stakes or flags) should supplement surface marks. Marks and markers indicate the name, initials or logo of the company that owns or operates the line, and width of the facility if it is greater than 2" (50 mm). Marks placed by other than line owner/operator or its agent indicate the identity of the designating firm. Multiple lines in joint trench are marked in tandem. If the surface over the buried line is to be removed, supplementary offset markings are used. Offset markings are on a uniform alignment and clearly indicate the actual facility is a specific distance away.

TOLERANCE ZONE
Any excavation within the tolerance zone is performed with non-powered hand tools or non-invasive method until the marked facility is exposed. The width of the tolerance zone may be specified in law or code. If not, a tolerance zone including the width of the facility plus 18" (450 mm) measured horizontally from each side of the facility is recommended.

ADOPT UNIFORM COLOR CODE
The American Public Works Association encourages public agencies, utilities, contractors, other associations, manufacturers and all others involved in excavation to adopt the APWA Uniform Color Code, using ANSI standard Z535.1 Safety Colors for temporary marking and facility identification.

Rev. 4/99

STANDARD OPERATING PROCEDURE

Water-Level Measurements

I. Purpose and Scope

The purpose of this procedure is to provide a guideline for the measurement of the depth to groundwater in piezometers and monitoring wells, even where a second phase of floating liquid (e.g., gasoline) is encountered, and on staff gages in surface-water bodies. This SOP includes guidelines for discrete measurements of static water levels and does not cover the use of continuously recording loggers (see SOP *Use of Data Loggers and Pressure Transducers)*.

II. Equipment and Materials

- Electronic water-level meter (Solinst® or equivalent) with a minimum 100-foot tape; the tape should have graduations in increments of 0.01 feet or less
- Interface probe (Solinst® Model 122 Interface Meter or equivalent)

III. Procedures and Guidelines

Verify that the unit is turned on and functioning properly. Slowly lower the probe on its cable into the piezometer or well until the probe just contacts the water surface; the unit will respond with a tone or light signal. Note the depth from a reference point indicated on the piezometer or well riser. Typically this is the top of the PVC casing. If no reference is clearly visible, measure the depth to water from the northern edge of the PVC casing. If access to the top of the PVC casing is difficult, sight across the top of the locking casing adjacent to the measuring point, recording the position of the cable when the probe is at the water surface.

Measure the distance from this point to the closest interval marker on the tape, and record the water level reading in the logbook. Water levels will be measured to the nearest 0.01-foot. Also when specified in the project plans, measure and record the depth of the piezometer or well. The depth of the piezometer or well may be measured using the water-level probe with the instrument turned off.

Free product light or dense nonaqueous phase liquid may be present in the piezometer or well. If the presence of free product is suspected, the thickness of the product should be determined using appropriate equipment (e.g., Solinst® Model 122 Interface Meter). The depth to water also is determined with this equipment and the water-level meter should not be used in the piezometer or well as long as product is present. Typically, a constant sound is emitted from the device when free product is encountered and an alternating on/off beep sound is emitted when water is encountered.

The apparent elevation of the water level in the well or piezometer is determined by measuring both the apparent depth to water and the thickness of free product. The corrected water-level elevation is calculated by the following equation:

$$WL_c = Wl_a + (\text{Free-product thickness} \times 0.80)$$

Where WL_c = Corrected water-level elevation

Wl_a = Apparent water-level elevation

0.80 = Typical value for the density of petroleum hydrocarbon products.

If free product is detected on the surface of the water in the piezometer or well, the value of sampling should be reconsidered because of the potential for contaminating the sampling equipment.

Staff gages may be installed in some surface-water bodies. These facilities typically are constructed by attaching a calibrated, marked staff gage to a wood or metal post, driving the post into the bottom of the surface-water body, and surveying the elevation of the top of the post to a resolution or 0.01-foot. The elevation of the water in the surface-water body then can be determined by reading off the distance the water level is from the top of the post. A shield or other protection may be needed to calm the fluctuations in water level if the gage is installed at a location exposed to wind or wave.

IV. Attachments

None.

V. Key Checks

- Before each use, verify that the battery is charged by pressing the test button on the water-level meter.
- Verify that the unit is operating correctly by testing the probe in distilled or de-ionized water. Leave the unit turned off when not in use.

STANDARD OPERATING PROCEDURE

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

I. Purpose and Scope

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

II. Equipment and Materials

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

III. Procedures and Guidelines

A. Parameters and Specifications:

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

B. Calibration:

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

Horiba Calibration procedure:

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

YSI Calibration procedure:

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

A. Conductivity Calibration:

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

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

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

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

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

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

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

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

B. Dissolved Oxygen Calibration:

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

1) Go to the calibrate screen as described in Section

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

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

   NOTE: Be sure to completely immerse all the sensors.

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

C. pH Calibration:

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

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

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

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

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

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

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

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

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

D. ORP Calibration:

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

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

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

C. Sample Measurement:

Horiba measurement procedure:

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

YSI measurement procedure:

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

IV. Key Checks and Preventive Maintenance

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

V. References

YSI 556 Multi Probe System Operator Manual

YSI **Environmental**

Pure Data for a Healthy Planet.™

YSI 556 MPS

Multi Probe System

Operations Manual

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1. Safety

1.1 General Safety Information

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

⚠ **WARNING**

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

⚠ **CAUTION**

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

⚠ **IMPORTANT SAFETY INSTRUCTIONS!**

⚠ **SAVE THESE INSTRUCTIONS!**

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

⚠ YSI 6117 Rechargeable Battery Pack Safety Information

⚠ **Restrictions on Usage**

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

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

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

⚠ Precautions for Users with Small Children

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

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

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

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

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

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

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

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

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

⚠ YSI 616 Cigarette Lighter Charger Safety Information

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

⚠ YSI 556 MPS Water Leakage Safety Information

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

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

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

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

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

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

2. General Information

2.1 Description

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

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

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

Features

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

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

2.2 Unpacking the Instrument

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

   NOTE: Do not discard any parts or supplies.

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

3. Visually inspect all components for damage.

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

2.3 Features of the YSI 556 Multi-Probe System

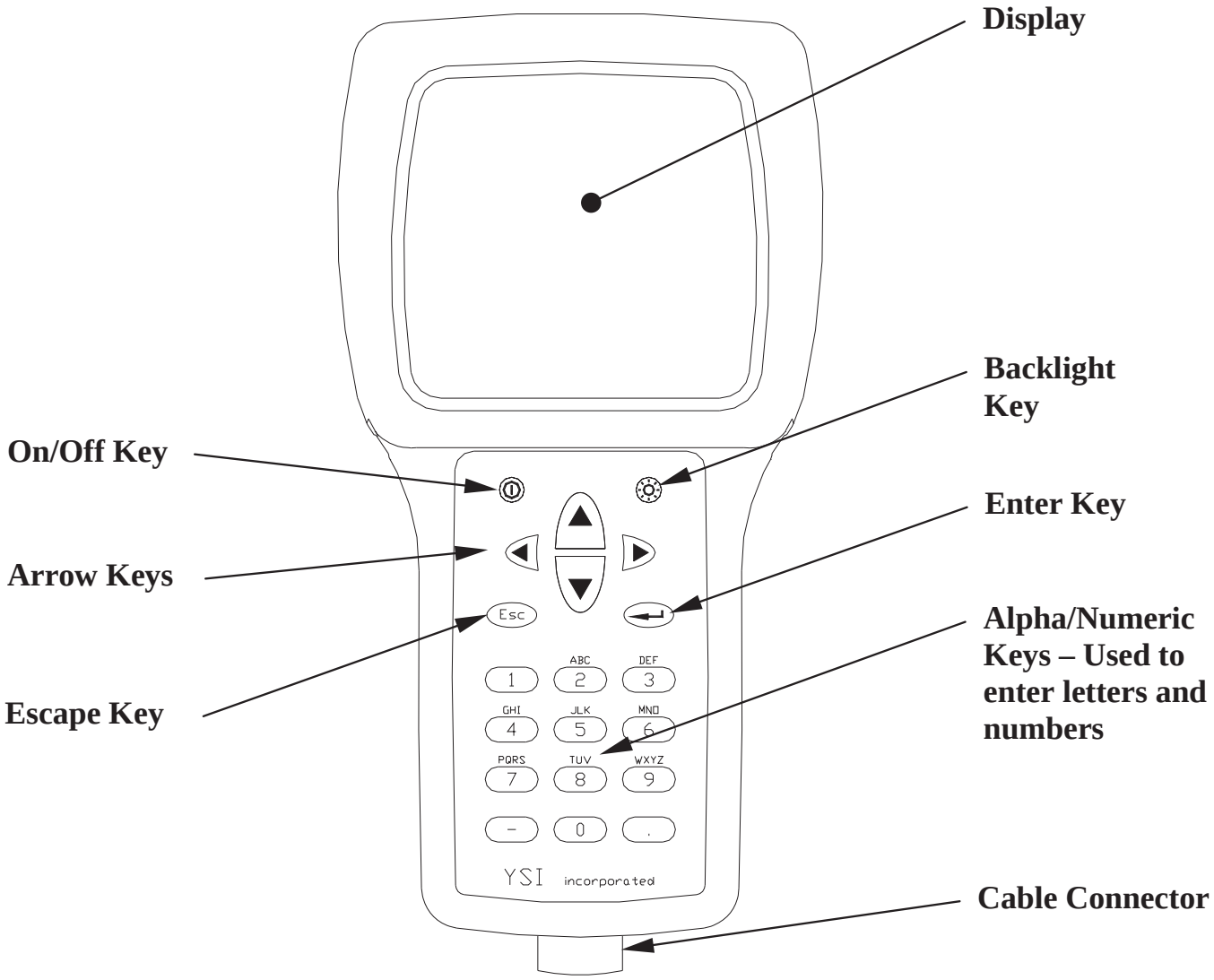


Figure 2.1 Front View of YSI 556 MPS

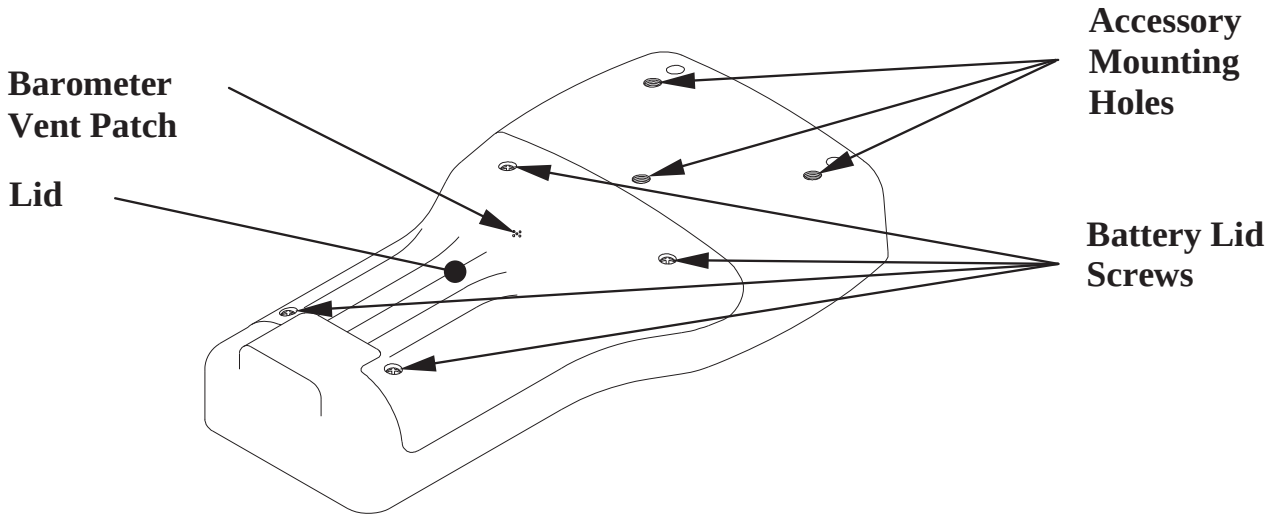


Figure 2.2 Back View of YSI 556 MPS

2.4 Batteries

2.4.1 Battery Life

Standard Alkaline Batteries

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

Optional Rechargeable Battery Pack

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

2.4.2 Inserting 4 C Batteries

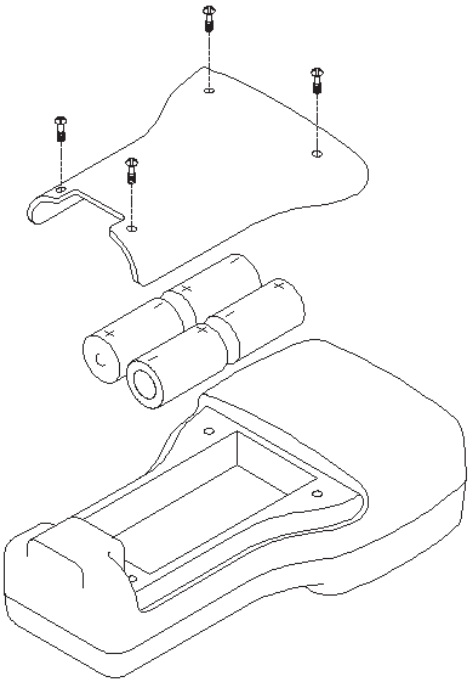


Figure 2.3 Inserting C Cells

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

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

2. Remove the battery lid.

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

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

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

   NOTE: Do not over-tighten the screws.

2.4.3 Inserting Optional Rechargeable Battery Pack

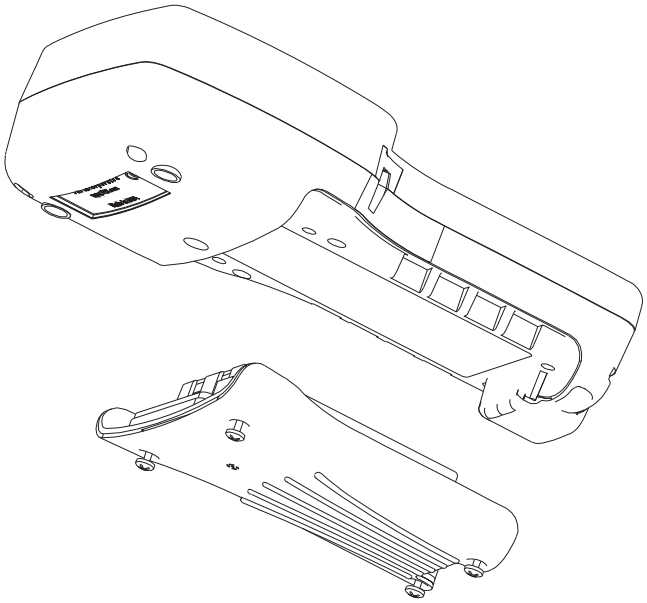


Figure 2.4 Inserting Battery Pack

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

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

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

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

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

   NOTE: Do not over tighten the screws.

2.4.4 Charging the Optional Rechargeable Battery Pack

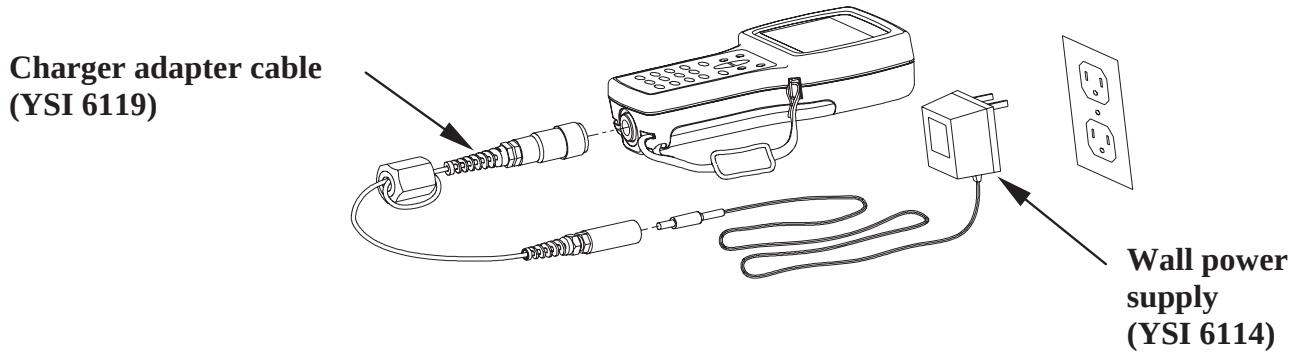


Figure 2.5 Charging the Battery Pack

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

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

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

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

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

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

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

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

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

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

2.4.5 Storing the Battery Pack

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

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

2.4.6 Optional Cigarette Lighter Charger

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

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

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

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

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

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

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

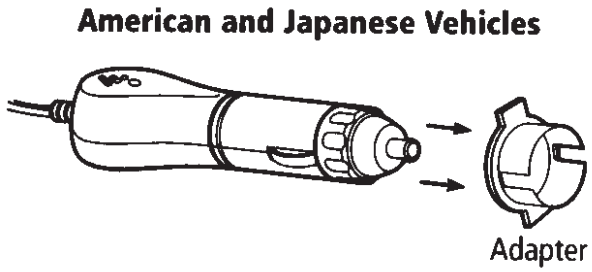


Figure 2.6 Charger Plug Adapter Use

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

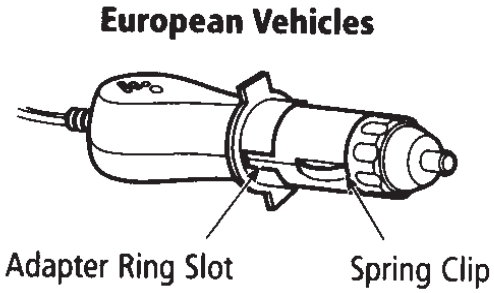


Figure 2.7 European Charger Plug Adapter Use

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

2.5 Power On

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

2.6 Setting Display Contrast

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

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

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

2.7 Backlight

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

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

2.8 General Screen Features

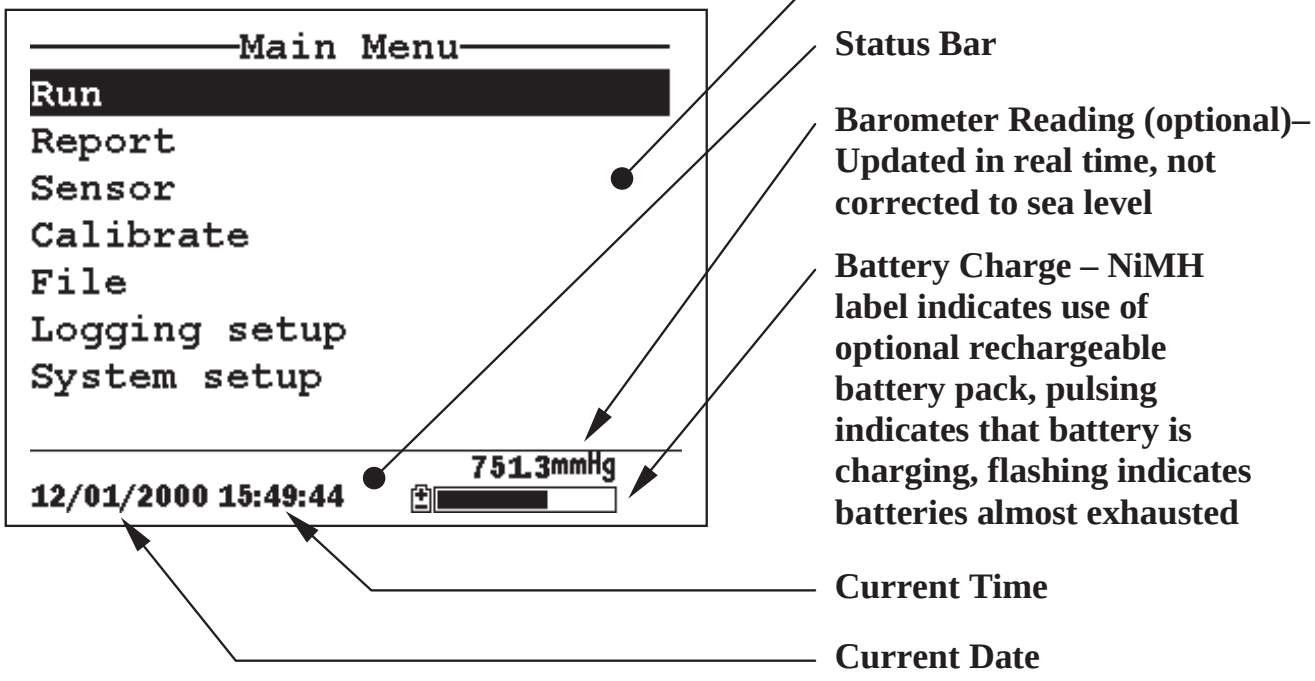


Figure 2.8 Main Menu Screen

2.9 Keypad Use

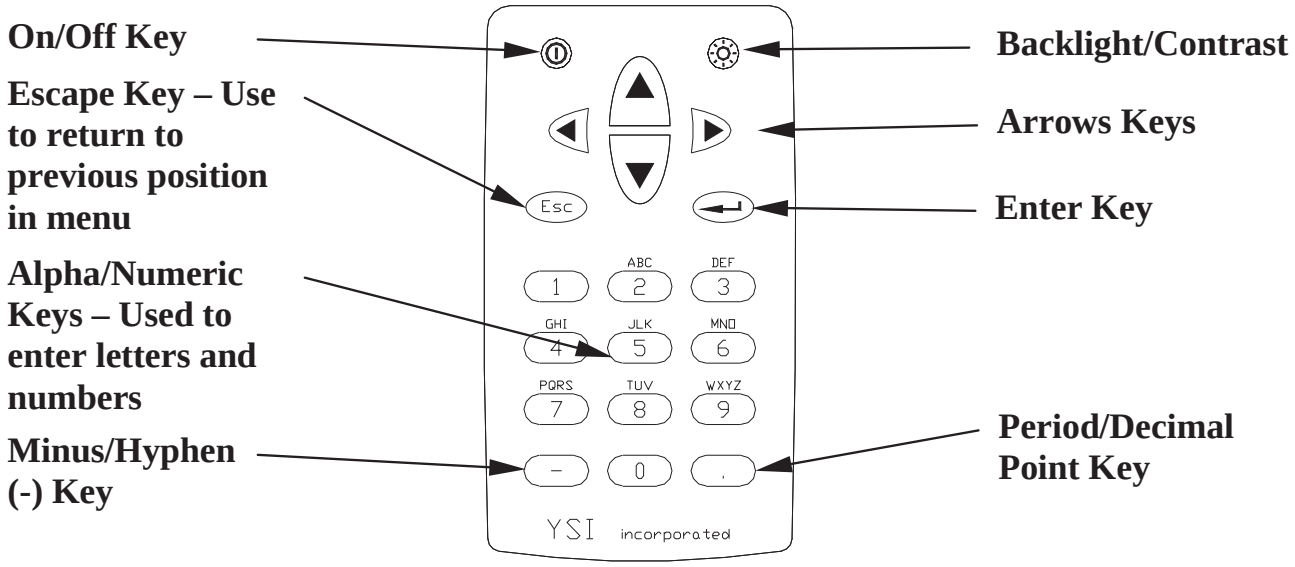


Figure 2.9 Keypad Features

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

Figure 2.10 Keypad Letters & Numbers

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

   NOTE: Press the key repeatedly in rapid succession to get to the desired letter or number. If you pause for more than a

second, the cursor automatically scrolls to the right to prepare for the next input.

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

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

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

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

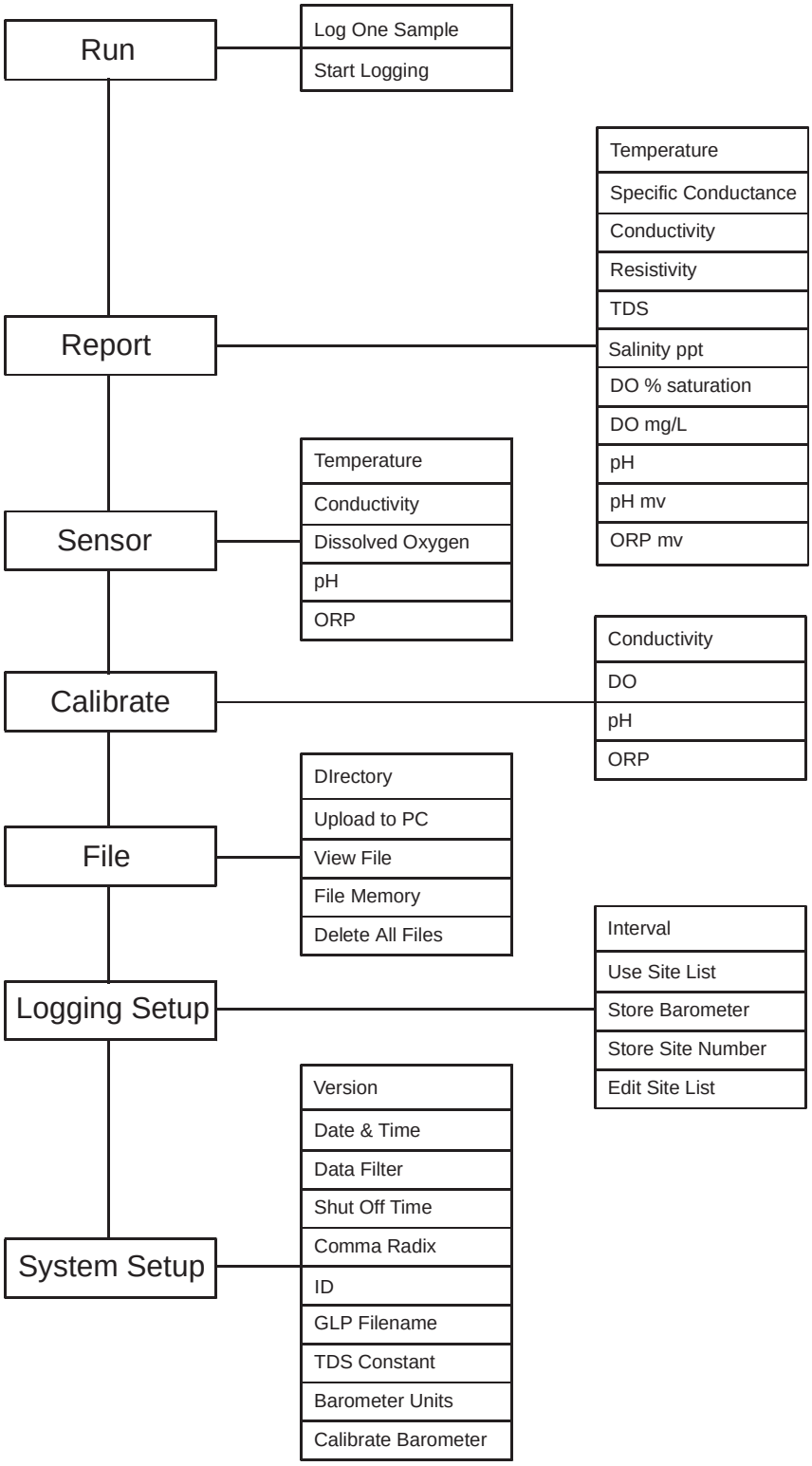
3. Press the **Enter** key when your entry is complete.

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

2.10 Instrument Reset

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

2.11 Menu Flowchart



3. Probe Module

3.1 Introduction

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

3.2 Unpacking the Probe Module

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

   NOTE: Do not discard any parts or supplies.

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

3. Visually inspect all components for damage.

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

3.3 Features of the YSI 5563 Probe Module

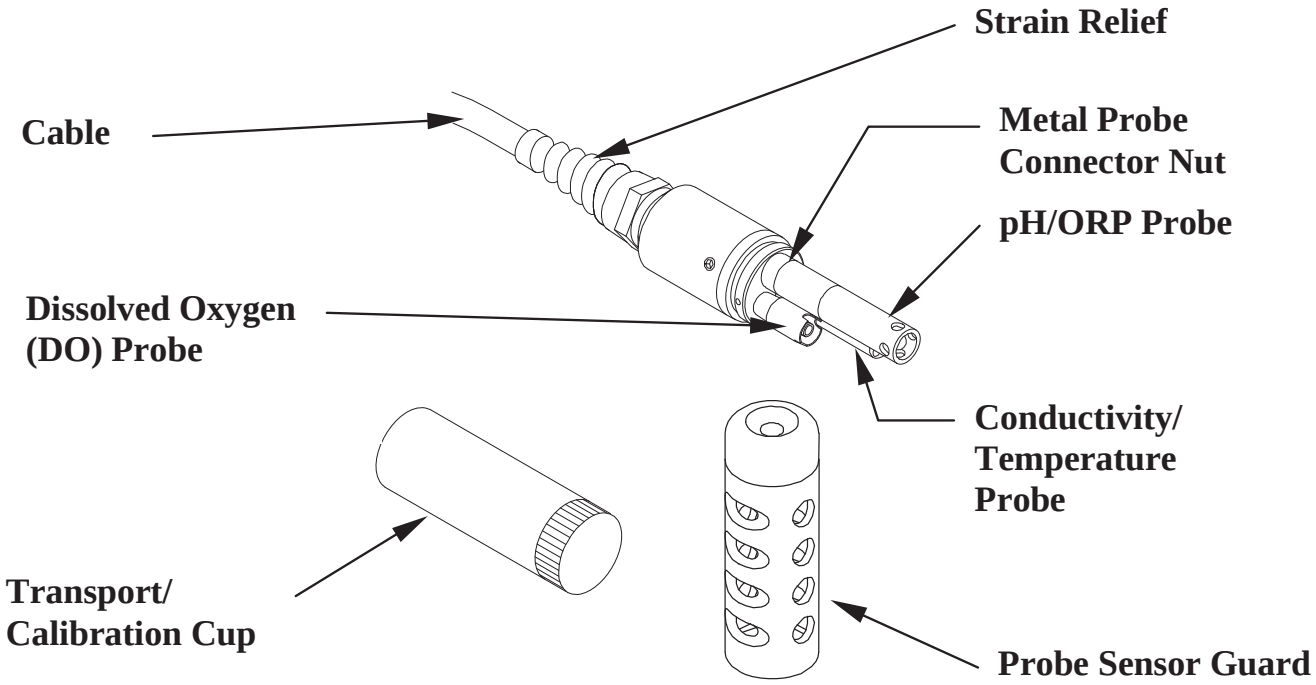


Figure 3.1 Probe Module

3.4 Preparing the Probe Module

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

3.4.1 Sensor Installation

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

Conductivity/Temperature and pH, pH/ORP Sensor Installation

1. Unscrew and remove the probe sensor guard.

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

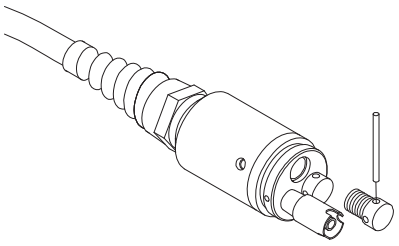


Figure 3.2 Port Plug Removal

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

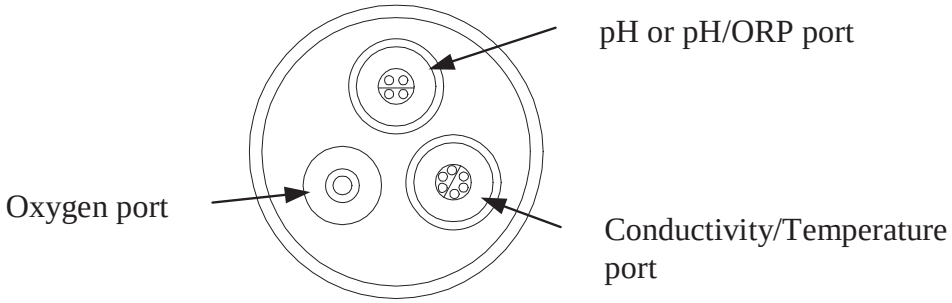


Figure 3.3 Sensor Port Identification

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

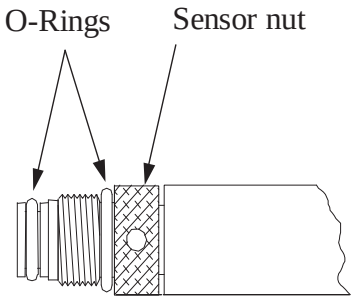


Figure 3.4 O-Ring Lubrication

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

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

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

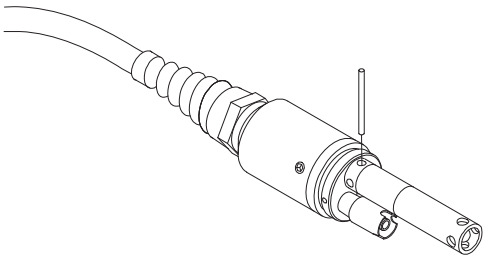


Figure 3.5 Sensor Installation

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

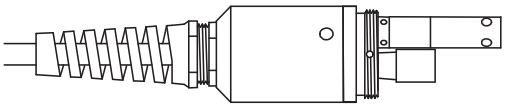


Figure 3.6 Bulkhead Seating

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

8. Replace the probe sensor guard.

Dissolved Oxygen Sensor Installation

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

3.4.2 Membrane Cap Selection

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

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

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

IMPORTANT: No matter which type of membrane cap you select, you will also have to confirm your selection in the 556

software from the Sensor menu as described in Section *4 Sensors*.

3.4.3 Membrane Cap Installation

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

1. Unscrew and remove the probe sensor guard.
2. Unscrew, remove, and discard the old membrane cap.
3. Thoroughly rinse the sensor tip with distilled water.
4. Prepare the electrolyte according to the directions on the electrolyte solution bottle.
5. Hold the new membrane cap and fill it at least 1/2 full with the electrolyte solution.
6. Screw the membrane cap onto the sensor moderately tight. A small amount of electrolyte should overflow.

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

7. Screw the probe sensor guard on moderately tight.

3.5 Transport/Calibration Cup

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

3.5.1 Transport/Calibration Cup Installation

1. Remove probe sensor guard, if already installed.

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

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

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

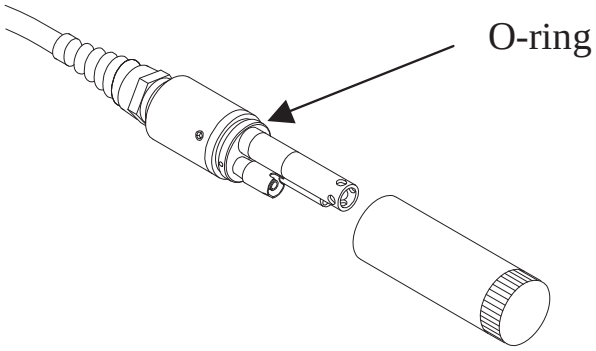


Figure 3.7 Transport/Calibration Cup Installation

3.6 Instrument/Cable Connection

Attach the cable to the instrument as follows:

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

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

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

4. Sensors

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

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

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

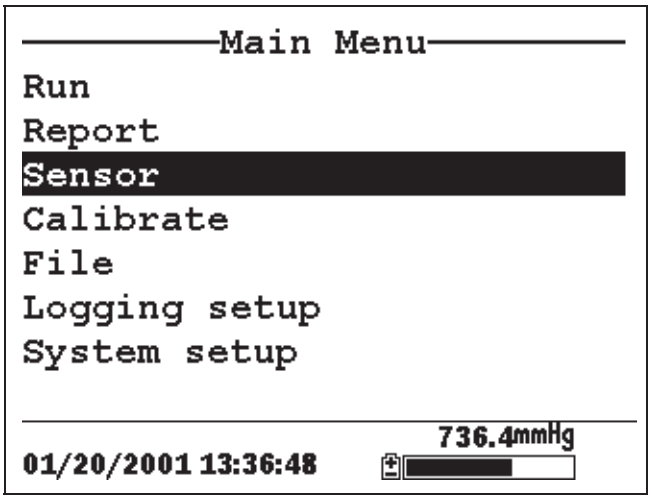


Figure 4.1 Main Menu Screen

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

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

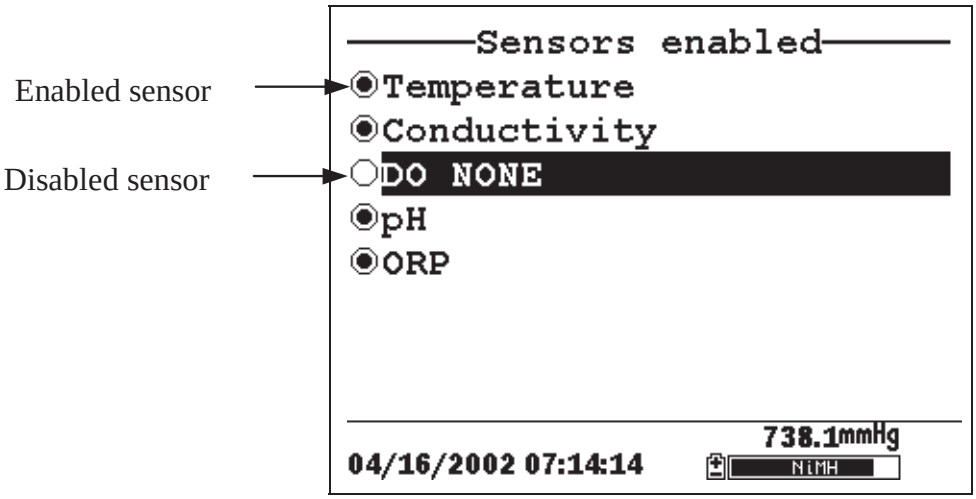


Figure 4.2 Sensors Enabled Screen Before DO Membrane Selection

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

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

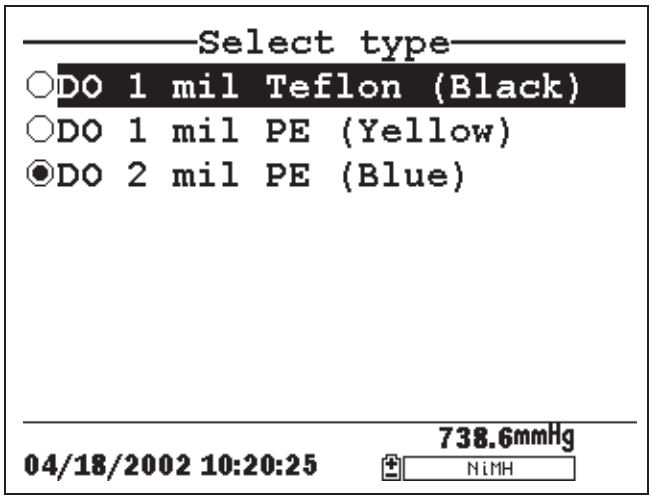


Figure 4.3 Membrane Selection Screen

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

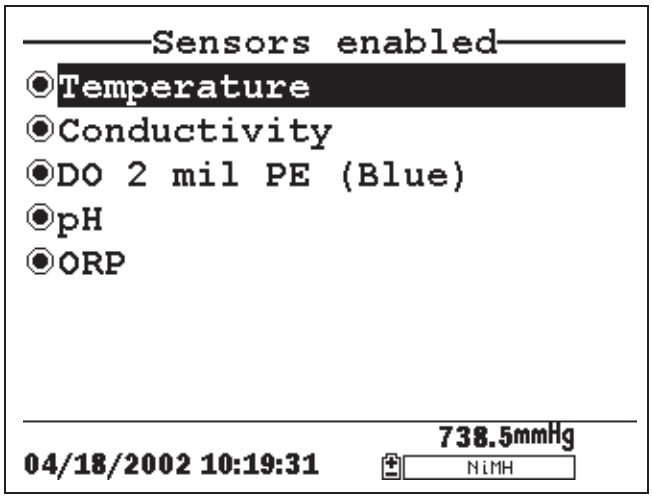


Figure 4.4 Sensors Enabled Screen After DO Membrane Selection

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

5. Use the arrow keys to highlight the sensor you want to change, then press the **Enter** key to enable or disable it.

6. Repeat step 5 for each sensor you want to change.

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

5. Report

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

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

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

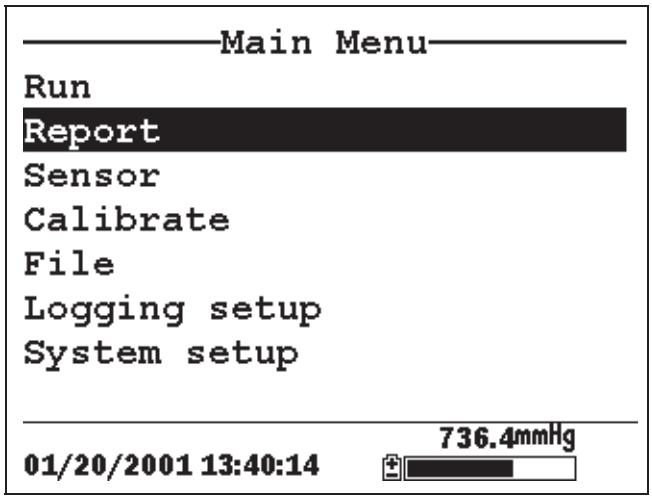


Figure 5.1 Main Menu

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

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

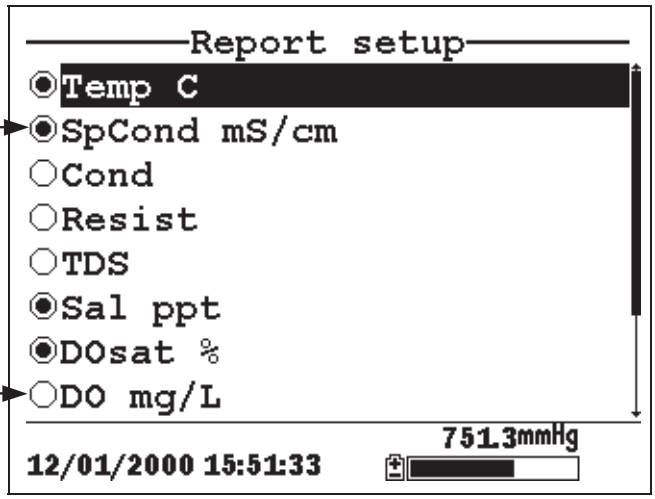


Figure 5.2 Report Setup Screen

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

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

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

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

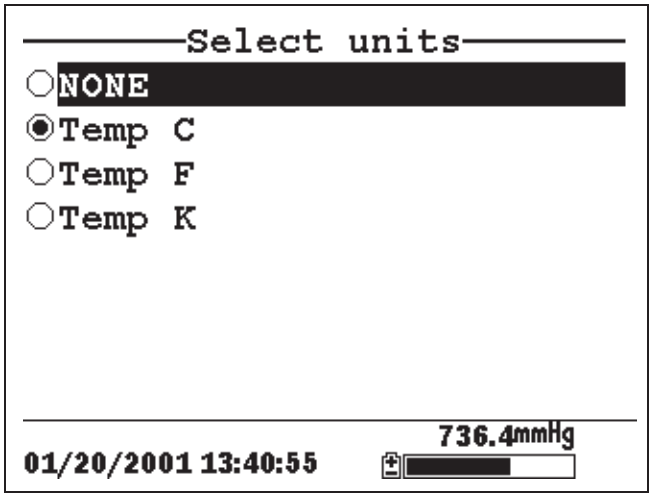


Figure 5.3 Units Screen

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

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

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

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

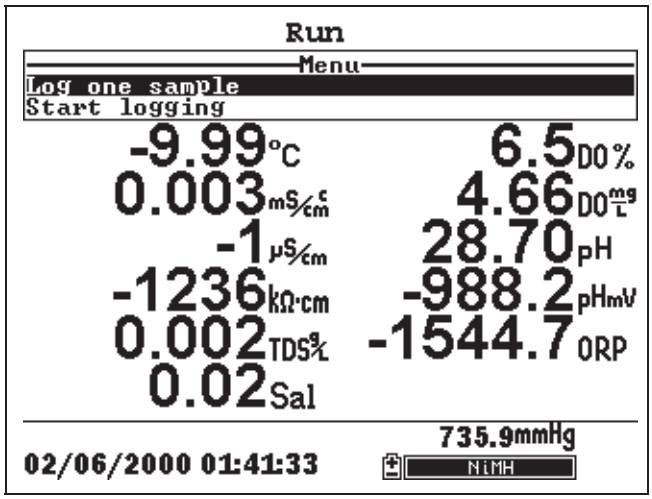


Figure 5.4 All Parameters Displayed

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

6. Calibrate

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

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

6.1 Getting Ready to Calibrate

6.1.1 Containers Needed to Calibrate the Probe Module

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

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

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

6.1.2 Calibration Tips

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

6.1.3 Recommended Volumes

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

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

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

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

Table 6.1 Calibration Volumes

6.2 Calibration Procedures

6.2.1 Accessing the Calibrate Screen

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

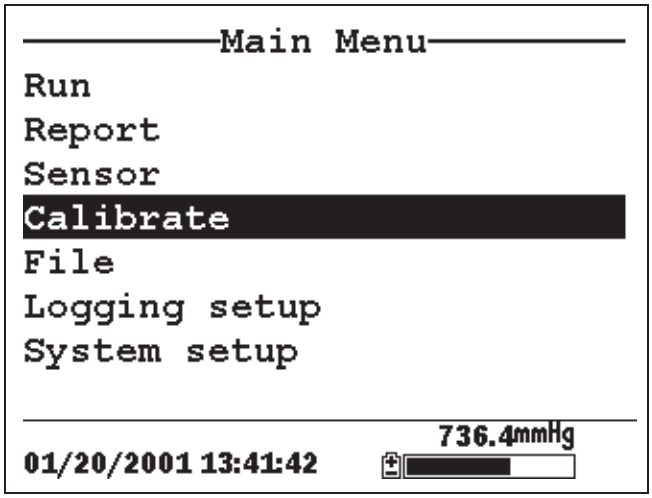


Figure 6.1 Main Menu

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

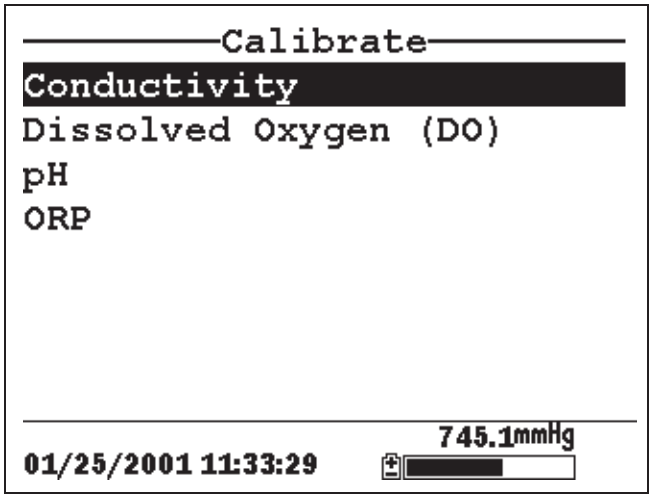


Figure 6.2 Calibrate Screen

6.2.2 Conductivity Calibration

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

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

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

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

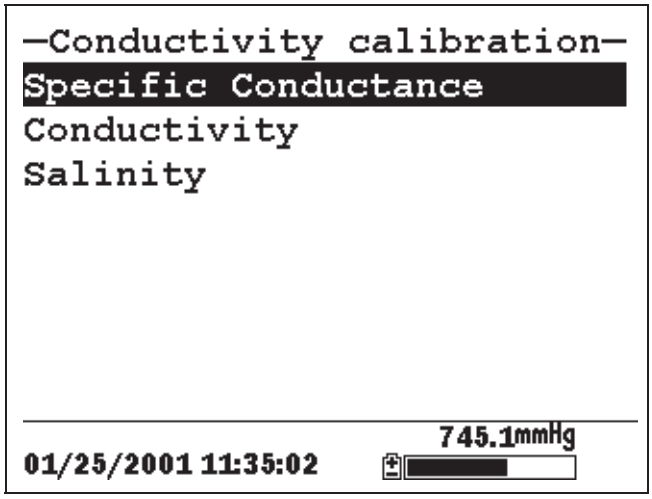


Figure 6.3 Conductivity Calibration Selection Screen

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

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

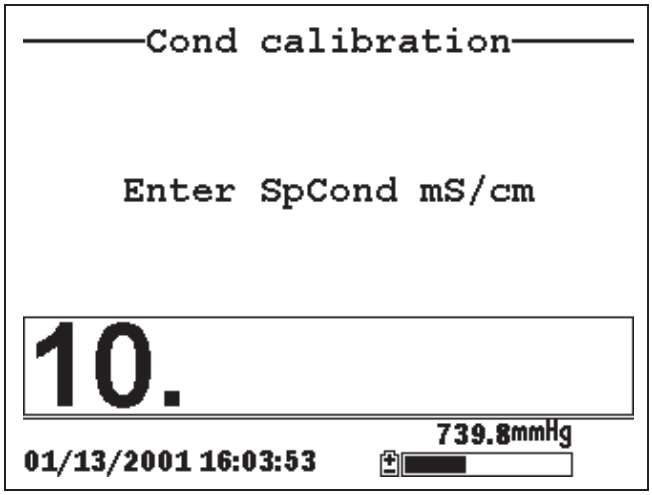


Figure 6.4 Conductivity Calibration Entry Screen

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

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

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

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

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

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

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

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

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

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

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

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

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

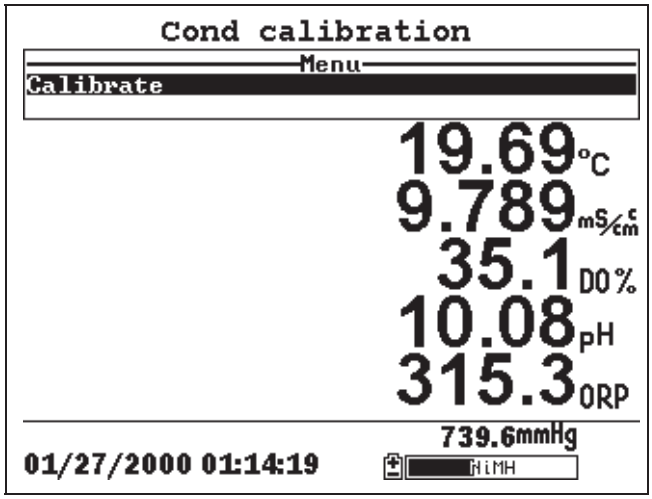


Figure 6.5 Conductivity Calibration Screen

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

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

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

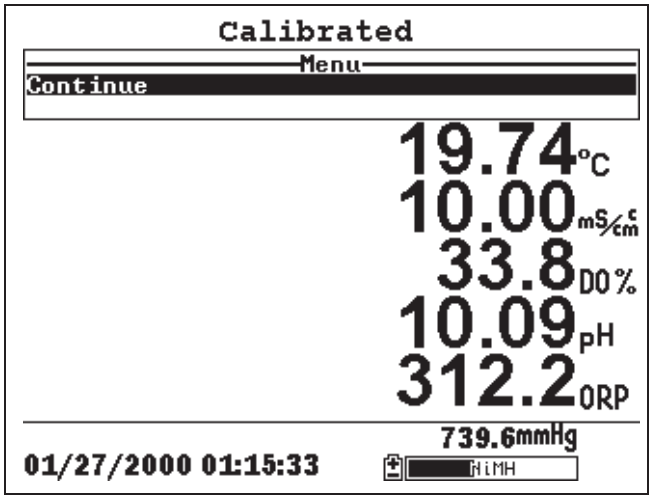


Figure 6.6 Calibrated

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

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

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

6.2.3 Dissolved Oxygen Calibration

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

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

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

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

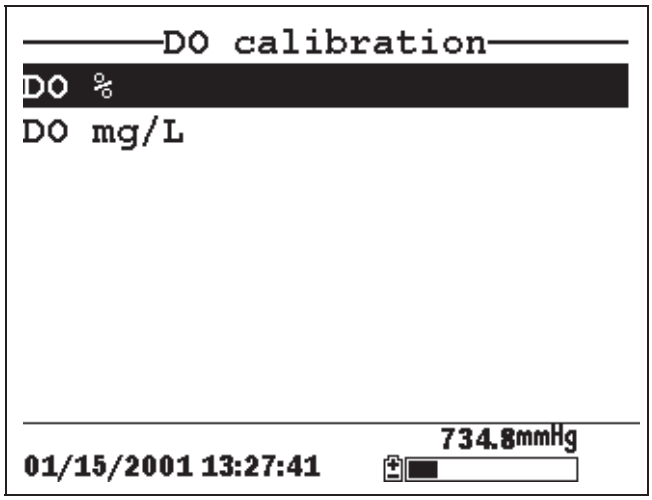


Figure 6.7 DO Calibration Screen

DO Calibration in % Saturation

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

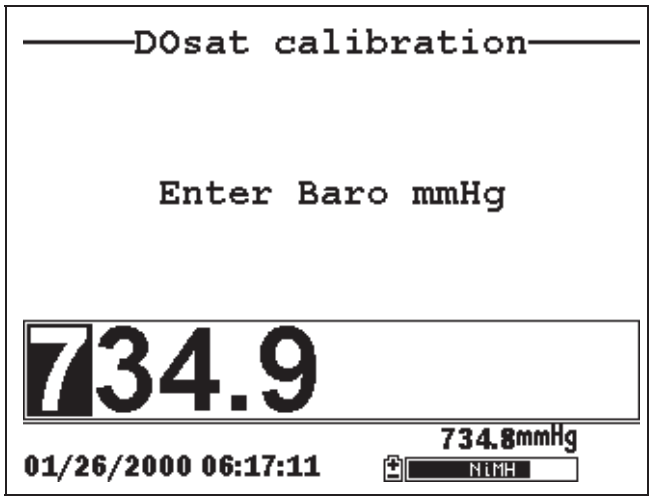


Figure 6.8 DO Barometric Pressure Entry Screen

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

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

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

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

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

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

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

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

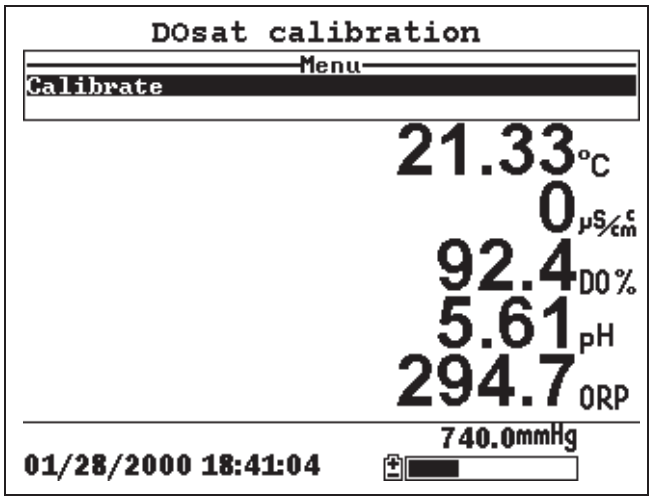


Figure 6.9 DO Sat Calibration Screen

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

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

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

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

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

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

DO Calibration in mg/L

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

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

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

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

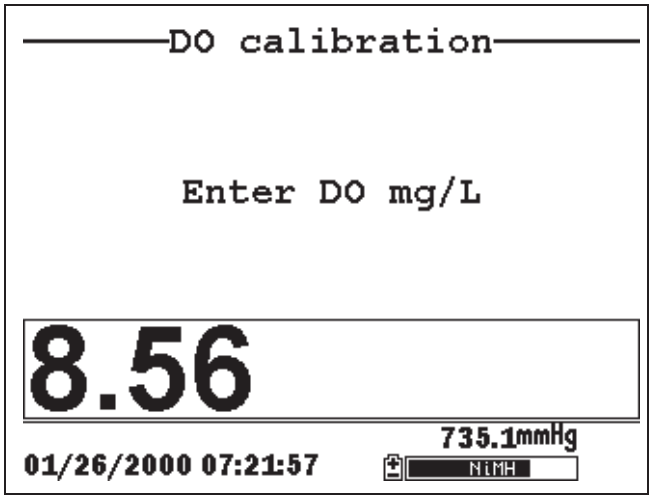


Figure 6.10 DO mg/L Entry Screen

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

   NOTE: Be sure to completely immerse all the sensors.

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

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

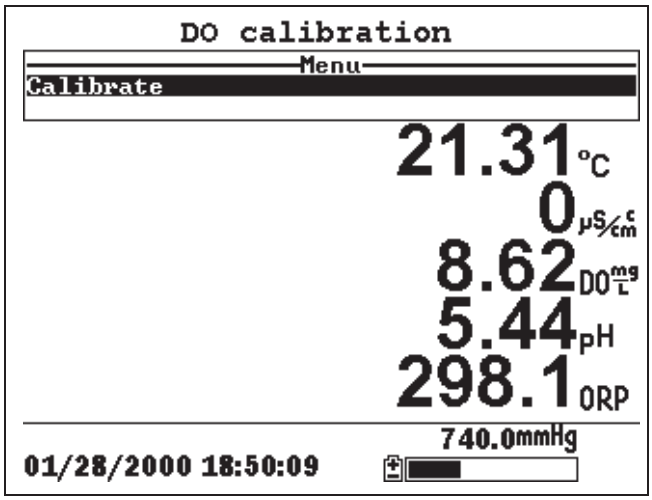


Figure 6.11 DO mg/L Calibration Screen

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

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

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

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

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

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

6.2.4 pH Calibration

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

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

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

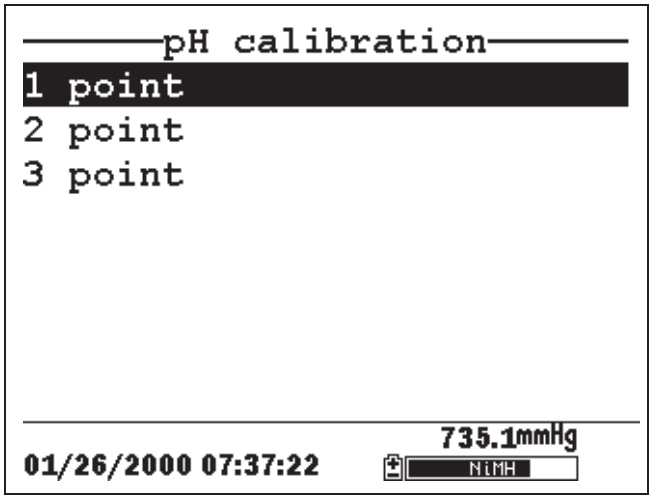


Figure 6.12 pH Calibration Screen

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

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

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

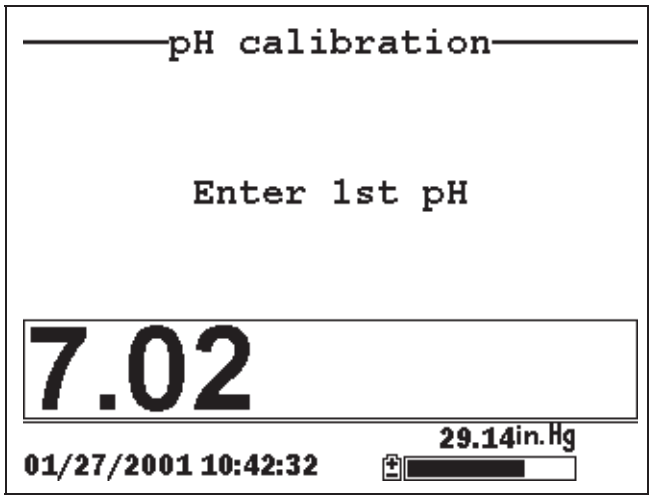


Figure 6.13 pH Entry Screen

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

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

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

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

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

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

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

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

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

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

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

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

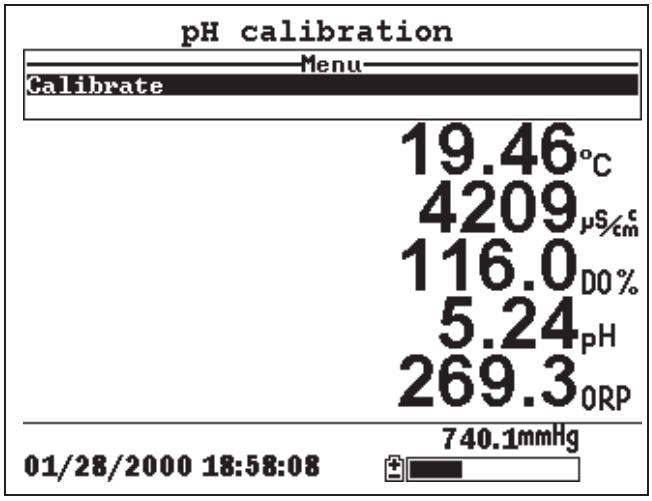


Figure 6.14 pH Calibration Screen

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

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

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

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

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

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

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

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

6.2.5 ORP Calibration

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

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

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

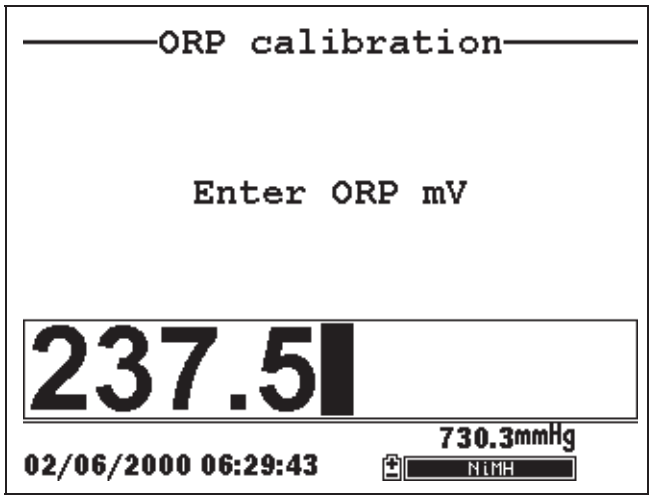


Figure 6.15 Specified ORP Calibration Screen

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

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

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

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

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

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

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

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

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

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

Table 6.2 Zobel Solution Values

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

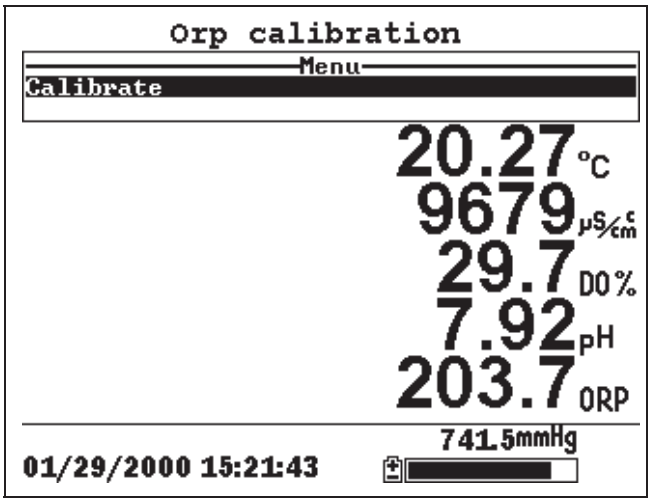


Figure 6.16 ORP Calibration Screen

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

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

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

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

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

6.3 Return to Factory Settings

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

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

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

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

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

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

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

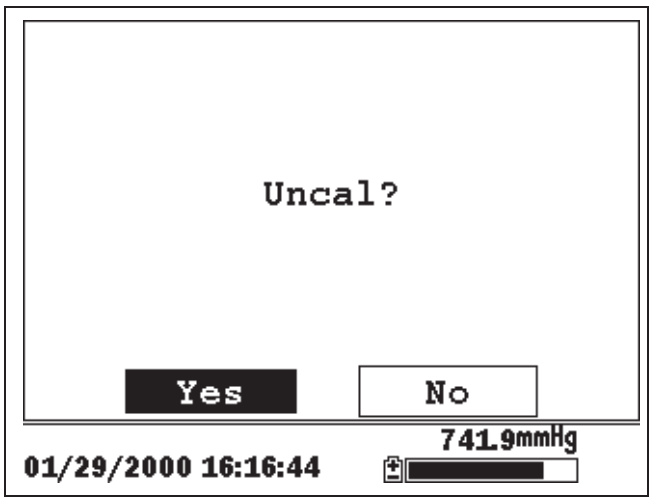


Figure 6.17 ORP Calibration Screen

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

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

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

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

7. Run

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

7.1 Real-Time Data

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

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

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

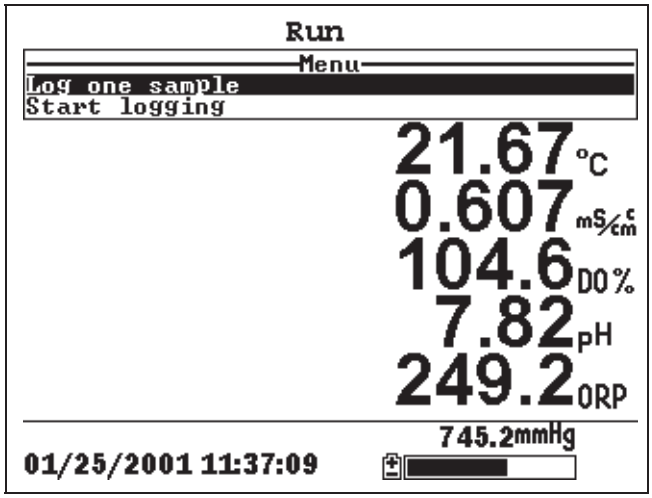


Figure 7.1 Run Screen

2. Make sure the probe sensor guard is installed.

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

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

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

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

8. File

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

8.1 Accessing the File Screen

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

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

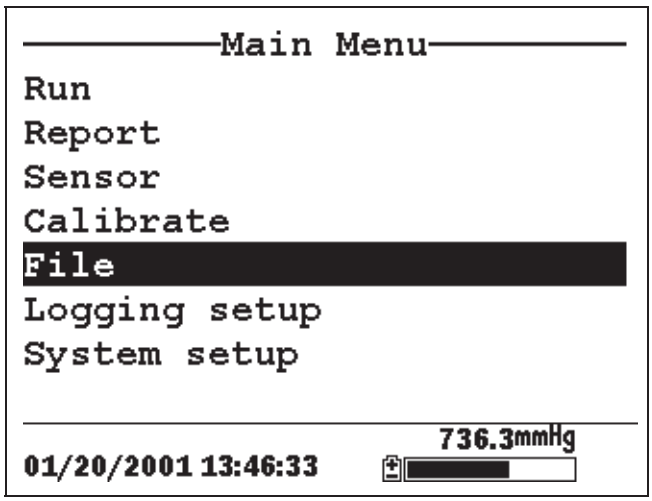


Figure 8.1 Main Menu Screen

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

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

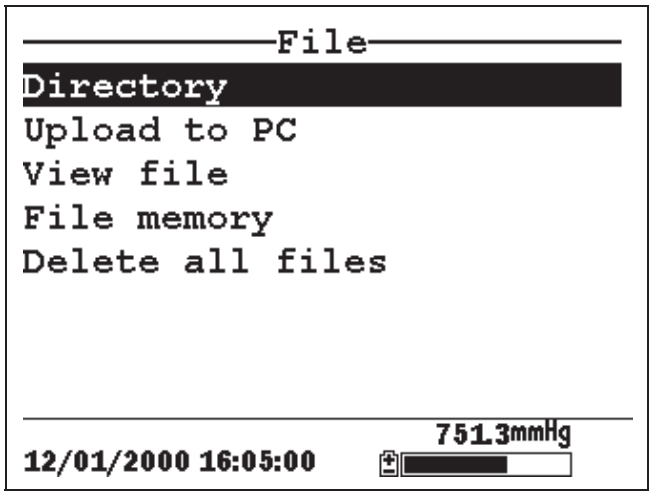


Figure 8.2 File Screen

8.2 Directory

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

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

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

   NOTE: Files are listed in the order in which they are logged to memory. Sample Data files have the file extension **.dat**, while Calibration Record files have the file extension **.glp**.

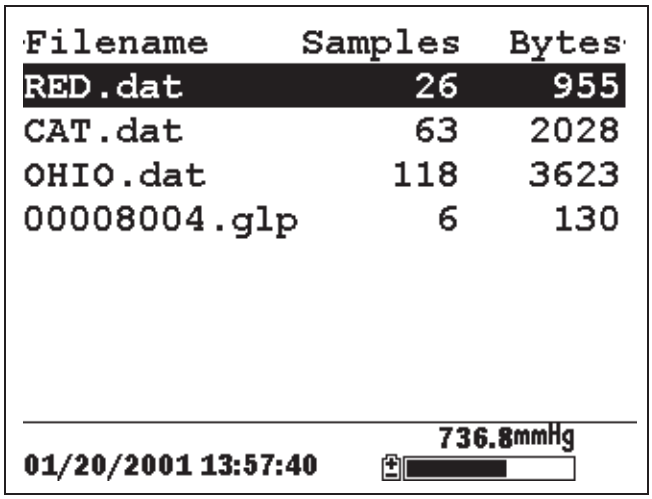


Figure 8.3 File List Screen

4. Use the arrow keys to highlight a file.

5. Press the **Enter** key. The file details screen is displayed.

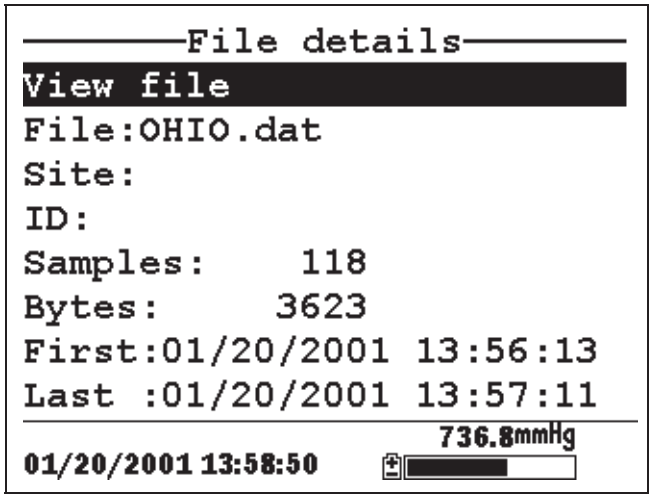


Figure 8.4 File Details Screen

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

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

8.3 View File

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

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

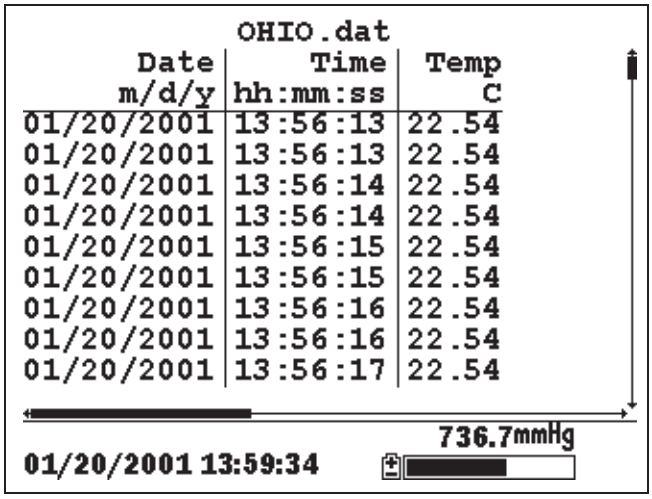
3. Press the **Enter** key. A list of files is displayed. See Figure 8.3 File List Screen.

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

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

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

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



OHIO.dat

Date m/d/y	Time hh:mm:ss	Temp C
01/20/2001	13:56:13	22.54
01/20/2001	13:56:13	22.54
01/20/2001	13:56:14	22.54
01/20/2001	13:56:14	22.54
01/20/2001	13:56:15	22.54
01/20/2001	13:56:15	22.54
01/20/2001	13:56:16	22.54
01/20/2001	13:56:16	22.54
01/20/2001	13:56:17	22.54

736.7mmHg

01/20/2001 13:59:34

Figure 8.5 File Data Screen

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

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

8.4 Upload to PC

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

8.4.1 Upload Setup

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

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

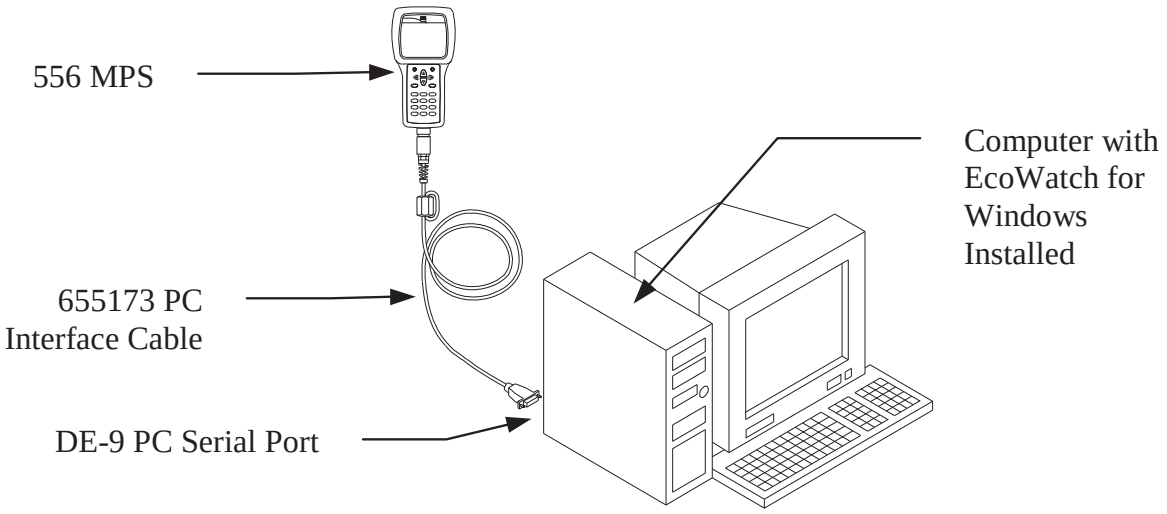


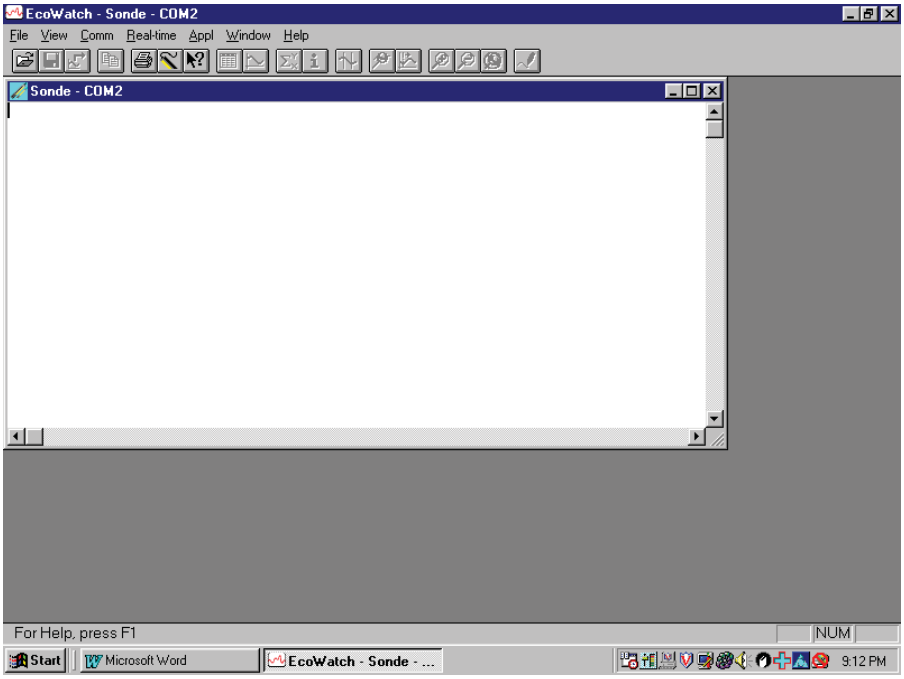
Figure 8.6 Computer/Instrument Interface

3. Open EcoWatch for Windows on your computer.

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

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

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



8.4.2 Uploading a .DAT File

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

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

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

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

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

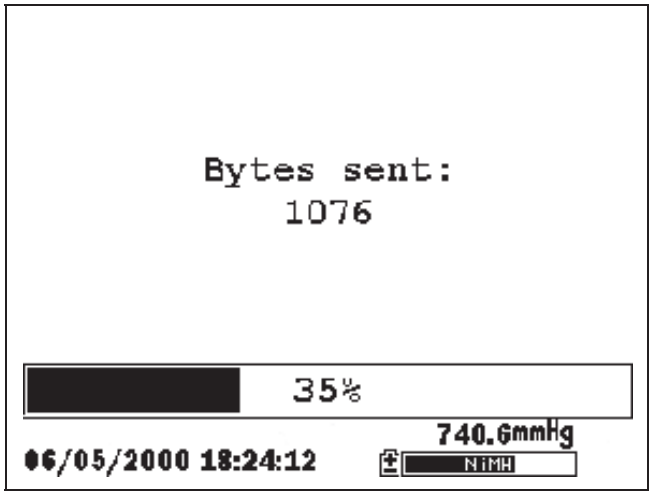
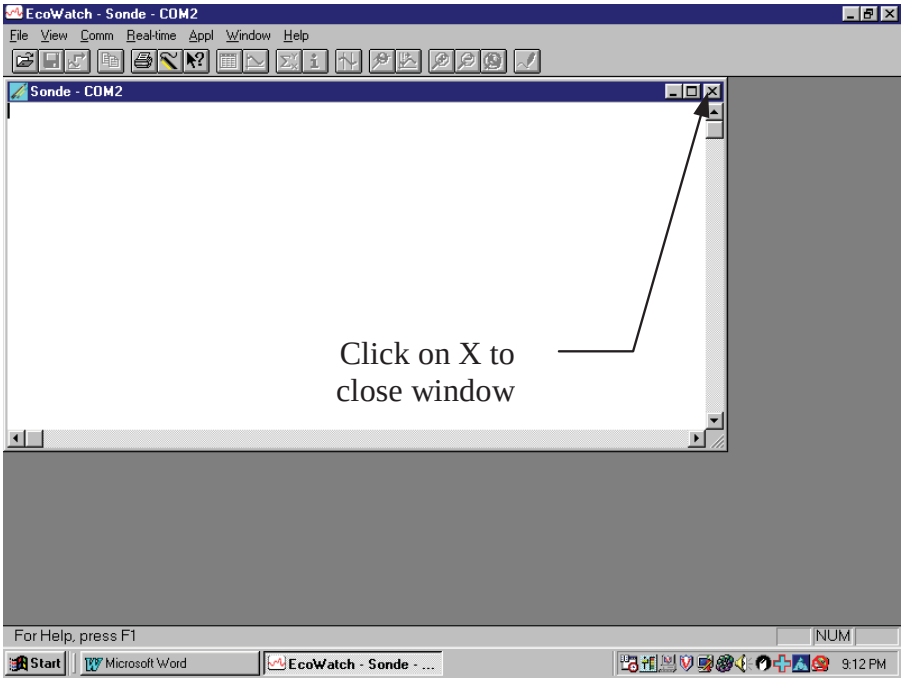


Figure 8.7 File Transfer Progress Screen

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

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



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

8.4.3 Uploading a Calibration Record (.glp) File

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

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

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

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

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

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

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

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

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

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

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

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

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

8.5 File Memory

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

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

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

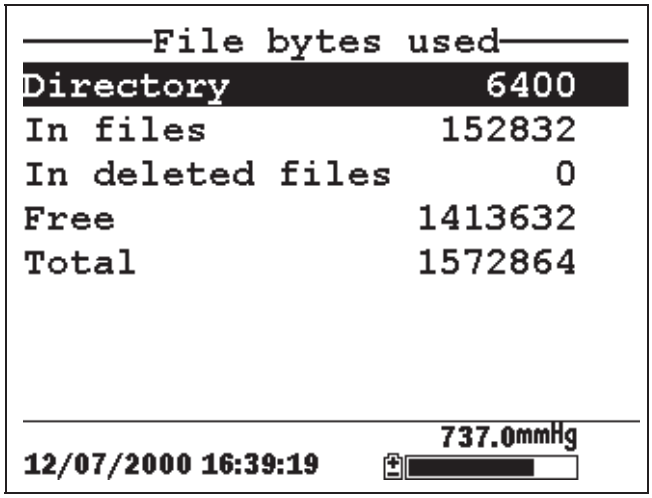


Figure 8.8 File Bytes Used Screen

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

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

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

8.6 Delete All Files

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

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

2. Use the arrow keys to highlight the **Delete all files** selection. See Figure 8.2 File Screen.

3. Press the **Enter** key. The Delete all Files screen is displayed.

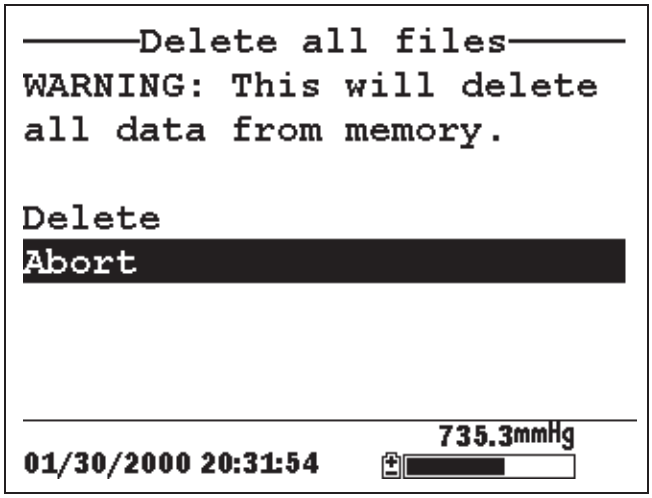


Figure 8.9 Delete All Files Screen

4. Use the arrow keys to highlight the **Delete** selection.

5. Press the **Enter** key.

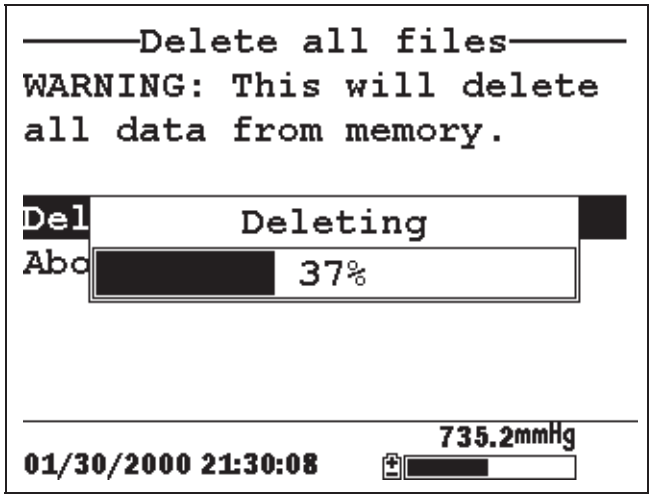


Figure 8.10 Deleting

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

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

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

9. Logging

9.1 Accessing the Logging Setup Screen

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

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

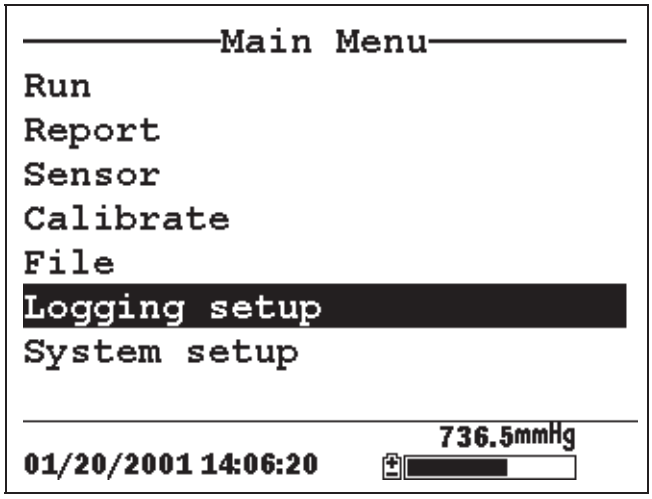


Figure 9.1 Main Menu

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

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

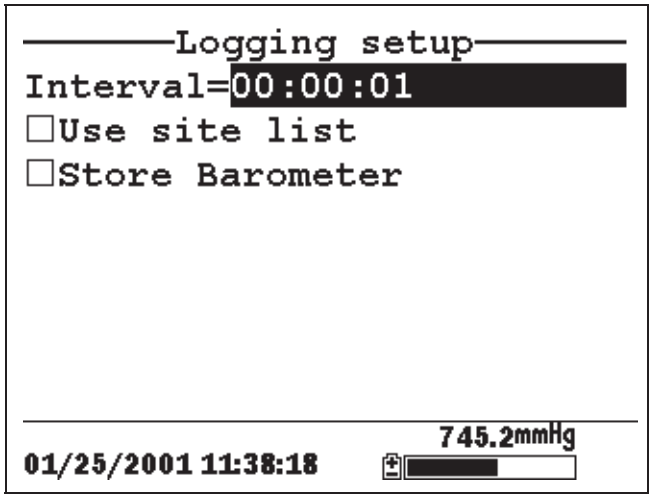


Figure 9.2 Logging Setup Screen

9.2 Setting Logging Interval

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

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

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

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

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

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

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

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

9.3 Storing Barometer Readings

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

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

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

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

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

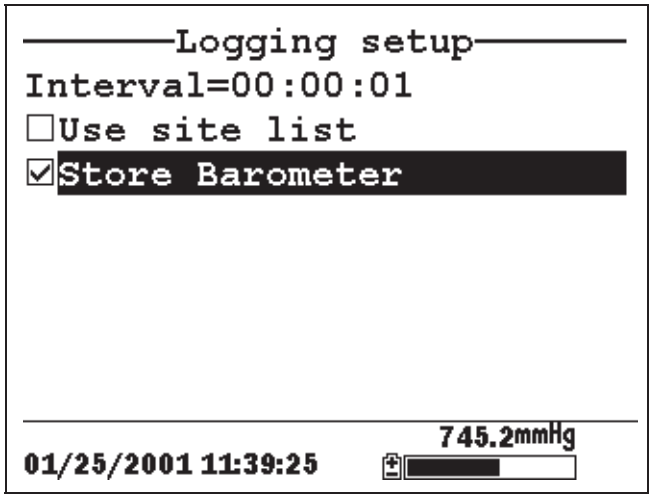


Figure 9.3 Store Barometer

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

9.4 Creating a Site List

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

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

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

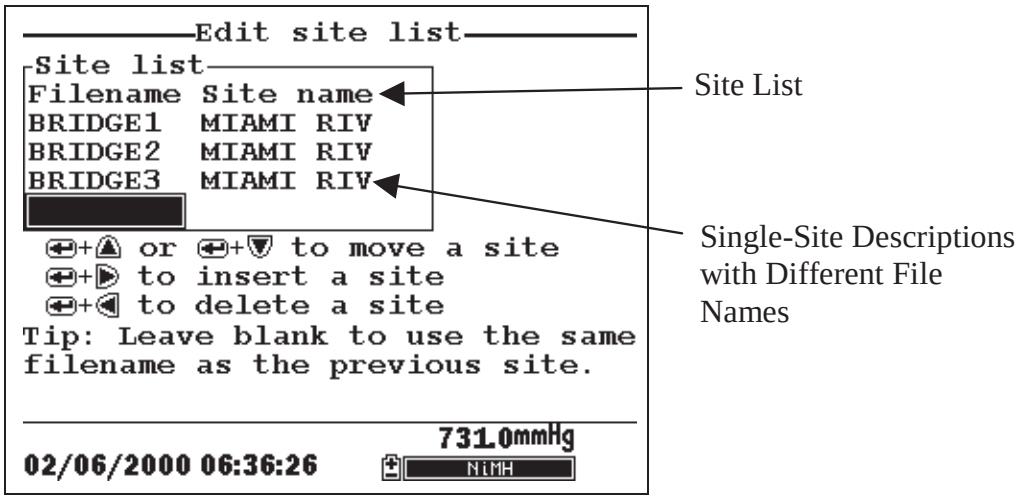


Figure 9.4 Single-Site Descriptions

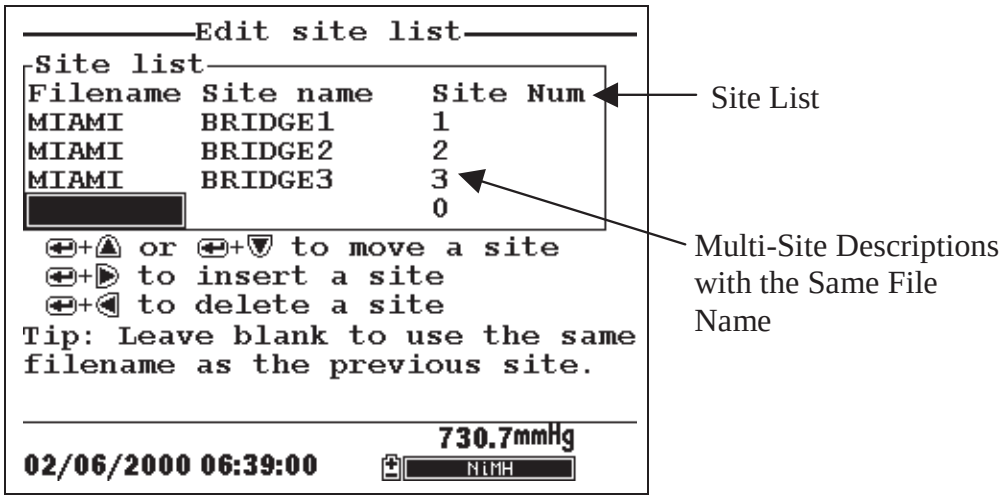


Figure 9.5 Multiple-Site Descriptions

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

To create a site list:

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

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

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

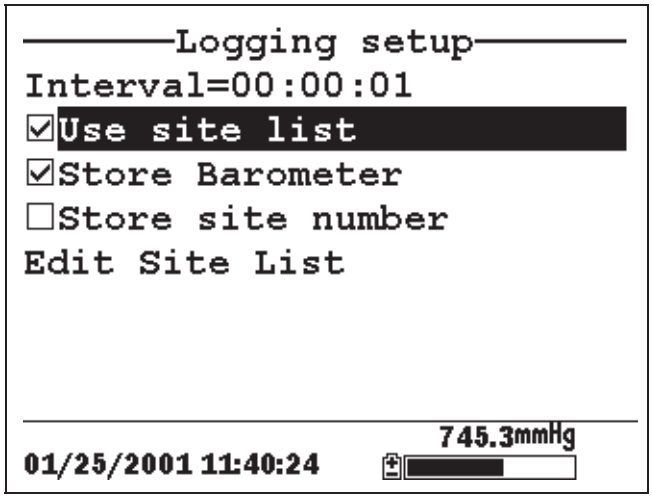


Figure 9.6 Logging Setup Screen

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

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

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

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

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

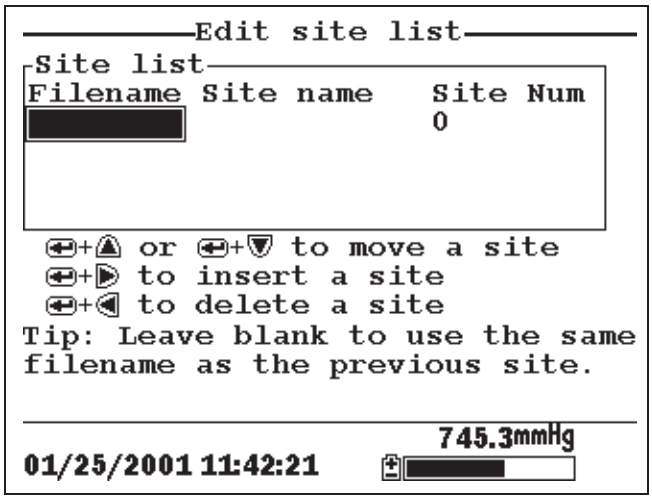


Figure 9.7 Edit Site List Screen

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

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

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

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

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

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

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

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

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

9.5 Editing a Site List

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

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

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

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

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

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

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

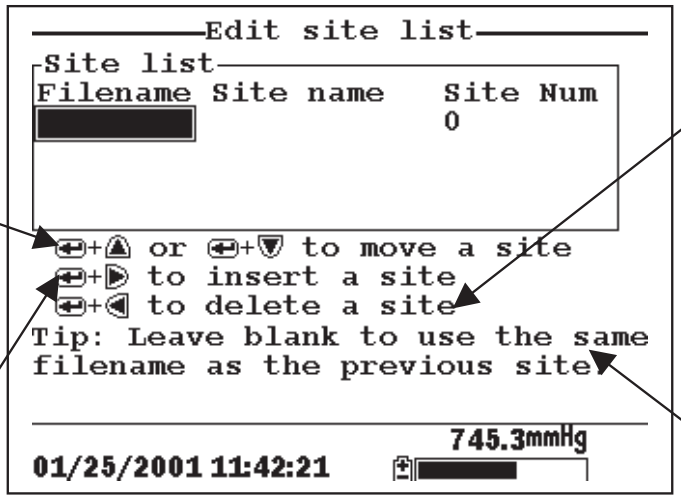


Figure 9.8 Keystrokes for Editing Site List

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

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

9.6 Logging Data Without a Site List

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

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

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

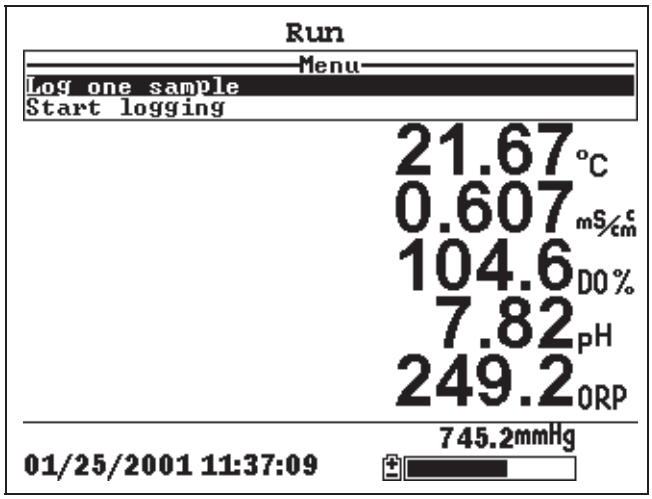


Figure 9.9 Run Screen

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

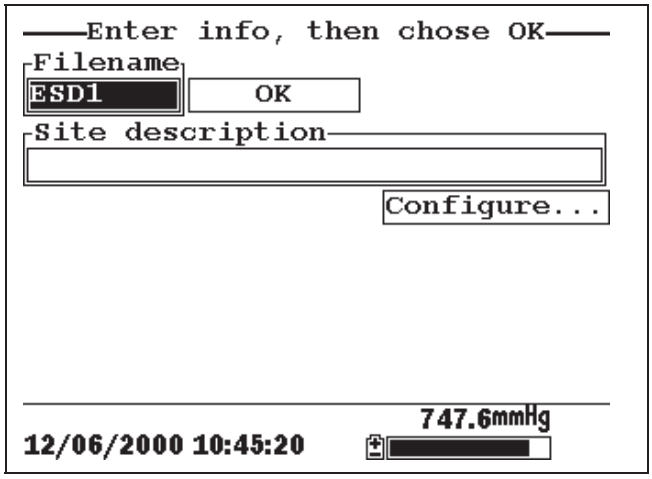


Figure 9.10 Enter Information Screen

NOTE: The last filename used will be displayed.

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

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

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

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

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

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

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

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

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

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

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

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

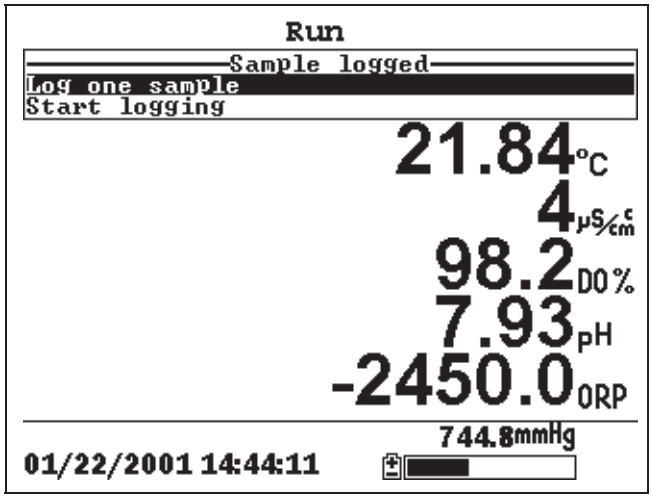


Figure 9.11 Sample Logged Screen

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

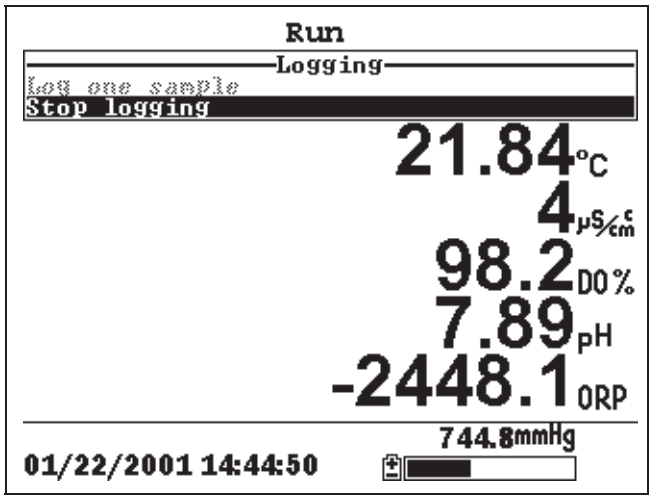


Figure 9.12 Logging Screen

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

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

9.7 Logging Data With a Site List

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

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

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

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

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

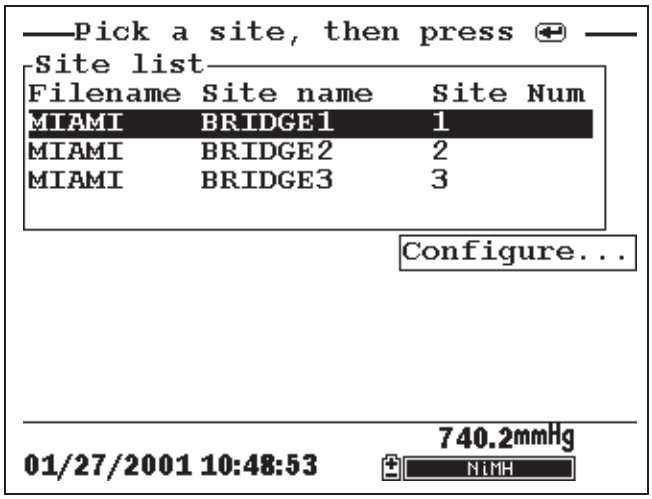


Figure 9.13 Pick a Site Screen

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

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

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

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

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

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

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

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

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

9.8 Adding Data to Existing Files

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

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

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

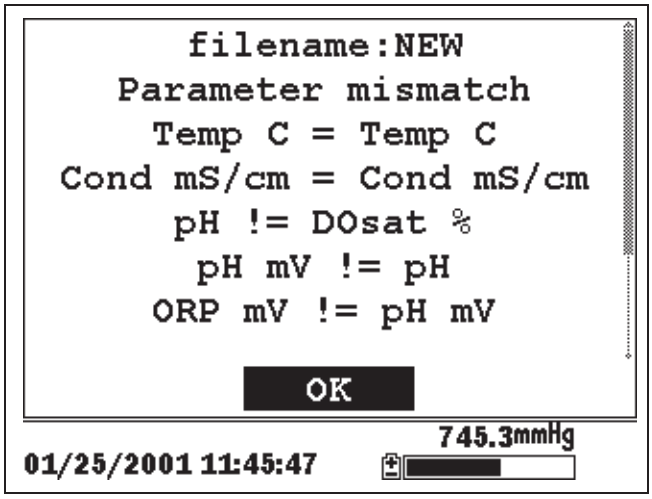


Figure 9.14 Parameter Mismatch Screen

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

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

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

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

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

10. System Setup

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

10.1 Accessing the System Setup Screen

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

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

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

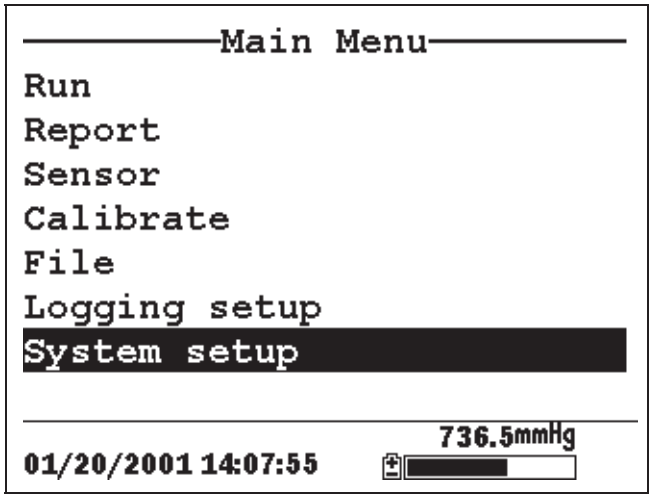


Figure 10.1 Main Menu

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

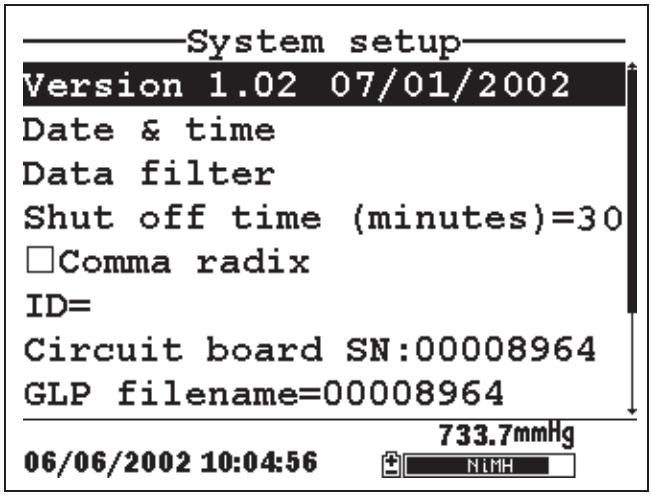


Figure 10.2 System Setup Screen

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

10.2 Date and Time Setup

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

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

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

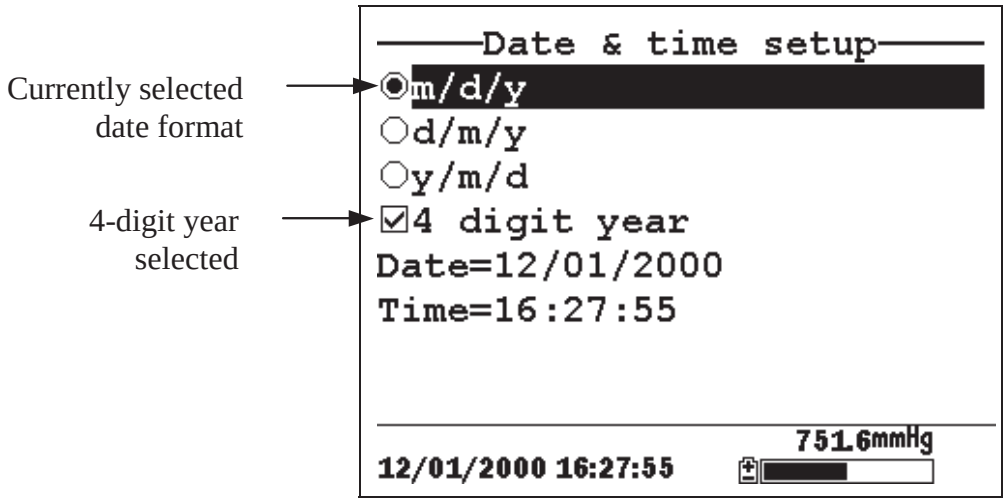


Figure 10.3 Date Setup Screen

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

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

5. Press **Enter**.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

10.3 Data Filter

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

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

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

10.3.1 Changing the Data Filter Settings

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

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

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

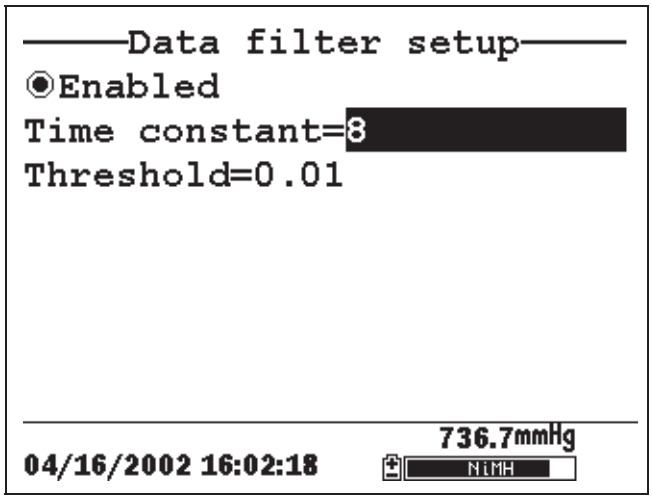


Figure 10.4 Data Filter Screen

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

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

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

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

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

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

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

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

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

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

10.4 Shutoff Time

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

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

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

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

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

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

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

10.5 Comma Radix

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

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

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

3. Press the **Enter** key. A check mark appears in the check box next to the comma radix selection indicating that the radix mark is a comma.

10.6 ID

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

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

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

3. Use the keypad to enter an alphanumeric ID up to 15 characters in length. Refer to Section *2.9 Keypad Use*.

4. Press the **Enter** key to enter the ID.

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

10.7 GLP Filename

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

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

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

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

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

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

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

10.8 TDS Constant

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

10.8.1 Changing the TDS Constant

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

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

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

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

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

10.9 Barometer Units

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

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

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

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

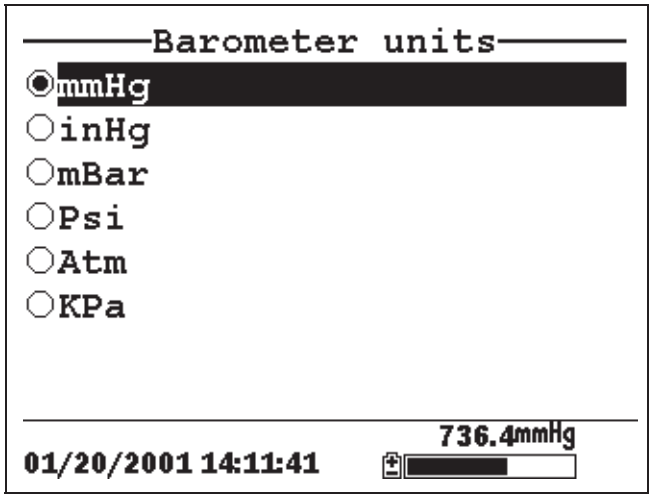


Figure 10.5 Barometer Units Screen

A black dot indicates the currently selected units.

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

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

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

10.10 Calibrate Barometer

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

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

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

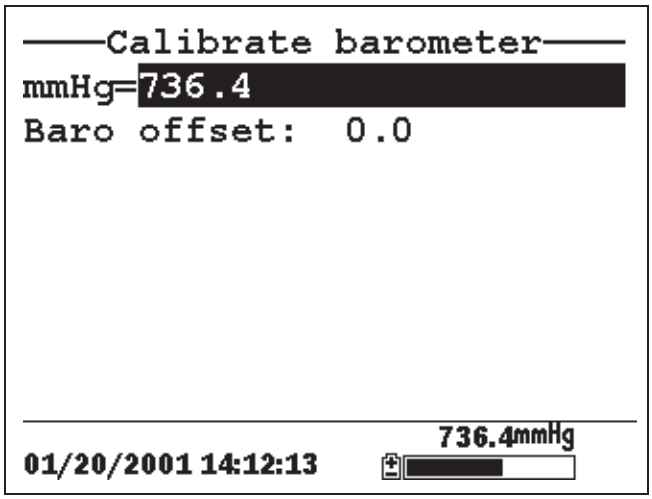
   NOTE: For this equation to be accurate, the barometric pressure units must be in mm Hg.

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

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

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

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



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

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

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

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

11. Maintenance

11.1 Sensor Care and Maintenance

Once the sensors have been properly installed, remember that periodic cleaning and DO membrane changes are required.

11.1.1 DO Sensor

For best results, we recommend that the KCl solution and the membrane cap be changed at least once every 30 days.

1. It is important to recognize that oxygen dissolved in the sample is consumed during sensor operation. It is therefore essential that the sample be continuously stirred at the sensor tip. If stagnation occurs, your readings will be artificially low. Stirring may be accomplished by mechanically moving the sample around the sensor tip, or by rapidly moving the sensor through the sample. The rate of stirring should be at least 1 foot per second.

2. Membrane life depends on usage. Membranes will last a long time if installed properly and treated with care. Erratic readings are a result of loose, wrinkled, damaged, or fouled membranes, or from large (more than 1/8" diameter) bubbles in the electrolyte reservoir. If erratic readings or evidence of membrane damage occurs, you should replace the membrane and the electrolyte solution. The average replacement interval is two to four weeks.

3. If the membrane is coated with oxygen consuming (e.g. bacteria) or oxygen producing organisms (e.g. algae), erroneous readings may occur.

4. Chlorine, sulfur dioxide, nitric oxide, and nitrous oxide can affect readings by behaving like oxygen at the sensor. If you suspect erroneous readings, it may be necessary to determine if these gases are the cause.

5. Avoid any environment that contains substances that may attack the probe module and sensor materials. Some of these substances are concentrated acids, caustics, and strong

solvents. The sensor materials that come in contact with the sample include FEP Teflon, acrylic plastic, EPR rubber, stainless steel, epoxy, polyetherimide and the PVC cable covering.

6. It is possible for the silver anode, which is the entire silver body of the sensor, to become contaminated. This will prevent successful calibration. To restore the anode, refer to Section *11.1.1 DO Sensor, Silver Anode Cleaning*.

7. For correct sensor operation, the gold cathode must always be bright. If it is tarnished (which can result from contact with certain gases), or plated with silver (which can result from extended use with a loose or wrinkled membrane), the gold surface must be restored. To restore the cathode, refer to Section *11.1.1 DO Sensor, Gold Cathode Cleaning*.

8. To keep the electrolyte from drying out, store the sensor in the transport/calibration cup with at least 1/8″ of water.

Silver Anode Cleaning

After extended use, a thick layer of AgCl builds up on the silver anode reducing the sensitivity of the sensor. The anode must be cleaned to remove this layer and restore proper performance. The cleaning can be chemical or mechanical:

Chemical Cleaning: Remove the membrane cap and soak the entire anode section in a 14% ammonium hydroxide solution for 2 to 3 minutes, followed by a thorough rinsing with distilled or deionized water. The anode should then be thoroughly wiped with a wet paper towel to remove the residual layer from the anode.

Mechanical Cleaning: Sand off the dark layer from the silver anode with 400 grit wet/dry sandpaper. Wrap the sandpaper around the anode and twist the sensor. Rinse the anode with clean water after sanding, followed by wiping thoroughly with a wet paper towel.

NOTE: After cleaning, a new membrane cap must be installed. Refer to Section *3.4.3 Membrane Cap Installation***.**

Turn the instrument on and allow the system to stabilize for at least 30 minutes. If, after several hours, you are still unable to calibrate, contact your dealer or YSI Customer Service. Refer to *Appendix E Customer Service*.

Gold Cathode Cleaning

For correct sensor operation, the gold cathode must be textured properly. It can become tarnished or plated with silver after extended use. The gold cathode can be cleaned by using the adhesive backed sanding disc and tool provided in the YSI 5238 Probe Reconditioning Kit.

Using the sanding paper provided in the YSI 5238 Probe Reconditioning Kit, wet sand the gold with a twisting motion about 3 times or until all silver deposits are removed and the gold appears to have a matte finish. Rinse the cathode with clean water after sanding, followed by wiping thoroughly with a wet paper towel. If the cathode remains tarnished, contact your dealer or YSI Customer Service. Refer to *Appendix E Customer Service*.

NOTE: After cleaning, a new membrane cap must be installed. Refer to Section *3.4.3 Membrane Cap Installation***.**

11.1.2 DO Sensor Replacement

1. Remove the probe sensor guard.

⚠ **CAUTION:** Thoroughly dry the sensor so that no water enters the probe module sensor port when the sensor is removed.

2. Insert the long end of the hex key wrench into the small hole in the side of the probe module bulkhead. Turn the wrench counterclockwise and remove the screw. (You do not have to remove the screw all the way to release the sensor.)

3. Pull the old DO sensor module straight out of the probe module body.

   NOTE: The DO sensor is not threaded, it is keyed, so it cannot be removed by twisting.

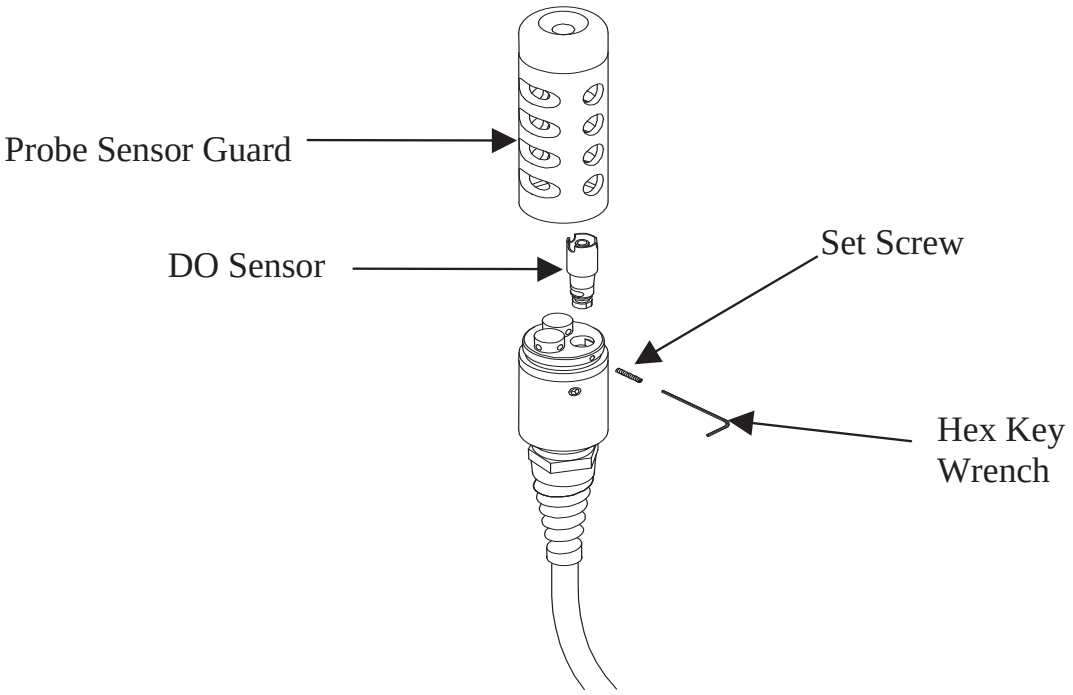


Figure 11.1 DO Sensor Replacement

4. Insert the new DO sensor module. Make sure that the inside of the probe module sensor port and the o-ring on the sensor are clean, with no contaminants, such as grease, dirt, or hair. The DO sensor is keyed, or has a flat side, so that it cannot be aligned improperly.

NOTE: Make sure the DO sensor bottoms out before the set screw is inserted.

5. Insert the set screw into the small hole in the side of the probe module bulkhead, and turn clockwise to rethread.

⚠ **CAUTION:** Make sure that you do not cross-thread the set screw. Use the hex key wrench to tighten the screw in properly, making sure that the screw does not stick out of the side of the probe module bulkhead. The probe sensor guard will not thread

on properly and damage may result if the screw is allowed to stick out.

NOTE: The YSI 5563 DO sensor is shipped dry. A shipping membrane was installed to protect the electrode. A new membrane cap must be installed before the first use. Refer to Section *3.4.1 Sensor Installation.*

11.1.3 YSI 5564 pH and 5565 Combination pH/ORP Sensor Cleaning

Cleaning is required whenever deposits or contaminants appear on the glass and/or platinum surfaces of these sensors or when the response of the sensor becomes slow.

1. Remove the sensor from the probe module.

2. Initially, simply use clean water and a soft clean cloth, lens cleaning tissue, or cotton swab to remove all foreign material from the glass bulb (YSI 5564 and YSI 5565) and platinum button (YSI 5565). Then use a moistened cotton swab to carefully remove any material that may be blocking the reference electrode junction of the sensor.

⚠ **CAUTION:** When using a cotton swab with the YSI 5564 or YSI 5565, be careful NOT to wedge the swab tip between the guard and the glass sensor. If necessary, remove cotton from the swab tip, so that the cotton can reach all parts of the sensor tip without stress.

NOTE: If good pH and/or ORP response is not restored by the above procedure, perform the following additional procedure:

1. Soak the sensor for 10-15 minutes in clean water containing a few drops of commercial dishwashing liquid.

2. GENTLY clean the glass bulb and platinum button by rubbing with a cotton swab soaked in the cleaning solution.

3. Rinse the sensor in clean water, wipe with a cotton swab saturated with clean water, and then re-rinse with clean water.

NOTE: If good pH and/or ORP response is still not restored by the above procedure, perform the following additional procedure:

1. Soak the sensor for 30-60 minutes in one molar (1 M) hydrochloric acid (HCl). This reagent can be purchased from most distributors. Be sure to follow the safety instructions included with the acid.

2. GENTLY clean the glass bulb and platinum button by rubbing with a cotton swab soaked in the acid.

3. Rinse the sensor in clean water, wipe with a cotton swab saturated with clean water, and then re-rinse with clean water. To be certain that all traces of the acid are removed from the sensor crevices, soak the sensor in clean water for about an hour with occasional stirring.

NOTE: If biological contamination of the reference junction is suspected or if good response is not restored by the above procedures, perform the following additional cleaning step:

1. Soak the sensor for approximately 1 hour in a 1 to 1 dilution of commercially available chlorine bleach.

2. Rinse the sensor with clean water and then soak for at least 1 hour in clean water with occasional stirring to remove residual bleach from the junction. (If possible, soak the sensor for period of time longer than 1 hour in order to be certain that all traces of chlorine bleach are removed.) Then re-rinse the sensor with clean water and retest.`

11.1.4 Temperature/Conductivity Sensor Cleaning

The single most important requirement for accurate and reproducible results in conductivity measurement is a clean cell. A dirty cell will change the conductivity of a solution by contaminating it. The small cleaning brush included in the YSI 5511 Maintenance Kit is ideal for this purpose.

To clean the conductivity cell:

1. Dip the brush in clean water and insert it into each hole 15-20 times.

2. Rinse the cell thoroughly in deionized or clean tap water.

NOTE: In the event that deposits have formed on the electrodes, perform the following additional procedure:

1. Use a mild detergent solution in combination with the brush. Dip the brush in the solution and insert it into each hole 15-20 times.

2. Rinse the cell thoroughly in deionized or clean tap water.

   NOTE: After cleaning, check the response and accuracy of the conductivity cell with a calibration standard.

   NOTE: If this procedure is unsuccessful, or if sensor performance is impaired, it may be necessary to return the sensor to a YSI authorized service center for service, Refer to *Appendix E Customer Service*.

   The temperature portion of the sensor requires no maintenance.

11.2 Upgrading YSI 556 MPS Software

1. Access the YSI Environmental Software Downloads page as described in *Appendix G EcoWatch* Step 1 through 3.

2. Click on the **YSI Instruments Software Updates** link (or scroll down until you see YSI 556 MPS).

3. Click on the file icon to the right of the **YSI 556 MPS** listing and save the file to a temporary directory on your computer.

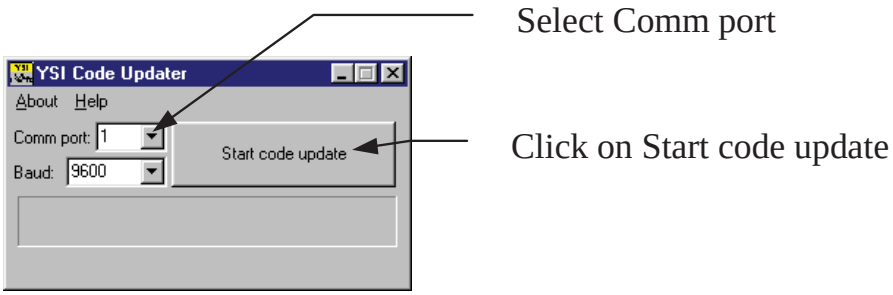
4. After the download is complete, run the file (that you just downloaded) and follow the on screen instructions to install the YSI Code Updater on your computer. If you encounter difficulties, contact YSI customer service for advice. Refer to *Appendix E Customer Service*.

5. If necessary, disconnect the YSI 5563 Probe Module from the YSI 556 MPS instrument.

6. Connect the YSI 556 MPS to a serial port of your computer via the 655173 PC interface cable. See Figure 8.6 Computer/Instrument Interface.

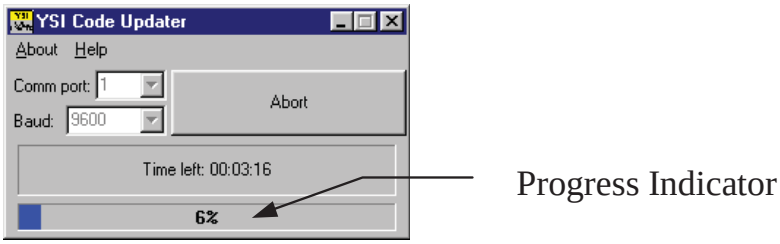
7. Press the **On/off** key on the YSI 556 MPS to display the run screen.

8. Run the YSI Code Updater software that you just installed on your computer. The following window will be displayed:

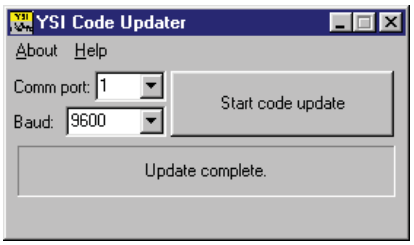


9. Set the Comm port number to match the port that you connected the 655173 PC Interface Cable to, then click on the **Start Code Update button**.

The YSI 556 MPS screen will blank out and a progress indicator will be displayed on the PC.



When the update is finished (indicated on the PC screen), the YSI 556 MPS will return to the Run screen. See Figure 7.1 Run Screen.



10. Close the YSI Code Updater window (on the PC) by clicking on the "X" in the upper right corner of the window.

11. Disconnect the YSI 556 MPS from the 655173 PC interface cable and reconnect it to the YSI 5563 Probe Module. Refer to Section *3.6 Instrument/Cable Connection*.

12. Storage

Proper storage between periods of usage will not only extend the life of the sensors, but will also ensure that the unit will be ready to use as quickly as possible in your next application.

12.1 General Recommendations for Short Term Storage

No matter what sensors are installed in the instrument, it is important to keep them moist without actually immersing them in liquid. Immersing them could cause some of them to drift or result in a shorter lifetime.

YSI recommends that short term storage of all multi-parameter instruments be done by placing approximately 1/2 inch of tap water in the transport/calibration cup that was supplied with the instrument, and by placing the probe module with all of the sensors installed into the cup. The use of a moist sponge instead of a 1/2 inch of tap water is also acceptable, as long as its presence does not compromise the attachment of the cup to the probe module. The transport/calibration cup should be sealed to prevent evaporation.

NOTE: Ensure that an o-ring is installed in the o-ring groove on the threaded end of the probe module body. See Figure 3.7 Transport/Calibration Cup Installation.

⚠ **CAUTION:** The water level has to be low enough so that none of the sensors are actually under water. Check the transport/calibration cup periodically to make certain that the water is still present or the sponge is still moist.

NOTE: If the storage water (tap water) is accidentally lost during field use, environmental water can be used.

12.2 General Recommendations for Long Term Storage

12.2.1 Probe Module Storage

1. Remove the pH or pH/ORP sensor from the probe module and store according to the individual sensor storage instructions found in Section *12.2.2 Sensor Storage*.

2. Seal the empty port with the provided port plug.

NOTE: Leave the conductivity/temperature sensor and dissolved oxygen sensor, with membrane cap still on, in the probe module.

3. Place 1/2″ of water, deionized, distilled or tap, in the transport/calibration cup.

⚠ **CAUTION:** The water level has to be low enough so that none of the sensors are actually under water. Check the transport/calibration cup periodically to make certain that the water is still present or the sponge is still moist.

4. Insert the probe module into the cup.

NOTE: Ensure that an o-ring is installed in the o-ring groove on the threaded end of the probe module body. See Figure 3.7 Transport/Calibration Cup Installation.

12.2.2 Sensor Storage

Temperature/Conductivity Sensor

No special precautions are required. Sensor can be stored dry or wet, as long as solutions in contact with the thermistor and conductivity electrodes are not corrosive (for example, chlorine bleach). However, it is recommended that the sensor be cleaned with the provided brush prior to long term storage. Refer to Section *11.1.4 Temperature/Conductivity Sensor Cleaning*.

pH and Combination pH/ORP Sensor

The key to sensor storage is to make certain that the reference electrode junction does not dry out. Junctions which have been allowed to dry out due to improper storage procedures can usually be rehydrated by soaking the sensor for several hours (overnight is recommended) in a solution which is 2 molar in potassium chloride. If potassium chloride solution is not available, soaking the sensor in tap water or commercial pH buffers may restore sensor function. However in some cases the sensor may have been irreparably damaged by the dehydration and will require replacement.

⚠ **CAUTION:** Do not store the sensor in distilled or deionized water as the glass sensor may be damaged by exposure to this medium.

1. Remove the pH or pH/ORP sensor from the probe module.

2. Seal the empty port with the provided port plug.

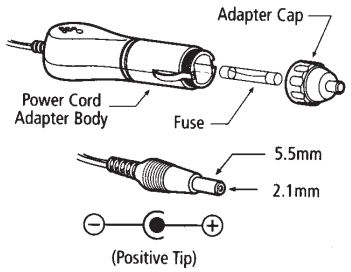
3. Place the sensor in the storage vessel (plastic boot or bottle) which was on the sensor at delivery. The vessel should contain a solution which is 2 molar in potassium chloride.

   NOTE: Make certain that the vessel is sealed to prevent evaporation of the storage solution.

13. Troubleshooting

The following sections describe problems you may encounter when using the YSI 556 MPS and provides suggestions to overcome the symptom.

PROBLEM	POSSIBLE SOLUTION
Display Problems	
No display is visible after pressing the on/off key.	If C cells are used, make certain that they are installed properly with regard to polarity and that good batteries are used. If a rechargeable battery pack is used, place the pack in the instrument and charge for 30 minutes.
Instrument software appears to be locked up as evidenced by no response to keypad entries or display not changing.	First, attempt to reset the instrument by simply turning off and then on again. If this fails, remove battery power from the instrument for 30 seconds and then reapply power. When using C cells, remove the battery lid and one of the batteries; when using the rechargeable battery pack, remove the pack completely from the instrument. After 30 seconds replace the battery or battery pack and check for instrument function.
The 556 display flashes and the instrument speaker makes a continuous clicking sound.	The battery voltage is low. Change to new C cells or recharge the 6117 battery pack.
Water Damage to Instrument	
Leakage detected in battery compartment when using C cells	Dispose of batteries properly. Dry the battery compartment using compressed air if possible. If corrosion is present on battery terminals, contact YSI Customer Service.
Water has contacted rechargeable battery pack	Remove battery pack immediately. Send battery pack to YSI Product Service for evaluation. **CAUTION**: DO NOT REUSE BATTERY PACK UNTIL YSI PRODUCT SERVICE HAS EVALUATED IT.
Leakage suspected into the main cavity of the instrument case	Remove the batteries immediately. Return the instrument to YSI Product Service.

PROBLEM	POSSIBLE SOLUTION
Optional Cigarette Lighter Charger	
Power cord fuse blown 	1. Unscrew adapter's cap, remove tip and pull out fuse. 2. Replace fuse with a new 2-amp fast-blow fuse from an electronics store such as Radio Shack. 3. Reassemble the adapter and securely screw the cap back onto the adapter body.
File Problems	
Upload of files from YSI 556 MPS to PC fails	1. Make sure that cable is connected properly to both 556 and PC. 2. Make certain that the proper Comm port is selected in EcoWatch for Windows.
Barometer data is not stored with sensor data file.	Make sure **Store barometer** is active in the 556 **Logging setup** menu.
Site Descriptions in the **Site List** are "grayed-out" and not available for appending files with additional data.	There is a parameter mismatch between the current 556 setup and that initially used. Change the current logging and sensor setup to match the setup that was initially used to create the file.
Sensor Problems	
Dissolved Oxygen reading unstable or inaccurate. Out of Range message appears during calibration.	Sensor not properly calibrated. Follow DO cal procedures.
	Membrane not properly installed or may be punctured. Replace membrane cap.
	DO sensor electrodes require cleaning. Follow DO cleaning procedure. Use 5511 Maintenance kit.
	Water in sensor connector. Dry connector; reinstall sensor.
	Algae or other contaminant clinging to DO sensor. Rinse DO sensor with clean water.
	Barometric pressure entry is incorrect. Repeat DO cal procedure.
	Calibrated at extreme temperature. Recalibrate at (or near) sample temperature.
	DO sensor has been damaged. Replace sensor.
	Internal failure. Return probe module for service.

PROBLEM	POSSIBLE SOLUTION
Sensor Problems	
pH or ORP readings are unstable or inaccurate. Out of Range message appears during calibration.	Sensor requires cleaning. Follow sensor cleaning procedure.
	Sensor requires calibration. Follow cal procedures.
	pH sensor reference junction has dried out from improper storage. Soak sensor in tap water or buffer until readings become stable.
	Water in sensor connector. Dry connector; reinstall sensor.
	Sensor has been damaged. Replace sensor.
	Calibration solutions out of spec or contaminated with other solution. Use new calibration solutions.
	ORP fails Zobell check. Take into account temperature dependence of Zobell solution readings.
	Internal failure. Return probe module for service.
Conductivity unstable or inaccurate. Out of Range message appears during calibration.	Conductivity improperly calibrated. Follow calibration procedure.
	Conductivity sensor requires cleaning. Follow cleaning procedure.
	Conductivity sensor damaged. Replace sensor.
	Calibration solution out of spec or contaminated. Use new calibration solution.
	Internal failure. Return probe module for service.
	Calibration solution or sample does not cover entire sensor. Immerse sensor fully.
Temperature, unstable or inaccurate	Water in connector. Dry connector; reinstall sensor.
	Sensor has been damaged. Replace the 5560 sensor.
Installed sensor has no reading	The sensor has been disabled. Enable sensor.
	Water in sensor connector. Dry connector; reinstall sensor.
	Sensor has been damaged. Replace the sensor.
	Report output improperly set up. Set up report output.
	Internal failure. Return probe module for service.

If these guidelines and tips fail to correct your problem or if any other symptoms occur, contact YSI Customer Service for Advice. Refer to *Appendix E Customer Service*.

14. Appendix A YSI 556 MPS Specifications

14.1 Sensor Specifications

Dissolved Oxygen	
Sensor Type	Steady state polarographic
Range: *% air sat'n* *mg/L*	▪ 0 to 500% air saturation ▪ 0 to 50 mg/L
Accuracy: *% air sat'n* *mg/L*	▪ 0 to 200% air saturation: ±2% of the reading or 2% air saturation; whichever is greater ▪ 200 to 500% air saturation: ±6% of the reading ▪ 0 to 20 mg/L: ±2% of the reading or 0.2 mg/L; whichever is greater ▪ 20 to 50 mg/L: ±6% of the reading
Resolution: *% air sat'n* *mg/L*	▪ 0.1% air saturation ▪ 0.01 mg/L
Temperature	
Sensor Type:	YSI Precision™ thermistor
Range:	-5 to 45°C
Accuracy:	±0.15°C
Resolution:	0.01°C
Conductivity	
Sensor Type:	4-electrode cell with auto-ranging
Range:	0 to 200 mS/cm
Accuracy:	±0.5% of reading or ±0.001 mS/cm; whichever is greater–4 meter cable ±1.0% of reading or ±0.001 mS/cm; whichever is greater–20 meter cable
Resolution:	0.001 mS/cm to 0.1 mS/cm (range-dependent)
Salinity	
Sensor Type:	Calculated from conductivity and temperature
Range:	0 to 70 ppt
Accuracy:	±1.0% of reading or 0.1 ppt; whichever is greater
Resolution:	0.01 ppt

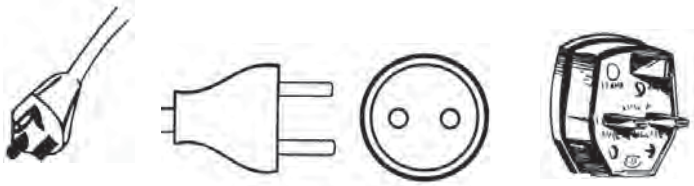
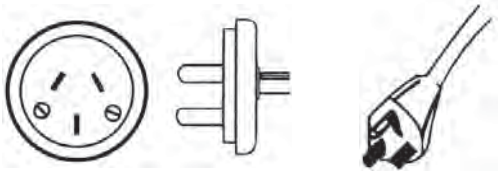
pH (optional)	
Sensor Type:	Glass combination electrode
Range:	0 to 14 units
Accuracy:	±0.2 units
Resolution:	0.01 units
ORP (optional)	
ORP Sensor Type:	Platinum button
Range:	-999 to +999 mV
Accuracy:	±20 mV
Resolution:	0.1 mV

Barometer (optional)	
Range:	500 to 800 mm Hg
Accuracy:	±3 mm Hg within ±15°C temperature range from calibration point
Resolution:	0.1 mm Hg

14.2 Instrument Specifications

Memory Size:	1.5 MB Flash Memory 49,000 data sets (@ 6 parameters per set plus time stamp) 100 Sites
Size:	11.9 cm width x 22.9 cm length (4.7 in. x 9 in.)
Weight with batteries:	0.92 kg (2.1 lbs)
Power:	4 alkaline C-cells; optional rechargeable pack
Cables:	4, 10, and 20 m (13.1, 32.8, 65.6 ft.) lengths
Warranty:	3-Years for the instrument; 1-Year for the probe modules and cable

15. Appendix B Instrument Accessories

ITEM #	ACCESSORY
5563-4	4m Cable with DO/temp/conductivity
5563-10	10m Cable with DO/temp/conductivity
5563-20	20m Cable with DO/temp/conductivity
5564	pH Kit
5565	pH/ORP Kit
6118	Rechargeable Battery Pack Kit for use in US
5094	Rechargeable Battery Pack Kit with universal charger and three adapter cables for use in international applications 
5095	Rechargeable Battery Pack Kit with universal charger and two adapter cables for use in international applications 
5083	Flow Cell – probe module is secured in the flow cell and groundwater is pumped through it
616	Charger, Cigarette Lighter – used to power up the instrument from a car's cigarette lighter
4654	Tripod
614	Ultra Clamp, C Clamp –used to clamp the instrument to a table top or car dashboard
6081	Large Carrying Case, Hard-sided
5085	Hands-free Harness
5065	Carrying Case, Form-fitted, for use in the field – has a clear vinyl window, shoulder strap, belt loop strap and hand strap

16. Appendix C Required Federal Communications Notice

The Federal Communications Commission defines this product as a computing device and requires the following notice.

This equipment generates and uses radio frequency energy and if not installed and used properly, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class A or Class B computing device in accordance with the specification in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient the receiving antenna
- Relocate the computer with respect to the receiver
- Move the computer away from the receiver
- Plug the computer into a different outlet so that the computer and receiver are on different branch circuits.

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet, prepared by the Federal Communications Commission, helpful: "How to Identify and Resolve Radio-TV Interference Problems". This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock No.0004-000-00345-4.

17. Appendix D Health and Safety

YSI Conductivity solutions: 3161, 3163, 3165, 3167, 3168, 3169

INGREDIENTS:

- ❑ Iodine
- ❑ Potassium Chloride
- ❑ Water

WARNING: INHALATION MAY BE FATAL.

⚠ ***CAUTION*: AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY EVOLVE TOXIC FUMES IN FIRE.**

Harmful if ingested or inhaled. Skin or eye contact may cause irritation. Has a corrosive effect on the gastro-intestinal tract, causing abdominal pain, vomiting, and diarrhea. Hyper-sensitivity may cause conjunctivitis, bronchitis, skin rashes etc. Evidence of reproductive effects.

FIRST AID:
INHALATION: Remove victim from exposure area. Keep victim warm and at rest. In severe cases seek medical attention.
SKIN CONTACT: Remove contaminated clothing immediately. Wash affected area thoroughly with large amounts of water. In severe cases seek medical attention.
EYE CONTACT: Wash eyes immediately with large amounts of water, (approx. 10 minutes). Seek medical attention immediately.
INGESTION: Wash out mouth thoroughly with large amounts of water and give plenty of water to drink. Seek medical attention immediately.

YSI pH 4.00, 7.00, and 10.00 Buffer Solutions: 3821, 3822, 3823

pH 4 INGREDIENTS:

- ❑ Potassium Hydrogen Phthalate
- ❑ Formaldehyde
- ❑ Water

pH 7 INGREDIENTS:

- ❑ Sodium Phosphate, Dibasic
- ❑ Potassium Phosphate, Monobasic
- ❑ Water

pH 10 INGREDIENTS:

- ❑ Potassium Borate, Tetra
- ❑ Potassium Carbonate
- ❑ Potassium Hydroxide
- ❑ Sodium (di) Ethylenediamine Tetraacetate
- ❑ Water

⚠ ***CAUTION* - AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.**

Inhalation may cause severe irritation and be harmful. Skin contact may cause irritation; prolonged or repeated exposure may cause Dermatitis. Eye contact may cause irritation or conjunctivitis. Ingestion may cause nausea, vomiting and diarrhea.

FIRST AID:

INHALATION - Remove victim from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Keep victim warm and at rest. Seek medical attention immediately.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes). Seek medical attention immediately.

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - If victim is conscious, immediately give 2 to 4 glasses of water and induce vomiting by touching finger to back of throat. Seek medical attention immediately.

YSI Zobell Solution: 3682

INGREDIENTS:

- ❑ Potassium Chloride
- ❑ Potassium Ferrocyanide Trihydrate
- ❑ Potassium Ferricyanide

⚠ ***CAUTION* - AVOID INHALATION, SKIN CONTACT, EYE CONTACT OR INGESTION. MAY AFFECT MUCOUS MEMBRANES.**

May be harmful by inhalation, ingestion, or skin absorption. Causes eye and skin irritation. Material is irritating to mucous membranes and upper respiratory tract. The chemical, physical, and toxicological properties have not been thoroughly investigated.

Ingestion of large quantities can cause weakness, gastrointestinal irritation and circulatory disturbances.

FIRST AID:

INHALATION - Remove victim from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Keep victim warm and at rest. Seek medical attention immediately.

SKIN CONTACT - Remove contaminated clothing immediately. Wash affected area with soap or mild detergent and large amounts of water (approx. 15-20 minutes). Seek medical attention immediately.

EYE CONTACT - Wash eyes immediately with large amounts of water (approx. 15-20 minutes), occasionally lifting upper and lower lids. Seek medical attention immediately.

INGESTION - If victim is conscious, immediately give 2 to 4 glasses of water and induce vomiting by touching finger to back of throat. Seek medical attention immediately.

18. Appendix E Customer Service

For information on Authorized Service Centers, refer to *Authorized Service Centers* in this appendix.

Equipment exposed to biological, radioactive, or toxic materials must be cleaned and disinfected before being returned or presented for service. A cleaning certificate must accompany the equipment. Refer to *18.2 Cleaning Instructions* in this appendix.

18.1 YSI Environmental Authorized Service Centers

For information on the nearest authorized service center, please contact:

YSI Technical Support • 1725 Brannum Lane
Yellow Springs, Ohio • 45387 • Phone: +1 (937) 767-7241
Phone: 800-897-4151 (US) • Email: environmental@ysi.com

or visit our website for the most current information:

www.ysi.com

18.2 Cleaning Instructions

Equipment exposed to biological, radioactive, or toxic materials must be cleaned and disinfected before being serviced. Biological contamination is presumed for any instrument, probe, or other device that has been used with body fluids or tissues, or with wastewater. Radioactive contamination is presumed for any instrument, probe or other device that has been used near any radioactive source.

If an instrument, probe, or other part is returned or presented for service without a Cleaning Certificate, and if in our opinion it represents a potential biological or radioactive hazard, our service personnel reserve the right to withhold service until appropriate cleaning, decontamination, and certification has been completed. We will contact the sender for instructions as to the disposition of the equipment. Disposition costs will be the responsibility of the sender.

When service is required, either at the user's facility or at a YSI Service Center, the following steps must be taken to ensure the safety of service personnel.

- In a manner appropriate to each device, decontaminate all exposed surfaces, including any containers. 70% isopropyl alcohol or a solution of 1/4-cup bleach to 1-gallon tap water is suitable for most disinfecting. Instruments used with wastewater may be disinfected with .5% Lysol if this is more convenient to the user.
- The user shall take normal precautions to prevent radioactive contamination and must use appropriate decontamination procedures should exposure occur.
- If exposure has occurred, the customer must certify that decontamination has been accomplished and that no radioactivity is detectable by survey equipment.
- Any product being returned to the YSI Repair Center should be packed securely to prevent damage.
- Cleaning must be completed and certified on any product before returning it to YSI.

18.3 Packing Procedure

- Clean and decontaminate items to ensure the safety of the handler.
- Complete and include the Cleaning Certificate.
- Place the product in a plastic bag to keep out dirt and packing material.
- Use a large carton, preferably the original, and surround the product completely with packing material.
- Insure for the replacement value of the product.

18.4 Cleaning Certificate

Organization _____

Department _____

Address _____

City _____ State __ Zip _____

Country _____ Phone _____

Model No. of Device __ Lot Number _____

Contaminant (if known) _____

Cleaning Agent(s) used _____

Radioactive Decontamination Certified?

(Answer only if there has been radioactive exposure)

_____ Yes _____ No

Cleaning Certified By _____

Name Date

18.5 Warranty

The instrument is warranted for three years against defects in workmanship and materials when used for its intended purposes and maintained according to instructions. The probe module and cables are warranted for one year. The dissolved oxygen, temperature/conductivity, pH, and pH/ORP combination sensors are warranted for one year. Damage due to accidents, misuse, tampering, or failure to perform prescribed maintenance is not covered. The warranty period for chemicals and reagents is determined by the expiration date printed on their labels. Within the warranty period, YSI will repair or replace, at its sole discretion, free of charge, any product that YSI determines to be covered by this warranty.

To exercise this warranty, write or call your local YSI representative, or contact YSI Customer Service in Yellow Springs, Ohio. Send the product and proof of purchase, transportation prepaid, to the Authorized Service Center selected by YSI. Repair or replacement will be made and the product returned transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days from date of repair or replacement.

Limitation of Warranty

This Warranty does not apply to any YSI product damage or failure caused by (i) failure to install, operate or use the product in accordance with YSI's written instructions, (ii) abuse or misuse of the product, (iii) failure to maintain the product in accordance with YSI's written instructions or standard industry procedure, (iv) any improper repairs to the product, (v) use by you of defective or improper components or parts in servicing or repairing the product, or (vi) modification of the product in any way not expressly authorized by YSI.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. YSI'S LIABILITY UNDER THIS WARRANTY IS LIMITED TO REPAIR OR REPLACEMENT OF THE PRODUCT, AND THIS SHALL BE YOUR SOLE AND EXCLUSIVE REMEDY FOR ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY. IN NO EVENT SHALL YSI BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY.

19. Appendix F Ferrite Bead Installation

⚠ **WARNING:** If you are using your YSI 556 in a European Community (CE) country or in Australia or New Zealand, you must attach a ferrite bead to the 655173 PC Interface Cable and the YSI 6117 Charger Adapter Cable in order to comply with the Residential, Commercial and Light Industrial Class B Limits for radio-frequency emissions specified in EN55011 (CISPR11) for Industrial, Scientific and Medical laboratory equipment. These ferrite assemblies are supplied as part of cable kits.

1. Make a small loop (approximately 5 cm in diameter) in the cable near the YSI 556 MS-19 connector.

2. Lay the open ferrite bead assembly under the loop with the cable cross-over position within the cylinder of the ferrite bead.

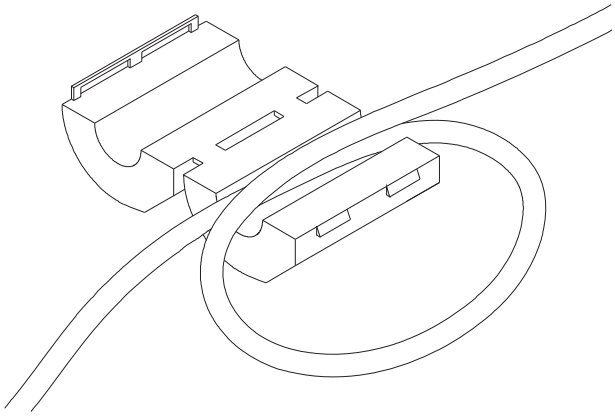


Figure 19.1 Ferrite Bead Installation

3. Snap the two pieces of the bead together making certain that the tabs lock securely.

4. When the installation is complete, the 655173 and YSI 6117 cables should resemble the following drawings.

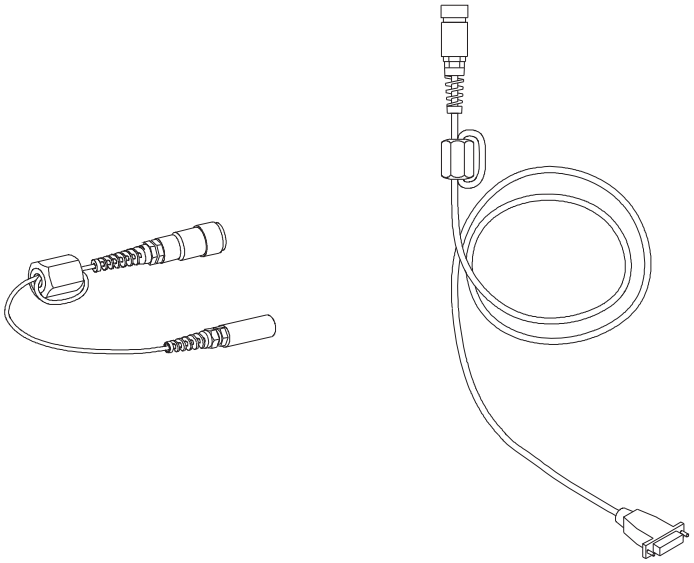


Figure 19.2 Cables with Ferrite Beads

20. Appendix G EcoWatch

EcoWatch™ for Windows™ must be used as the PC software interface to the YSI 556 MPS. EcoWatch is a powerful tool that can also be used with YSI 6-series sondes. Many features of the software will only be utilized by advanced users or are not relevant to the 556 MPS at all. This section is designed in tutorial format to familiarize you with the commonly used features of EcoWatch so that it will be possible to:

- Upload data from a 556 MPS to a PC
- Assemble plots and reports of your data
- Zoom in on certain segments of the plots of your data to facilitate analysis
- Show statistical data for your studies
- Export data in spreadsheet-compatible formats
- Print plots and reports

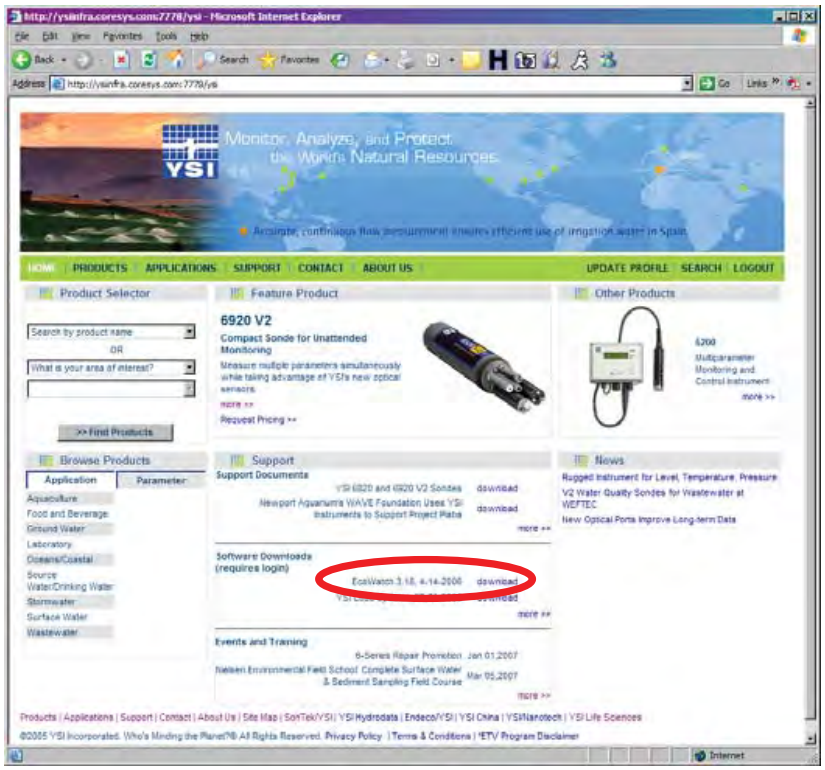
The advanced features of EcoWatch can be explored by downloading a 6-series manual from the YSI Web Site (www.ysi.com), purchasing a hard copy of the manual through YSI Customer Service (Item # 069300), or utilizing the on-line help feature of the software.

20.1 Installing EcoWatch for Windows

EcoWatch for Windows is available at no cost via a download from the YSI Web Site.

1. Access the YSI Web Site at www.ysi.com.

2. Click on the **Login** link and login (or register if you have not previously registered).



3. Click on the EcoWatch link and save the file to a directory on your computer.

4. After the download is complete, run the EcoWatch file (that you just downloaded) and follow the on screen instructions to install the software on your computer.

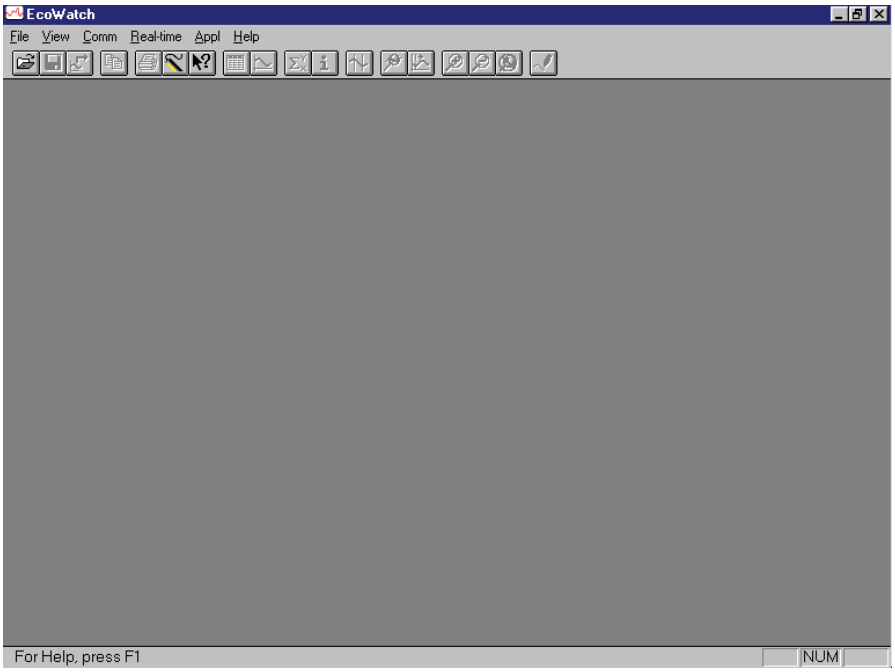
If you encounter difficulties in the download procedure, contact YSI Customer Service. Refer to ***Appendix E Customer Service***. Alternatively, you may purchase the software on CD ROM (Item #006075) by contacting YSI Customer Service.

20.2 EcoWatch Tutorial

This EcoWatch tutorial is designed to teach you the commonly used operations associated with the software when used with your 556 MPS.

After you have uploaded a file, Refer to Section 8.4 Upload to PC, you will see two files in the C:\ECOWWIN\DATA directory; the file you transferred and a file supplied by YSI designated SAMPLE.DAT. This SAMPLE.DAT file is referred to in the remainder of this tutorial section. After following the instructions below for the analysis of SAMPLE.DAT, you apply the same analysis to the data file which was uploaded from your 556 MPS to assure that you are familiar with the basic features and capabilities of EcoWatch for Windows.

To start the analysis of the SAMPLE.DAT file, note that a shortened menu bar is visible and many of the tools in the toolbar appear dimmed or “grayed out” before any file is opened (see below).



Full activation of EcoWatch features will be realized after a file is opened.

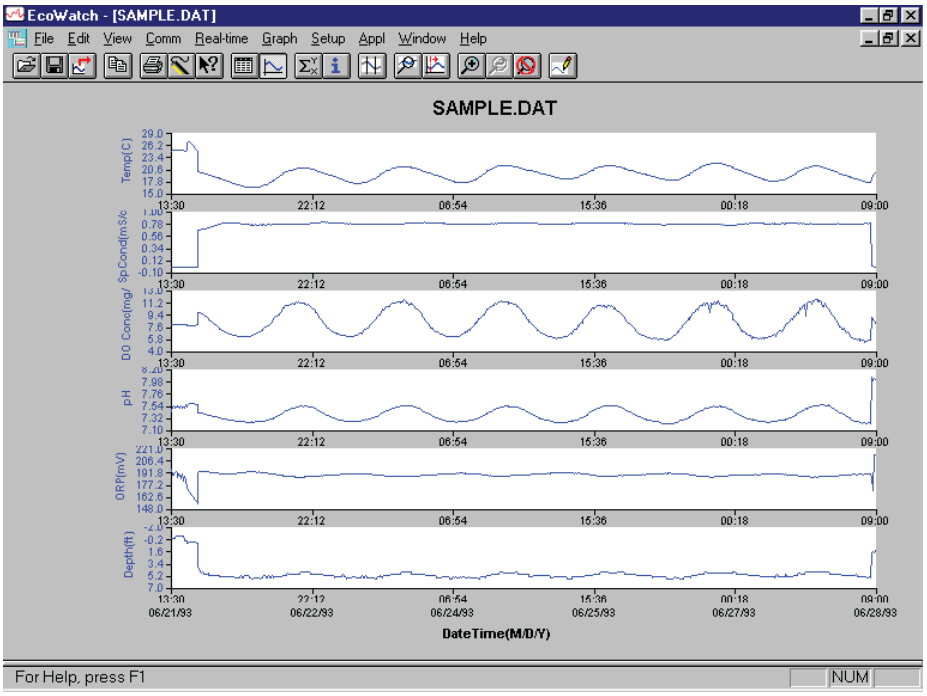
To open the sample data file:

5. 1. Click the **File** menu button in the toolbar.

6. 2. Select the **SAMPLE.DAT** file.

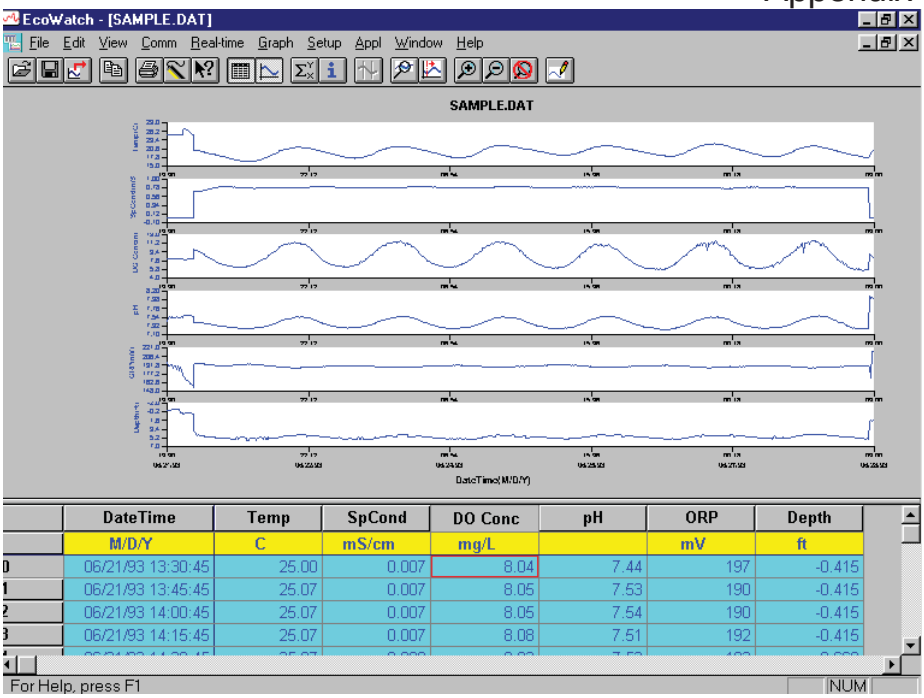
7. 3. Click **OK** to open the file.

The following display will appear:



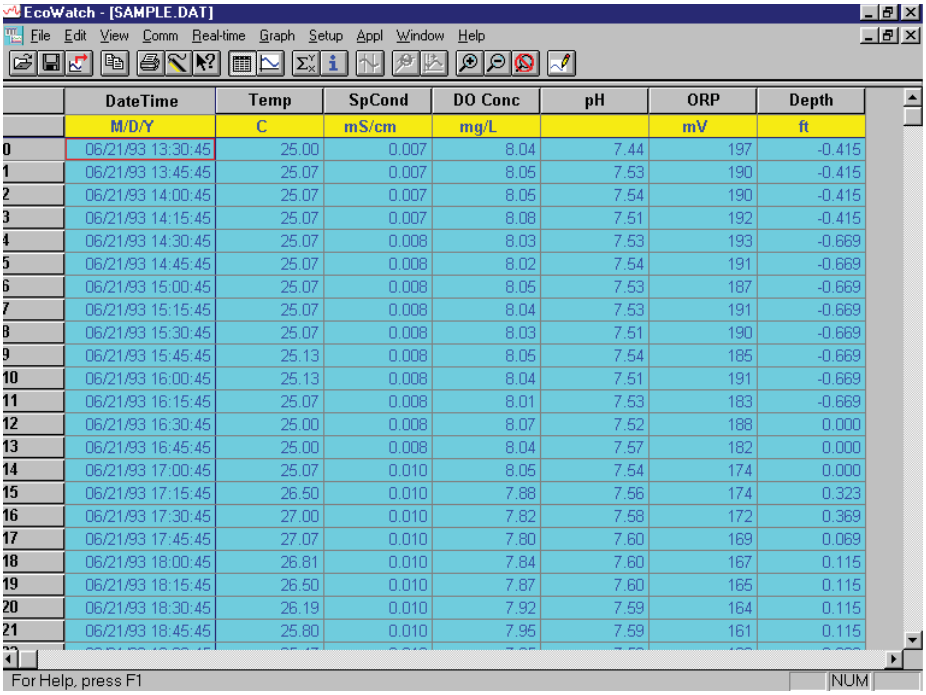
Note that the data in this file appears as a graph of temperature, specific conductance, dissolved oxygen, pH, ORP, and depth, all versus time. The graphs are scaled automatically so that all data fits comfortably on the computer screen. Note also that this data file was obtained with a 6-series sonde for which a depth sensor is available. Depth is NOT a current parameter for the 556 MPS.

The **Table** and **Graph** buttons on the toolbar are on/off switches that are used to display or hide the graph and table pages respectively. When displaying a graph and a table at the same time, you can control the relative size of the two pages by placing the cursor over the small bar that separates them and then dragging it to the desired location. Click the **Table** button to generate the following dual display of data.



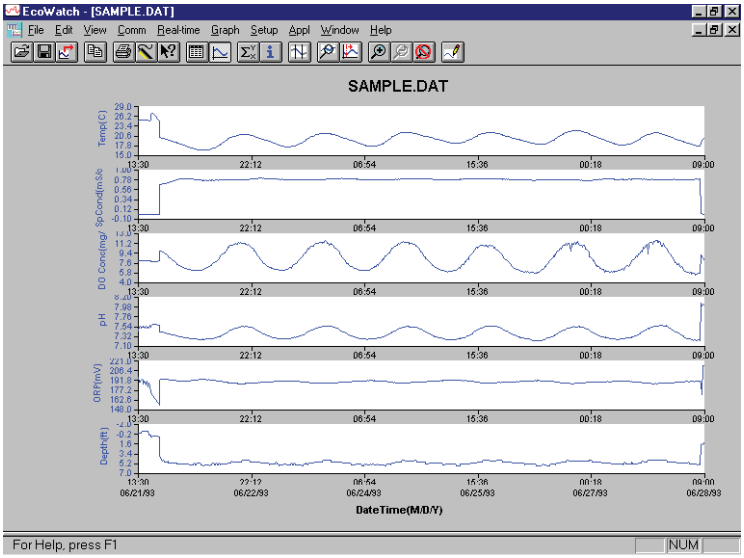
	DateTime	Temp	SpCond	DO Conc	pH	ORP	Depth
	M/D/Y	C	mS/cm	mg/L		mV	ft
0	06/21/93 13:30:45	25.00	0.007	8.04	7.44	197	-0.415
1	06/21/93 13:45:45	25.07	0.007	8.05	7.53	190	-0.415
2	06/21/93 14:00:45	25.07	0.007	8.05	7.54	190	-0.415
3	06/21/93 14:15:45	25.07	0.007	8.08	7.51	192	-0.415

Now click the **Graph** button (turn it off) to display only a report of your data as shown below. Note that the size of the report can be varied by clicking on the and buttons in the Toolbar.

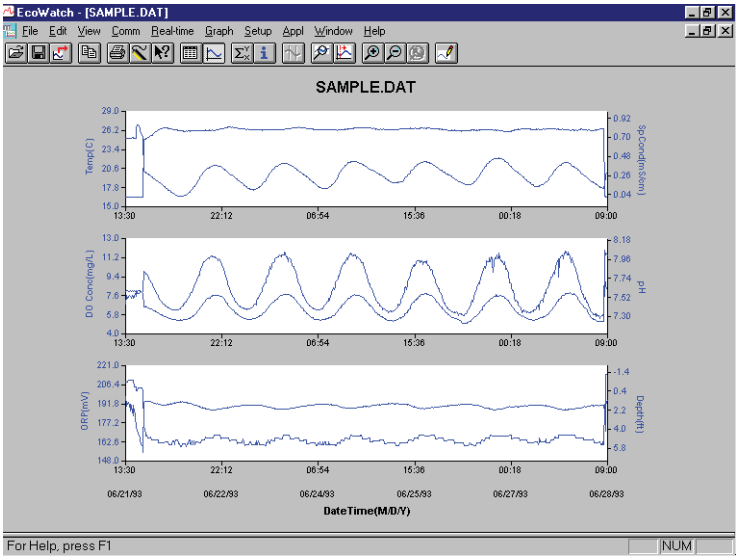


	DateTime	Temp	SpCond	DO Conc	pH	ORP	Depth
	M/D/Y	C	mS/cm	mg/L		mV	ft
0	06/21/93 13:30:45	25.00	0.007	8.04	7.44	197	-0.415
1	06/21/93 13:45:45	25.07	0.007	8.05	7.53	190	-0.415
2	06/21/93 14:00:45	25.07	0.007	8.05	7.54	190	-0.415
3	06/21/93 14:15:45	25.07	0.007	8.08	7.51	192	-0.415
4	06/21/93 14:30:45	25.07	0.008	8.03	7.53	193	-0.669
5	06/21/93 14:45:45	25.07	0.008	8.02	7.54	191	-0.669
6	06/21/93 15:00:45	25.07	0.008	8.05	7.53	187	-0.669
7	06/21/93 15:15:45	25.07	0.008	8.04	7.53	191	-0.669
8	06/21/93 15:30:45	25.07	0.008	8.03	7.51	190	-0.669
9	06/21/93 15:45:45	25.13	0.008	8.05	7.54	185	-0.669
10	06/21/93 16:00:45	25.13	0.008	8.04	7.51	191	-0.669
11	06/21/93 16:15:45	25.07	0.008	8.01	7.53	183	-0.669
12	06/21/93 16:30:45	25.00	0.008	8.07	7.52	188	0.000
13	06/21/93 16:45:45	25.00	0.008	8.04	7.57	182	0.000
14	06/21/93 17:00:45	25.07	0.010	8.05	7.54	174	0.000
15	06/21/93 17:15:45	26.50	0.010	7.88	7.56	174	0.323
16	06/21/93 17:30:45	27.00	0.010	7.82	7.58	172	0.369
17	06/21/93 17:45:45	27.07	0.010	7.80	7.60	169	0.069
18	06/21/93 18:00:45	26.81	0.010	7.84	7.60	167	0.115
19	06/21/93 18:15:45	26.50	0.010	7.87	7.60	165	0.115
20	06/21/93 18:30:45	26.19	0.010	7.92	7.59	164	0.115
21	06/21/93 18:45:45	25.80	0.010	7.95	7.59	161	0.115

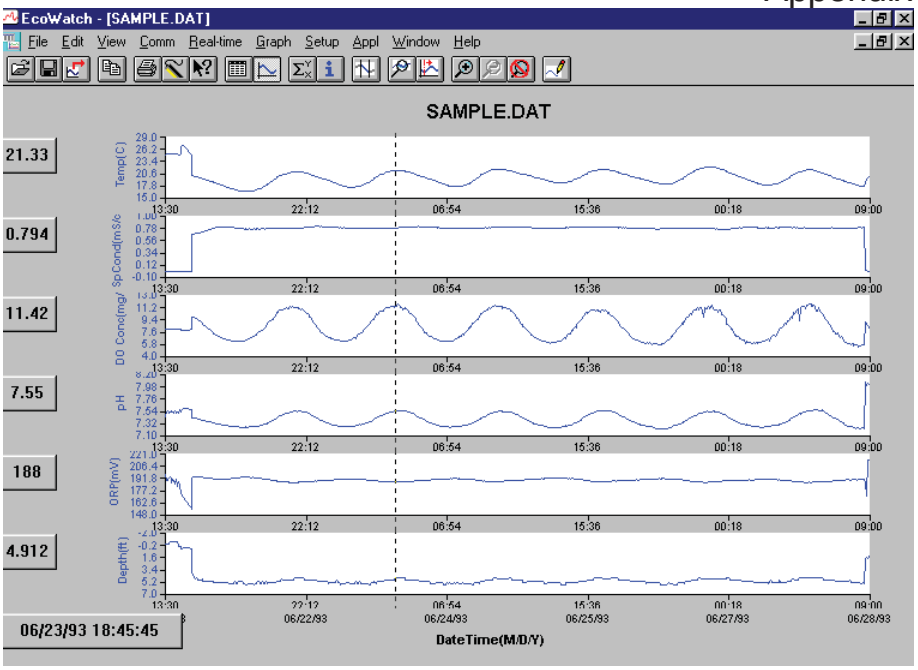
Now return to the original graphic display by toggling the **Table** button “off” and **Graph** button “on”.



From the **Setup** menu, click **Graph**. Click **2 Traces per Graph** and notice that the parameters are now graphed in pairs for easy comparison of parameters.

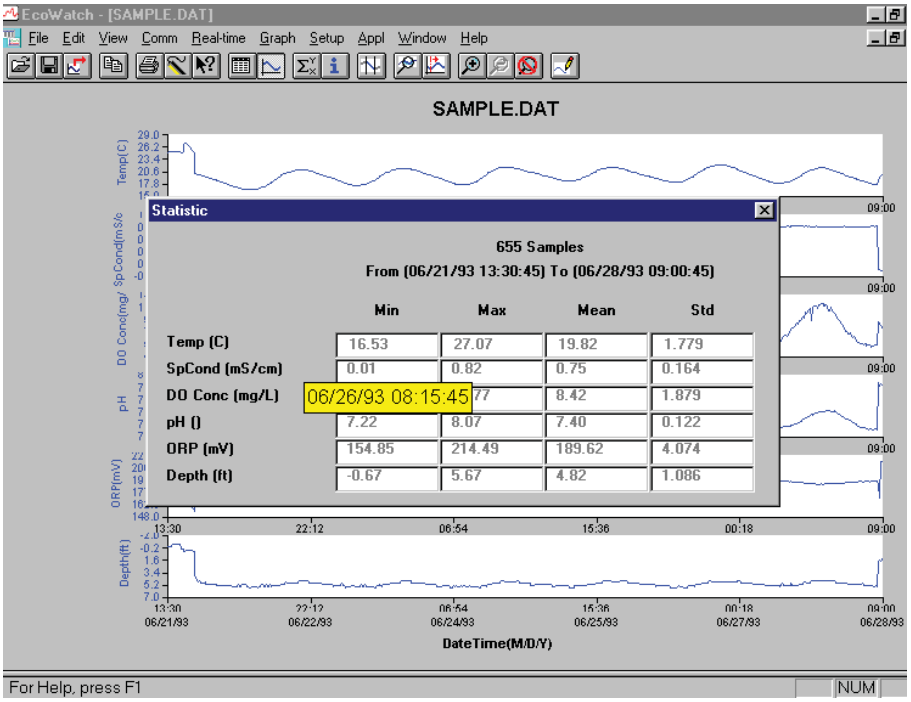


Click **1 Trace per Graph** to return the display to the original setting. Move the cursor to any position in the graph, then click and hold the right mouse button.



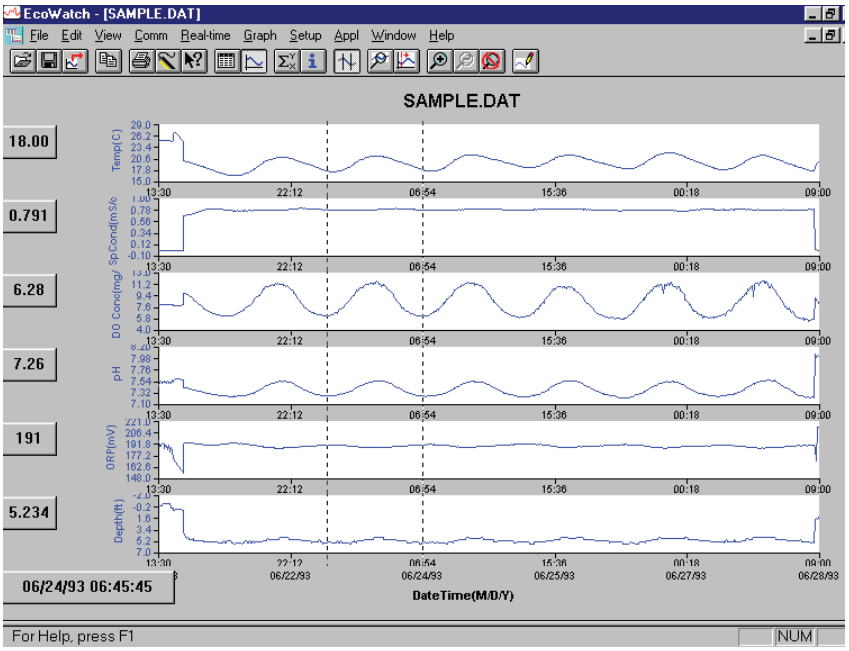
Note that the exact measurements for this point in time are displayed to the left of the graph. While holding down the right mouse button, move to another area on the graph. Notice how the measurements change as you move. When you release the mouse button, the display returns to normal.

To view statistical information for the study, click the **Statistics** button on the toolbar. On the statistics window, click on any min or max value to display the time when it occurred.

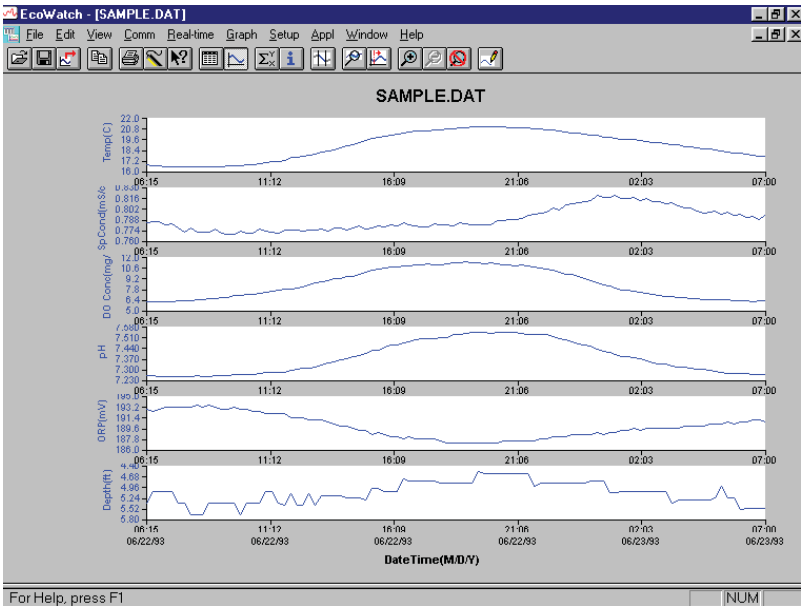


After viewing statistics, click the “x” at the upper right to close the window and return to the normal display.

Now click on the delimiter icon in the toolbar and then move the displayed icon to the graph. Click at the two points shown by dotted lines in the display below, being sure that the first click is to the left of the second.

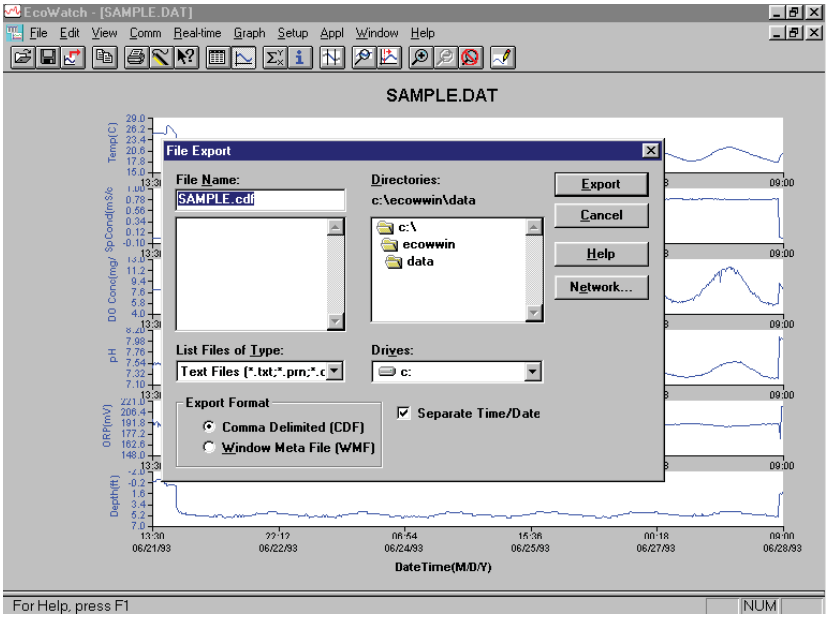


The data between the two selected points will then be graphed in higher resolution as shown below.

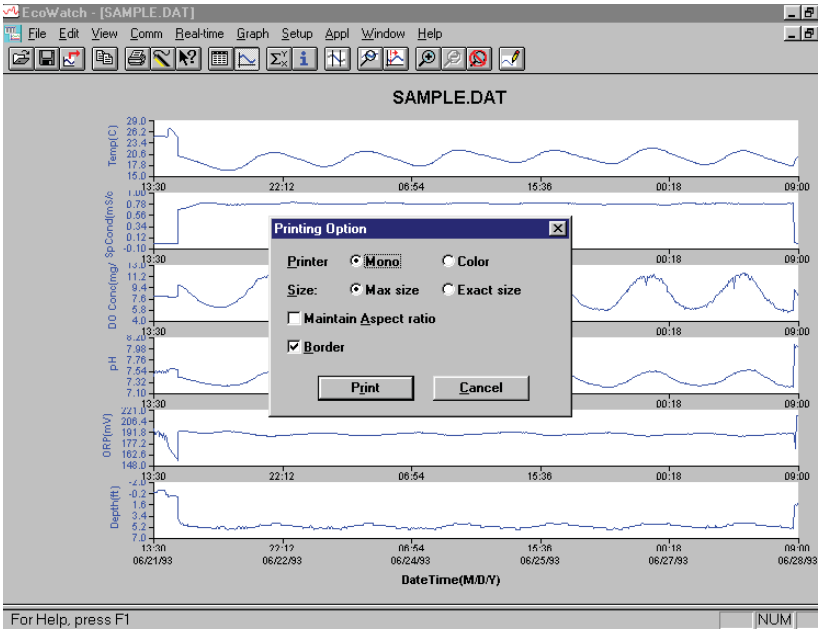


To return to the complete data set, select **Graph** from the toolbar and then click **Cancel Limits**.

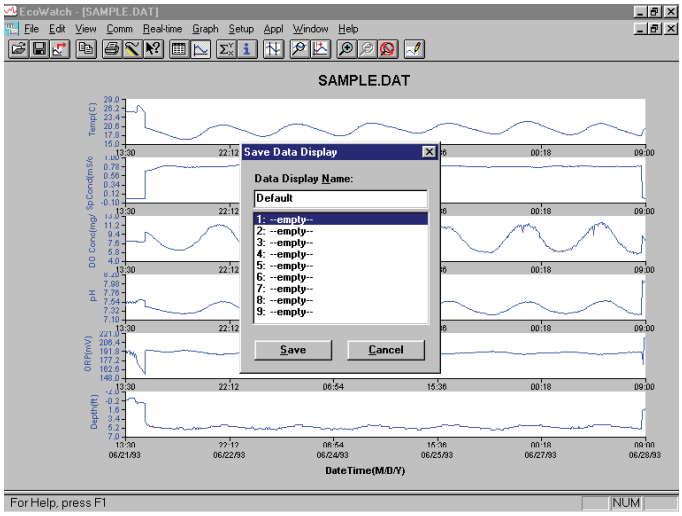
Now select the icon from the Toolbar to create a new data file which will allow your data to be imported into spreadsheets. Select the default export settings for a Comma Delimited File (.CDF) and click OK. A new spreadsheet-importable file (SAMPLE.CDF) is now present in the same folder as the SAMPLE.DAT file.



Now select the icon from the toolbar to print the plot. Accept the default settings and click OK to complete the printing operation.



Finally, end the tutorial by saving the **Data Display** in the format shown. From the **File** menu, click **Save Data Display**.



Then type “Default” for the file name and click **Save**. The parameters, colors, format, and x-axis time interval associated with the current display are now saved and can be accessed any time in the future. Nine different data displays may be saved for any data file. You can easily switch between various displays of the data. The data files can be accessed by clicking **Load Data Display** from the file menu and then selecting the desired presentation.

20.2.1 Summary of Toolbar Capability

The EcoWatch toolbar includes buttons for some of the most common commands in EcoWatch, such as **File Open**. To display or hide the toolbar, open the **View** menu and click on the **Toolbar** command. A check mark appears next to the menu item when the toolbar is displayed.

The toolbar is displayed across the top of the application window, below the menu bar.

Click To:

Open an existing data file (.DAT). EcoWatch displays the **Open** dialog box, in which you can locate and open the desired file.

Save the working Data Display of the active data file. EcoWatch displays the **Save Data Display** dialog box in which you can overwrite existing Data Display or save to a new one.

Export data as a graph in Window Meta File (.WMF) format or as data in Comma Delimited (.CDF) format.

Copy the whole graph page or data from the selection on the table to the clipboard.

Print the active graph page or table page depending on which one is currently active.

Open a new terminal window to communicate with the sonde.

Access context sensitive help (Shift+F1).

Toggle table window during file processing.

Toggle graph window during file processing.

Display study statistics.

Display study info.

Limit the data to be processed in a study.

Enlarge a selective portion of graph.

Center the graph under the cursor.

Enlarge graph or table 20%.

Reduce graph or table 20%.

Return graph or table to its normal state (unzoom)

Redraw the graph.

20.2.2 Other Capabilities

The above tutorial and function list for the toolbar provide basic information to allow you to view and analyze the field data which was stored in your 556 MPS. Some of the other commonly used capabilities of EcoWatch which the user may want to explore are listed below:

- Customize the units for each parameter, e.g., report uS/cm instead of mS/cm for conductivity.
- Customize the order of parameters in each plot or report.
- Customize the colors and fonts of each data display.
- Manually scale the y-axis sensitivity for each parameter.
- Merging of two or more data files with compatible parameter formats
- View information about the study such as number of points, instrument serial number, etc. which was stored in the 556 with the data.
- Print data reports in different statistical formats.
- Create plots of parameter vs. parameter rather than parameter vs. time.

These additional features of EcoWatch for Windows are explained in detail in the YSI 6-series manual (which can be downloaded at no cost from the YSI Web Site as described above) and the Help selection in the EcoWatch menubar. To purchase a hard copy of the 6-series manual, contact YSI Customer Service using the contact information in *Appendix E Customer Service*.

21. Appendix H Calibration Record Information

When your YSI 556 MPS sensors are initially calibrated, relevant information about the sensors will be stored in a separate file in the YSI 556 MPS memory.

NOTE: This file, by default, will have the name "556 Circuit Board Serial Number.glp." The circuit board serial number is assigned at the factory and has a hexadecimal format such as 000080A4. Thus the default calibration record file would be designated 00080A4.glp. Refer to Section *10.7 GLP Filename* to change the filename.

The information in the calibration record will track the sensor performance of your instrument and should be particularly useful for programs operating under Good Laboratory Practices (GLP) protocols.

21.1 Viewing the Calibration Record (.glp) File

NOTE: Make certain that you have performed a calibration on at least one of the sensors associated with your YSI 556 MPS.

1. Follow the procedures outlined in Section *8.3 View File*.

21.2 Uploading the Calibration Record (.glp) File

NOTE: Make certain that you have performed a calibration on at least one of the sensors associated with your YSI 556 MPS.

1. Follow the procedures outlined in Section *8.4 Upload to PC*.

21.3 Understanding the Calibration Record (.glp) File

1. Open a calibration record file. Refer to Section *8.3 View File*.

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

00008003.glp

m/d/y	hh:mm:ss	S/N
01/24/2001	08:17:51	00008003
01/24/2001	08:17:51	00008003
01/24/2001	08:17:51	00008003
01/24/2001	08:17:51	00008003
01/24/2001	08:17:51	00008003
01/24/2001	08:17:51	00008003
01/24/2001	08:17:51	00008003
01/24/2001	08:17:51	00008003
01/24/2001	08:25:40	00008003
01/24/2001	08:25:40	00008003

735.9mmHg

01/24/2001 08:39:53

Figure 21.1 Calibration Record Screen 1

00008003.glp

Type	Value
Conductivity gain	1.000000
DO gain	1.000000
pH gain (pH-7)*K/mV	-5.05833
pH offest (pH-7)*K	0.000000
ORP offset mV	0.000000
TDS constant	0.650000
Barometer offset PSI	0.000000
DO gain	1.110250
pH gain (pH-7)*K/mV	-5.05833
pH offest (pH-7)*K	-12.2899

735.9mmHg

01/24/2001 08:39:19

Figure 21.2 Calibration Record Screen 2

NOTE: Each sensor (not parameter) is characterized by either 1 line (Conductivity, Dissolved Oxygen, ORP, TDS, or Barometer (Optional)) or 2 lines (pH) of calibration documentation.

The left hand portion of each calibration entry shows the date and time that a calibration of a particular sensor was performed. In addition, each calibration entry is characterized by the instrument serial number, as defined by YSI. See Figure 21.1 Calibration Record Screen 1. The right hand portion shows the YSI designation of the calibration constants and their values after their calibration has been performed. A more detailed description of the calibration constants is provided below:

- **Conductivity Gain** – A relative number which describes the sensitivity of the sensor. Basically, the value represents the calculated cell constant divided by the typical value of the cell constant (5 cm^{-1}).

- **DO Gain** – A relative number which describes the sensitivity of the sensor. Basically, the value represents the sensor current at the time of calibration divided by the typical value of the sensor current (15 uA).

- **pH Gain** – A number which basically represents the sensitivity of the pH sensor. To remove the effect of temperature on the slope of the relationship of probe output in mv versus pH, the value of pH/mv is multiplied by the temperature in degrees Kelvin (K).

- **pH Offset** – A number which basically represents the offset (or intercept) of the relationship of probe output in mv versus pH, the value of pH is multiplied by the temperature in degrees Kelvin (K).

Anytime you perform a calibration, information concerning the calibration constants will be logged to the Calibration Record file (.glp file). However, if the **Delete All Files** command is used, Refer to Section *8.6 Delete All Files*, the Calibration Record file will also be lost. It is critical that this file should be uploaded to your PC prior to issuing a **Delete All Files** command. Refer to Section *8.4 Upload to PC*.

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655279Web
January 2004

Appendix D
Laboratory DoD ELAP Accreditation Certificates

CERTIFICATE OF ACCREDITATION

ANSI-ASQ National Accreditation Board/ACLASS
500 Montgomery Street, Suite 625, Alexandria, VA 22314, 877-344-3044

This is to certify that

TriMatrix Laboratories, Inc.
5560 Corporate Exchange Court, SE
Grand Rapids, MI 49512

has been assessed by ACLASS
and meets the requirements of

ISO/IEC 17025:2005 and DoD-ELAP

while demonstrating technical competence in the field(s) of

TESTING

Refer to the accompanying Scope(s) of Accreditation for information regarding the types of tests to which this accreditation applies.

ADE-1542
Certificate Number

ACLASS Approval

Certificate Valid: 4/30/2013-04/30/2015
Version No. 003 Issued: 05/30/2013

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated January 2009*).

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005 & DoD-ELAP

TriMatrix Laboratories, Inc

5560 Corporate Exchange Court, SE, Grand Rapids, MI 49512
Rick Wilburn Phone: 616-975-4500

TESTING

Valid to: April 30, 2015 Certificate Number: ADE - 1542

I. Environmental

MATRIX	SPECIFIC TEST or ANALYTE GROUP**	SPECIFICATION OR STANDARD METHOD (all EPA unless specified)	* KEY EQUIPMENT OR TECHNOLOGY
Water	Metals Digestion	200.2	Block Digestion
Water	Metals Digestion	3010A	Block Digestion
Water	Metals Digestion	3020A	Block Digestion
Solid	Metals Digestion	3050B	Block Digestion
Water	Metals	200.7 / 6010C	ICP
Water	Calcium Hardness (as $CaCO_3$)	SM 2340B	ICP
Solid	Metals	6010C	ICP
Water	Total Hardness (as $CaCO_3$)	SM 2340B	ICP
Water	Metals	200.8 / 6020A	ICP MS
Solid	Metals	6020A	ICP MS
Water	Mercury	245.1 / 7470A	CVAA
Solid	Mercury	7471B	CVAA

MATRIX	SPECIFIC TEST or ANALYTE GROUP**	SPECIFICATION OR STANDARD METHOD (all EPA unless specified)	* KEY EQUIPMENT OR TECHNOLOGY
Water	Mercury, Low-Level	1631E	CVAF
Water	1,2-Dibromo-3-Chloropropane & 1,2-Dibromoethane	8011	GC-ECD
Water / Solid	Carbonyl Compounds	8315A	HPLC-UV
Water / Solid	Nitroaromatics and Nitramines	8330A	HPLC-UV
Water / Solid	Nitroglycerine and PETN	8332	HPLC-UV
Water / Solid	Chlorinated Herbicides	8151A	GC-ECD
Water	Methoxychlor	608.2	GC-ECD
Water	Organochlorine Pesticides	608 / 8081B	GC-ECD
Solid	Organochlorine Pesticides	8081B	GC-ECD
Water	PCBs	608 / 8082A	GC-ECD
Solid	PCBs	8082A	GC-ECD
Water / Solid	Diesel Range Organics (DRO)	Wisconsin DRO / 8015C	GC-FID
Water / Solid	Oil Range Organics	8015C	GC-FID
Water	Dissolved Gas Analysis	RSK-175	GC-FID
Water / Solid	Nonhalogenated Organics	8015C	GC-FID
Water	Semivolatile Organic Compounds	625 / 8270C	GCMS
Solid	Semivolatile Organic Compounds	8270C	GCMS
Water / Solid	Semivolatile Organic Compounds	8270C SIM	GCMS

MATRIX	SPECIFIC TEST or ANALYTE GROUP**	SPECIFICATION OR STANDARD METHOD (all EPA unless specified)	* KEY EQUIPMENT OR TECHNOLOGY
Solid	Semivolatile Extraction	3545A	Pressurized Fluid Ext
Water	Semivolatile Extraction	3510C	Separatory Funnel Ext
Solid	Semivolatile Extraction	3550C	Ultrasonic Extraction
Water / Solid	Chlorinated Hydrocarbons	8121 / 612	GC-ECD
Water / Solid	Gasoline Range Organics (GRO)	Wisconsin GRO / 8015C	GC-FID
Solid	Volatile Organics	8021B	GC-PID; HECD
Water	Volatiles Organics	601 / 602 / 8021B	GC-PID; HECD
Water	Volatile Organics	524.2 / 624 / 8260B	GCMS
Solid	Volatile Organics	8260B	GCMS
Solid	Volatiles Extraction	5035A	Purge & Trap
Water	Volatiles Extraction	5030B	Purge & Trap/Water
Water / Solid	SPLP	1312	Acetic Acid Leaching
Water / Solid	TCLP	1311	Acetic Acid Leaching
Solid	Ignitability	1020A	Closed-Cup
Solid	Acid Volatile Sulfide and Selected Simultaneously Extractable Metals	821-R-91-100	Distillation/ Spectrophotometric
Solid	Paint Filter Test	9095B	Filtration
Water	HEM Oil and Grease / SGT-HEM Non-Polar Material	1664A / 9070A	Gravimetric

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MATRIX	SPECIFIC TEST or ANALYTE GROUP**	SPECIFICATION OR STANDARD METHOD (all EPA unless specified)	* KEY EQUIPMENT OR TECHNOLOGY
Solid	HEM Oil and Grease / SGT-HEM Non-Polar Material	9071B	Gravimetric
Water	Filterable Residue (TDS)	SM 2540C	Gravimetric
Water	Non-Filterable Residue (TSS)	SM 2540D	Gravimetric
Water	Total Residue / Solids (TS)	SM 2540B	Gravimetric
Solid	Total Residue / Solids (TS)	SM 3550C	Gravimetric
Water	Volatile Residue (VS)	SM 2540E	Gravimetric
Solid	Volatile Residue (VS)	SM 2540G	Gravimetric
Water	Settleable Residue / Solids	SM 2540 F	Imhoff cone
Water	Anions	300.0/9056A	Ion Chromatographic
Solid	Anions	9056A	Ion Chromatographic
Water	Bromide	ASTM D1246	ISE
Water / Solid	Fluoride	SM 4500-F C	ISE
Water	BOD and CBOD	SM 5210B	Luminescence
Water	Turbidity	SM 2130B	Nephelometric
Water	Color	SM 2120B	Platinum-Cobalt Color
Water	pH and Corrosivity	SM 4500-H^+ B / 9040C	Potentiometric
Solid	pH and Corrosivity	9045D	Potentiometric
Water	Conductivity	SM 2510B / 9050A	Specific Conductance

MATRIX	SPECIFIC TEST or ANALYTE GROUP**	SPECIFICATION OR STANDARD METHOD (all EPA unless specified)	* KEY EQUIPMENT OR TECHNOLOGY
Water / Solid	Ammonia-N	SM 4500-NH_3 B	Distillation
Water / Solid	Ammonia-N	SM 4500-NH_3 G	Spectrophotometric
Water	Chloride	SM 4500-Cl E / 9251	Spectrophotometric
Solid	Chromium (VI) Cr^{+6}	3060A	Digestion
Water	Chromium (VI) Cr^{+6}	SM 3500-Cr B / 7196A	Spectrophotometric
Solid	Chromium (VI) Cr^{+6}	7196A	Spectrophotometric
Water	COD	SM 5220D	Spectrophotometric
Water / Solid	Cyanide Available	OIA-1677	Amperometry
Solid	Cyanide	9010C	Distillation
Water	Cyanide	SM 4500-CN C / 9010C	Distillation
Solid	Cyanide Extraction	9013A	Extraction
Solid	Cyanide Amenable	9014	Spectrophotometric
Water	Cyanide Amenable	SM 4500-CN G / 9014	Spectrophotometric
Solid	Cyanide, Total	9014	Spectrophotometric
Water	Cyanide, Total	SM 4500-CN E / 9014	Spectrophotometric
Water	Ferrous Iron	SM 3500-Fe B	Spectrophotometric
Water / Solid	Nitrate-N	SM 4500-NO_3 F	Spectrophotometric
Water	Nitrate+Nitrite-N	SM 4500-NO_3 F	Spectrophotometric

MATRIX	SPECIFIC TEST or ANALYTE GROUP**	SPECIFICATION OR STANDARD METHOD (all EPA unless specified)	* KEY EQUIPMENT OR TECHNOLOGY
Water	Nitrite-N	SM 4500-NO_2 B / NO_3 F	Spectrophotometric
Water	o-Phosphate	SM 4500-P E	Spectrophotometric
Water / Solid	Phosphorus Total	SM 4500-P E	Spectrophotometric
Water	Silica as SiO_2	SM 4500-SiO_2 D	Spectrophotometric
Water	Surfactants (MBAS)	SM 5540C	Spectrophotometric
Water / Solid	TKN	SM 4500-N_{org} D	Spectrophotometric
Solid	Total Phenolics	9065	Spectrophotometric
Water	Total Phenolics	420.4 / 9065	Spectrophotometric
Water	Acidity	SM 2310B	Titrimetric
Water	Calcium Hardness (as $CaCO_3$)	SM 2340 C	Titrimetric
Water / Solid	Sulfide	9030B	Distillation
Water	Sulfide	SM 4500-S_2 D	Spectrophotometric
Water	Sulfide	SM 4500-S_2 F	Titrimetric
Water / Solid	Sulfide	9034	Titrimetric
Water / Solid	Reactive Sulfide	7.3.4.2	Titrimetric
Water	Sulfite	SM 4500-SO_3^{2-} B	Titrimetric
Water	Total Alkalinity (as $CaCO_3$)	SM 2320B	Titrimetric
Water	Total Hardness (as $CaCO_3$)	SM 2340C	Titrimetric

MATRIX	SPECIFIC TEST or ANALYTE GROUP**	SPECIFICATION OR STANDARD METHOD (all EPA unless specified)	* KEY EQUIPMENT OR TECHNOLOGY
Water	Sulfate	ASTM D516 / 9038	Turbidimetric
Solid	Total Organic Carbon (TOC)	Lloyd Kahn	Infrared
Water	Total Organic Carbon (TOC)	SM 5310C / 9060A	Oxidation/CO_2 Det
Solid	Total Organic Carbon (TOC)	WALKLEY BLACK	Titrimetric
Solid	Extractable Organic Halides	9023	Coulometric Titration
Water	Dissolved Organic Carbon	SM 5310C	Titrimetric
Solid	Fractional Organic Carbon	ASTM D2974	Gravimetric
Solid	Grain Size	ASTM D422	Size Exclusion
Water	Total Organic Halides (TOX)	9020B	Coulometric Titration
Solid	% Moisture in Soil and Rock	ASTM D2216	Gravimetric
Solid	Shake Extraction	ASTM D3987	Water Leaching

II. Microbiological

MATRIX	SPECIFIC TEST or ANALYTE GROUP**	SPECIFICATION OR STANDARD METHOD (all EPA unless specified)	* KEY EQUIPMENT OR TECHNOLOGY
Water	Fecal Coliform	SM 9222D	Microbiological
Water	Heterotrophic Bacteria (Std Plate)	SM 9215B	Microbiological
Water	Total Coliform / *E. coli*	SM 9223B	Microbiological

Notes:

1. ** = As Applicable*
2. *** = Refer to Accredited Analyte Listing for specific analytes in which the laboratory is accredited.*
3. *This scope is part of and must be included with the Certificate of Accreditation No. ADE-1542*

Vice President

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Accredited Analytes/Methods (by matrix)

TriMatrix Laboratoires, Inc.

Grand Rapids, MI

Analyte	Matrix								
	Aqueous						Solid		
Trace Metals									
Aluminum	200.7	200.8	6010C	6020A			6010C		
Antimony	200.7	200.8	6010C	6020A			6010C	6020A	
Arsenic	200.7	200.8	6010C	6020A			6010C	6020A	
Barium	200.7	200.8	6010C	6020A			6010C	6020A	
Beryllium	200.7	200.8	6010C	6020A			6010C	6020A	
Boron	200.7	200.8	6010C	6020A			6010C	6020A	
Cadmium	200.7	200.8	6010C	6020A			6010C	6020A	
Calcium	200.7		6010C				6010C		
Chromium, total	200.7	200.8	6010C	6020A			6010C	6020A	
Chromium VI	SM3500Cr B				7196A				7196A
Cobalt	200.7	200.8	6010C	6020A			6010C	6020A	
Copper	200.7	200.8	6010C	6020A			6010C	6020A	
Iron	200.7		6010C				6010C		
Lead	200.7	200.8	6010C	6020A			6010C	6020A	
Lithium	200.7		6010C				6010C		
Magnesium	200.7		6010C				6010C		
Manganese	200.7	200.8	6010C	6020A			6010C	6020A	
Mercury	245.1				7470A				7471B
Mercury (Low Level)					1631E				
Molybdenum	200.7	200.8	6010C	6020A			6010C	6020A	
Nickel	200.7	200.8	6010C	6020A			6010C	6020A	
Potassium	200.7		6010C				6010C		
Selenium	200.7	200.8	6010C	6020A			6010C	6020A	
Silver	200.7	200.8	6010C	6020A			6010C	6020A	
Sodium	200.7		6010C				6010C		
Strontium	200.7	200.8	6010C	6020A			6010C		
Thallium	200.7	200.8	6010C	6020A			6010C	6020A	
Tin	200.7	200.8	6010C	6020A			6010C	6020A	
Titanium	200.7		6010C				6010C		
Vanadium	200.7	200.8	6010C	6020A			6010C	6020A	
Zinc	200.7	200.8	6010C	6020A			6010C	6020A	
Demands									
TOC	SM5310C	9060A					Walkley Black	Lloyd Kahn	
COD			SM5220D						
DOC-Dissolved Organic Carbon							SM5310C		

Accredited Analytes/Methods (by matrix)

TriMatrix Laboratoires, Inc.

Grand Rapids, MI

Analyte	Matrix								
	Aqueous						Solid		
BOD and CBOD	SM5210B								
Misc Analytes									
Total Alkalinity (as $CaCO_3$)	SM2320B								
Calcium Hardness as $CaCO_3$	SM2340B								
Total Hardness as $CaCO_3$	SM2340B	SM2340C							
% Moisture in Soil and Rock							ASTM D2216		
Total Residue/Solids (TS)	SM2540B						3550C		
Filterable Residue (TDS)		SM2540C							
Ignitability							1020A		
Non-Filterable Residue (TSS)	SM2540D								
Volatile Residue (VS)		SM2540E					SM2540G		
Settleable Residue	SM2540F								
pH			9040C	SM4500H^+ B			9045D		
Sulfide	SM4500S^{2-} D	SM4500S^{2-} F	9034				9034		
Total Cyanide	SM4500CN E	9014					9014		
Cyanide, Amenable	SM4500CN G	9014					9014		
Ammonia	SM4500NH_3 G						SM4500NH_3 G		
Conductivity	SM2510B	9050A							
Nitrogen, Total Kjeldahl (TKN)	SM4500N_{org} D						SM4500N_{org} D		
Total Phenolics	420.4	9065					9065		
Total Organic Halides (TOX)	9020B								
Bromide	ASTM D1246		300.0	9056A					
Chloride	SM4500Cl E	9251	300.0	9056A			9056A		
Fluoride	SM4500F C		300.0	9056A			9056A		
Nitrate as N	SM4500NO_3 F		300.0	9056A			9056A	SM4500NO_3 F	
Nitrite as N	SM4500NO_2 B	SM4500NO_3 F	300.0	9056A			9056A		
Nitrate + Nitrite as N	SM4500NO_3 F		300.0	9056A			9056A		
ortho-phosphate	SM4500P E								
Total Phosphorus	SM4500P E						SM4500P E		
Silica as SiO_2	SM4500SiO_2 D								
Sulfate	ASTM D516	9038	300.0	9056A			9056A		
Surfactants - MBAS	SM5540C								
Fecal Coliform	SM9222D								
Heterotrophic Bacteria (Std Plate)	SM9215B								
Total Coliform, E. Coli	SM9223B								

Accredited Analytes/Methods (by matrix)

TriMatrix Laboratoires, Inc.

Grand Rapids, MI

Analyte	Matrix								
	Aqueous						Solid		
Turbidity		SM2130B							
EOX-Extractable Organic Halides							9023		
FOC-Fractional Organic Carbon							ASTM D2974		
Petroleum Hydrocarbons									
SGT-HEM; Non-Polar Material	1664A	9070A					9071B		
HEM; Oil and Grease	1664A	9070A					9071B		
Gasoline Range Organics (GRO)	8015C	Wisconsin GRO					8015C	Wisconsin GRO	
Diesel Range Organics (DRO)	8015C	Wisconsin DRO					8015C	Wisconsin DRO	
Oil Range Organics (ORO)	8015C						8015C		
VOCs									
Acetone		624	8260B					8260B	
Acetonitrile		624	8260B					8260B	
Acrolein		624	8260B					8260B	
Acrylonitrile		624	8260B					8260B	
Benzene	524.2	624	8260B		602	8021B	8021B	8260B	
Bromobenzene	524.2		8260B					8260B	
Bromochloromethane	524.2		8260B					8260B	
Bromodichloromethane	524.2	624	8260B	601		8021B	8021B	8260B	
Bromoform	524.2	624	8260B	601		8021B	8021B	8260B	
Bromomethane	524.2	624	8260B	601		8021B	8021B	8260B	
2-Butanone (MEK)		624	8260B					8260B	
n-Butylbenzene	524.2		8260B					8260B	
sec-Butylbenzene	524.2		8260B					8260B	
tert-Butylbenzene	524.2		8260B					8260B	
Carbon disulfide		624	8260B					8260B	
Carbon Tetrachloride	524.2	624	8260B	601		8021B	8021B	8260B	
Chlorobenzene	524.2	624	8260B	601	602	8021B	8021B	8260B	
Chlorodibromomethane	524.2	624	8260B	601		8021B	8021B	8260B	
Chloroethane	524.2	624	8260B	601		8021B	8021B	8260B	
2-Chloroethylvinylether		624	8260B	601		8021B	8021B	8260B	
Chloroform	524.2	624	8260B	601		8021B	8021B	8260B	
Chloromethane	524.2	624	8260B	601		8021B	8021B	8260B	
2-Chlorotoluene	524.2		8260B					8260B	
4-Chlorotoluene	524.2		8260B					8260B	
1,2-Dibromo-3-chloropropane (DBCP)		624	8260B					8260B	

Accredited Analytes/Methods (by matrix)

TriMatrix Laboratoires, Inc.

Grand Rapids, MI

Analyte	Matrix								
	Aqueous						Solid		
1,2-Dibromoethane (EDB)		624	8260B					8260B	
Dibromomethane	524.2	624	8260B					8260B	
1,2-Dichlorobenzene	524.2	624	8260B	601	602	8021B	8021B	8260B	
1,3-Dichlorobenzene	524.2	624	8260B	601	602	8021B	8021B	8260B	
1,4-Dichlorobenzene	524.2	624	8260B	601	602	8021B	8021B	8260B	
Dichlorodifluoromethane	524.2	624	8260B	601		8021B	8021B	8260B	
1,1-Dichloroethane	524.2	624	8260B	601		8021B	8021B	8260B	
1,2-Dichloroethane	524.2	624	8260B	601		8021B	8021B	8260B	
1,1-Dichloroethene	524.2	624	8260B	601		8021B	8021B	8260B	
cis -1,2-Dichloroethene	524.2	624	8260B	601		8021B	8021B	8260B	
trans -1,2-Dichloroethene	524.2	624	8260B	601		8021B	8021B	8260B	
Dichloromethane (Methylene Chloride)	524.2	624	8260B	601		8021B	8021B	8260B	
1,2-Dichloropropane	524.2	624	8260B	601		8021B	8021B	8260B	
1,3-Dichloropropane	524.2		8260B					8260B	
2,2-Dichloropropane	524.2		8260B					8260B	
1,1-Dichloropropene	524.2		8260B					8260B	
cis -1,3-Dichloropropene	524.2	624	8260B	601		8021B	8021B	8260B	
trans -1,3-Dichloropropene	524.2	624	8260B	601		8021B	8021B	8260B	
Di-isopropylether (DIPE)			8260B					8260B	
Ethylbenzene	524.2	624	8260B		602	8021B	8021B	8260B	
Ethanol			8260B			8015C	8015C	8260B	
1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113)			8260B					8260B	
Hexachlorobutadiene	524.2	624	8260B					8260B	
2-Hexanone		624	8260B					8260B	
Isopropylbenzene	524.2	624	8260B					8260B	
4-Isopropyltoluene	524.2		8260B					8260B	
4-Methyl-2-pentanone (MIBK)		624	8260B					8260B	
Methyl-tert-butylether (MTBE)	524.2	624	8260B					8260B	
Naphthalene	524.2	624	8260B					8260B	
n-Propylbenzene	524.2		8260B					8260B	
Styrene	524.2	624	8260B					8260B	
tert-amylmethylether (TAME)			8260B					8260B	
1,1,1,2-Tetrachloroethane	524.2	624	8260B					8260B	
1,1,2,2-Tetrachloroethane	524.2	624	8260B	601		8021B	8021B	8260B	
Tetrachloroethene	524.2	624	8260B	601		8021B	8021B	8260B	
Toluene	524.2	624	8260B		602	8021B	8021B	8260B	
1,2,3-Trichlorobenzene	524.2		8260B					8260B	

Accredited Analytes/Methods (by matrix)

TriMatrix Laboratoires, Inc.

Grand Rapids, MI

Analyte	Matrix								
	Aqueous						Solid		
1,2,4-Trichlorobenzene	524.2	624	8260B					8260B	
1,1,1-Trichloroethane	524.2	624	8260B	601		8021B	8021B	8260B	
1,1,2-Trichloroethane	524.2	624	8260B	601		8021B	8021B	8260B	
Trichloroethene	524.2	624	8260B	601		8021B	8021B	8260B	
Trichlorofluoromethane (Freon 11)	524.2	624	8260B	601		8021B	8021B	8260B	
1,2,3-Trichloropropane	524.2	624	8260B					8260B	
1,2,4-Trimethylbenzene	524.2		8260B					8260B	
1,3,5-Trimethylbenzene	524.2		8260B					8260B	
Vinyl acetate		624	8260B					8260B	
Vinyl chloride	524.2	624	8260B	601		8021B	8021B	8260B	
o-Xylene		624	8260B		602			8260B	
m+p-Xylene		624	8260B		602			8260B	
Xylenes, total	524.2	624	8260B		602	8021B	8021B	8260B	
SVOCs - Base/Neutrals/Acids									
Acenaphthene	8270C SIM	625	8270C				8270C	8270C SIM	
Acenaphthylene	8270C SiM	625	8270C				8270C	8270C SIM	
Aniline		625	8270C				8270C		
Anthracene	8270C SIM	625	8270C				8270C	8270C SIM	
Benzo(a)anthracene	8270C SIM	625	8270C				8270C	8270C SIM	
Benzo(b)fluoranthene	8270C SIM	625	8270C				8270C	8270C SIM	
Benzo(k)fluoranthene	8270C SIM	625	8270C				8270C	8270C SIM	
Benzo(g,h,i)perylene	8270C SIM	625	8270C				8270C	8270C SIM	
Benzo(a)pyrene	8270C SIM	625	8270C				8270C	8270C SIM	
Benzidine		625	8270C				8270C		
Benzoic acid		625	8270C				8270C		
Benzyl alcohol		625	8270C				8270C		
4-Bromophenyl-phenylether		625	8270C				8270C		
Butyl benzyl phthalate		625	8270C				8270C		
Carbazole			8270C				8270C		
4-Chloroaniline		625	8270C				8270C		
bis(2-Chloroethoxy)methane		625	8270C				8270C		
bis(2-Chloroethyl)ether		625	8270C				8270C		
bis(2-Chloroiospropyl) ether		625	8270C				8270C		
4-Chloro-3-methylphenol		625	8270C				8270C		
2-Chloronaphthalene		625	8270C	612		8121	8270C	8121	
4-Chlorophenyl-phenylether		625	8270C				8270C		

Accredited Analytes/Methods (by matrix)

TriMatrix Laboratoires, Inc.

Grand Rapids, MI

Analyte	Matrix								
	Aqueous						Solid		
2-Chlorophenol		625	8270C				8270C		
Chrysene	8270C SIM	625	8270C				8270C	8270C SIM	
Dibenzo(a,h)anthracene	8270C SIM	625	8270C				8270C	8270C SIM	
Dibenzofuran		625	8270C				8270C		
Di-n-butylphthalate		625	8270C				8270C		
1,2-Dichlorobenzene		625	8270C	612		8121	8270C	8121	
1,3-Dichlorobenzene		625	8270C	612		8121	8270C	8121	
1,4-Dichlorobenzene		625	8270C	612		8121	8270C	8121	
3,3'-Dichlorobenzidine		625	8270C				8270C		
2,4-Dichlorophenol		625	8270C				8270C		
2,6-Dichlorophenol		625	8270C				8270C		
Diethyl phthalate		625	8270C				8270C		
2,4-Dimethylphenol		625	8270C				8270C		
Dimethylphthalate		625	8270C				8270C		
Diphenylamine			8270C				8270C		
2,4-Dinitrophenol		625	8270C				8270C		
2,4-Dinitrotoluene		625	8270C				8270C		
2,6-Dinitrotoluene		625	8270C				8270C		
Di-n-octylphthalate		625	8270C				8270C		
Dinoseb			8270C				8270C		
1,4-Dioxane			8270C						
bis(2-ethylhexyl) phthalate		625	8270C				8270C		
Fluoranthene	8270C SIM	625	8270C				8270C	8270C SIM	
Fluorene	8270C SIM	625	8270C				8270C	8270C SIM	
Hexachlorobenzene		625	8270C	612		8121	8270C	8121	
Hexachlorobutadiene		625	8270C	612		8121	8270C	8121	
Hexachlorocyclopentadiene		625	8270C	612		8121	8270C	8121	
Hexachloroethane		625	8270C	612		8121	8270C	8121	
Indeno(1,2,3, cd)pyrene	8270C SIM	625	8270C				8270C	8270C SIM	
Isophorone		625	8270C				8270C		
2-Methyl-4,6-Dinitrophenol		625	8270C				8270C		
2-Methylphenol		625	8270C				8270C		
4-Methylphenol (and/or 3-Methylphenol)		625	8270C				8270C		
2-Methylnaphthalene	8270C SIM	625	8270C				8270C	8270C SIM	
Naphthalene	8270C SIM	625	8270C				8270C	8270C SIM	
2-Nitroaniline		625	8270C				8270C		
3-Nitroaniline		625	8270C				8270C		

Accredited Analytes/Methods (by matrix)

TriMatrix Laboratoires, Inc.

Grand Rapids, MI

Analyte	Matrix								
	Aqueous						Solid		
4-Nitroaniline		625	8270C				8270C		
Nitrobenzene		625	8270C				8270C		
2-Nitrophenol		625	8270C				8270C		
4-Nitrophenol		625	8270C				8270C		
4-nitroquinoline-1-oxide			8270C				8270C		
N-Nitrosodiethylamine		625	8270C				8270C		
N-Nitrosodimethylamine		625	8270C				8270C		
N-Nitrosodiphenylamine		625	8270C				8270C		
N-Nitroso-di-n-propylamine		625	8270C				8270C		
Pentachlorobenzene		625	8270C				8270C		
Pentachlorophenol		625	8270C				8270C		
Phenanthrene	8270C SIM	625	8270C				8270C	8270C SIM	
Phenol		625	8270C				8270C		
Pyrene	8270C SIM	625	8270C				8270C	8270C SIM	
Pyridine		625	8270C				8270C		
1,2,4,5-Tetrachlorobenzene		625	8270C				8270C		
2,3,4,6-Tetrachlorophenol		625	8270C				8270C		
o-Toluidine		625	8270C				8270C		
1,2,4-Trichlorobenzene		625	8270C	612		8121	8270C	8121	
2,4,5-Trichlorophenol		625	8270C				8270C		
2,4,6-Trichlorophenol		625	8270C				8270C		
Nitroaromatic and Nitramines									
4-Amino-2,6-dinitrotoluene	8330A						8330A		
2-Amino-4,6-dinitrotoluene	8330A						8330A		
1,3-Dinitrobenzene	8330A						8330A		
2,4-Dinitrotoluene	8330A						8330A		
2,6-Dinitrotoluene	8330A						8330A		
HMX (Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine)	8330A						8330A		
Nitrobenzene	8330A						8330A		
Nitroglycerin	8330A	8332					8330A	8332	
2-Nitrotoluene	8330A						8330A		
3-Nitrotoluene	8330A						8330A		
4-Nitrotoluene	8330A						8330A		
Pentaerythritoltetranitrate	8330A	8332					8330A	8332	
RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine)	8330A						8330A		
Tetryl (methyl-2,4,6-trinitrophenylnitramine)	8330A						8330A		

Accredited Analytes/Methods (by matrix)

TriMatrix Laboratoires, Inc.

Grand Rapids, MI

Analyte	Matrix								
	Aqueous						Solid		
1,3,5-Trinitrobenzene	8330A						8330A		
2,4,6-Trinitrotoluene	8330A						8330A		
Pesticides									
Aldrin	608	8081B					8081B		
alpha-BHC	608	8081B					8081B		
beta-BHC	608	8081B					8081B		
delta-BHC	608	8081B					8081B		
gamma-BHC (Lindane)	608	8081B					8081B		
alpha-Chlordane	608	8081B					8081B		
gamma-Chlordane	608	8081B					8081B		
Chlordane (technical)	608	8081B					8081B		
DDD (4,4)	608	8081B					8081B		
DDE (4,4)	608	8081B					8081B		
DDT (4,4)	608	8081B					8081B		
Dieldrin	608	8081B					8081B		
Endosulfan I	608	8081B					8081B		
Endosulfan II	608	8081B					8081B		
Endosulfan sulfate	608	8081B					8081B		
Endrin	608	8081B					8081B		
Endrin aldehyde	608	8081B					8081B		
Endrin ketone	608	8081B					8081B		
Heptachlor	608	8081B					8081B		
Heptachlor Epoxide (beta)	608	8081B					8081B		
Methoxychlor	608.2	8081B					8081B		
Toxaphene (total)	608	8081B					8081B		
Organophoshorus Pesticides									
Dimethoate		8270C					8270C		
Dichlorvos		8270C					8270C		
Disulfoton		8270C					8270C		
Parathion, ethyl		8270C					8270C		
Parathion, methyl		8270C					8270C		
Phorate		8270C					8270C		
Sulfotepp		8270C					8270C		
Herbicides									

Accredited Analytes/Methods (by matrix)

TriMatrix Laboratoires, Inc.

Grand Rapids, MI

Analyte	Matrix								
	Aqueous						Solid		
2,4,5-T	8151A						8151A		
2,4,5-TP (Silvex)	8151A						8151A		
2,4-D	8151A						8151A		
2,4-DB	8151A						8151A		
Dalapon	8151A						8151A		
Dicamba	8151A						8151A		
Dichloroprop	8151A						8151A		
Dinoseb	8151A						8151A		
MCPA	8151A						8151A		
MCPP	8151A						8151A		
Pentachlorophenol	8151A						8151A		
Picloram	8151A						8151A		
PCBs									
Aroclor 1016	608	8082A					8082A		
Aroclor 1221	608	8082A					8082A		
Aroclor 1232	608	8082A					8082A		
Aroclor 1242	608	8082A					8082A		
Aroclor 1248	608	8082A					8082A		
Aroclor 1254	608	8082A					8082A		
Aroclor 1260	608	8082A					8082A		
Misc. Analytes -Additional									
Iron, Ferrous	SM 3500Fe B								
Cyanide, Available	OIA-1677						OIA-1677		
Acidity	SM 2310 B								
Sulfite	SM 4500SO_3^{2-} B								
Paint Filter Liquids Test							9095B		
Color	SM 2120 B								
Acid Volatile Sulfides (AVS/SEM)							EPA-821-R-91-100		
Grain Size							ASTM D422-63		
Reactive Sulfide	7.3.4.2						7.4.3.2		
PCBs - Additional Aroclors									
Aroclor 1262	608	8082A					8082A		
Aroclor 1268	608	8082A					8082A		

Accredited Analytes/Methods (by matrix)

TriMatrix Laboratoires, Inc.

Grand Rapids, MI

Analyte	Matrix								
	Aqueous						Solid		
Misc. Organics									
Ethane	RSK-175								
Ethylene	RSK-175								
Methane	RSK-175								
Additional Compounds									
Volatiles									
1,2-dibromo-3-chloropropane	8011								
1,2-dibromoethane	8011								
1,2,3-Trimethylbenzene			8260B					8260B	
1,4-dioxane			8260B					8260B	
1-chlorohexane			8260B					8260B	
sec-butanol		8015C	8260B				8015C	8260B	
2-chloro-1,3-butadiene (Chloroprene)			8260B					8260B	
2-methylnaphthalene			8260B					8260B	
2-nitropropane			8260B					8260B	
allyl chloride			8260B					8260B	
cyclohexane			8260B					8260B	
ETBE			8260B					8260B	
ethanol		8015C					8015C		
ethyl acetate			8260B					8260B	
ethyl ether			8260B					8260B	
ethyl methacrylate			8260B					8260B	
hexachloroethane			8260B					8260B	
hexane			8260B					8260B	
iodomethane			8260B					8260B	
isobutanol		8015C	8260B				8015C	8260B	
isopropanol		8015C	8260B				8015C	8260B	
methacrylonitrile			8260B					8260B	
methanol		8015C					8015C		
methyl acetate			8260B					8260B	
methyl methacrylate			8260B					8260B	
methylcyclohexane			8260B					8260B	
n-butanol		8015C	8260B				8015C	8260B	
n-butyl acetate			8260B					8260B	
n-propanol		8015C	8260B				8015C	8260B	

Accredited Analytes/Methods (by matrix)

TriMatrix Laboratoires, Inc.

Grand Rapids, MI

Analyte	Matrix								
	Aqueous						Solid		
propionitrile			8260B					8260B	
t-butanol		8015C	8260B				8015C	8260B	
tetrahydrofuran			8260B					8260B	
trans -1,4,dichloro-2-butene			8260B					8260B	
trichlorotrifluoromethane			8260B					8260B	
SVOCs - Base/Neutrals/Acids									
1,1'-Biphenyl			8270C				8270C		
1,2-Bis(2-chloroethoxy)ethane			8270C				8270C		
1,2-Diphenylhydrazine			8270C				8270C		
1,3 Dinitrobenzene			8270C				8270C		
1,4-Naphthoquinone			8270C				8270C		
1,4-Phenylenediamine			8270C				8270C		
1-Methylnaphthalene			8270C				8270C		
1-Naphthylamine			8270C				8270C		
1-Nitrosopyrrolidine			8270C				8270C		
2-Acetylaminofluorene			8270C				8270C		
2-Chloroaniline			8270C				8270C		
2-Naphthylamine			8270C				8270C		
2-Picoline			8270C				8270C		
3,3'-Dimethylbenzidine			8270C				8270C		
3-Methylchloanthrene			8270C				8270C		
4-Aminobiphenyl			8270C				8270C		
5-Nitro-o-toluidine			8270C				8270C		
7,12-Dimethylbenz(a)anthracene			8270C				8270C		
a,a-Dimethylphenethylamine			8270C				8270C		
Acetophenone			8270C				8270C		
Aramite			8270C				8270C		
Atrazine			8270C				8270C		
Benzaldehyde			8270C				8270C		
Bis(2-ethylhexyl) adipate			8270C				8270C		
Caprolactam			8270C				8270C		
Chlorobenzilate			8270C				8270C		
Diallate			8270C				8270C		
Dicyclohexyl Phthalate			8270C				8270C		
Ethyl Methacrylate			8270C				8270C		
Ethyl Methansulfonate			8270C				8270C		

Accredited Analytes/Methods (by matrix)

TriMatrix Laboratoires, Inc.

Grand Rapids, MI

Analyte	Matrix								
	Aqueous						Solid		
Famphur			8270C				8270C		
Hexachlorophene			8270C				8270C		
Hexachloropropene			8270C				8270C		
Isodrin			8270C				8270C		
Isosafrole			8270C				8270C		
Kepone			8270C				8270C		
Methapyrilene			8270C				8270C		
Methyl Methacrylate			8270C				8270C		
Methyl Methanesulfonate			8270C				8270C		
N-Nitroso-di-n-butylamine			8270C				8270C		
N-Nitrosomethylethylamine			8270C				8270C		
N-Nitrosomorpholine			8270C				8270C		
N-Nitrosopiperidine			8270C				8270C		
o,o,o-Triethylphosphorothioate			8270C				8270C		
p-Dimethylaminoazobenzene			8270C				8270C		
Phenacetin			8270C				8270C		
Pentachloroethane			8270C				8270C		
Pentachloronitrobenzene			8270C				8270C		
Pronamide			8270C				8270C		
Safrole			8270C				8270C		
Thionazin			8270C				8270C		
1,3,5-Trinitrobenzene			8270C				8270C		
Carbonyls									
Formaldehyde	8315A						8315A		
Acetaldehyde	8315A						8315A		
Propanal	8315A						8315A		
Crotonaldehyde	8315A						8315A		
Butanal	8315A						8315A		
Pentanal	8315A						8315A		
Cyclohexanone	8315A						8315A		
m-Tolualdehyde	8315A						8315A		
Hexanal	8315A						8315A		
Heptanal	8315A						8315A		
Octanal	8315A						8315A		
Nonanal	8315A						8315A		
Decanal	8315A						8315A		

PERRY JOHNSON LABORATORY ACCREDITATION, INC.

Certificate of Accreditation

Perry Johnson Laboratory Accreditation, Inc. has assessed the Laboratory of:

Columbia Analytical Services

1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14623

(Hereinafter called the Organization) and hereby declares that Organization has met the requirements of ISO/IEC 17025:2005 "General Requirements for the competence of Testing and Calibration Laboratories" and the DoD Quality Systems Manual for Environmental Laboratories Version 4.1 4/22/2009 and is accredited is accordance with the:

United States Department of Defense
Environmental Laboratory Accreditation Program
(DoD-ELAP)

This accreditation demonstrates technical competence for the defined scope:

Environmental Testing

(As detailed in the supplement)

Accreditation claims for such testing and/or calibration services shall only be made from addresses referenced within this certificate. This Accreditation is granted subject to the system rules governing the Accreditation referred to above, and the Organization hereby covenants with the Accreditation body's duty to observe and comply with the said rules.

For PJLA:

Initial Accreditation Date:	*Issue Date:*	*Accreditation No.:*	*Certificate No.:*
January 22, 2010	April 7, 2012	65817	L12-48

Tracy Szerszen
President/Operations Manager

Perry Johnson Laboratory
Accreditation, Inc. (PJLA)
755 W. Big Beaver, Suite 1325
Troy, Michigan 48084

The validity of this certificate is maintained through ongoing assessments based on a continuous accreditation cycle. The validity of this certificate should be confirmed through the PJLA website: www.pjlabs.com

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Columbia Analytical Services

1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14609
Lisa Reyes Phone: 585-288-5380

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous	(CAS SOP) GEN-TICW	UV-VIS	Total inorganic carbon
Aqueous	EPA 1631	CVAFS	Mercury
Aqueous	EPA 1664A	Gravimetric	Oil and grease
Aqueous	EPA 1664A	Gravimetric	Total petroleum hydrocarbons
Aqueous	EPA 218.6	IC-UV	Chromium, Hexavalent
Aqueous	EPA 245.1	CVAA	Mercury
Aqueous	EPA 300.0	IC	Chloride
Aqueous	EPA 300.0	IC	Fluoride
Aqueous	EPA 300.0	IC	Nitrate
Aqueous	EPA 300.0	IC	Sulfate
Aqueous	EPA 351.2	UV-VIS	Nitrogen, total Kjeldahl
Aqueous	EPA 353.2	UV-VIS	Nitrite as N
Aqueous	EPA 410.4	UV-VIS	Chemical oxygen demand
Aqueous	EPA 7470A	CVAA	Mercury
Aqueous	EPA 8151A	GC-ECD	Dinoseb
Aqueous	EPA 8260C	GC-MS-SIM	1,1-Dichloroethene
Aqueous	EPA 8260C	GC-MS-SIM	1,2-Dichlorobenzene
Aqueous	EPA 8260C	GC-MS-SIM	1,2-Dichloroethane
Aqueous	EPA 8260C	GC-MS-SIM	1,4-Dioxane
Aqueous	EPA 8260C	GC-MS-SIM	Carbon tetrachloride
Aqueous	EPA 8260C	GC-MS-SIM	Dichloromethane
Aqueous	EPA 8260C	GC-MS-SIM	Ethylbenzene
Aqueous	EPA 8260C	GC-MS-SIM	m- + p-Xylene
Aqueous	EPA 8260C	GC-MS-SIM	o-Xylene
Aqueous	EPA 8260C	GC-MS-SIM	Tetrachloroethene
Aqueous	EPA 8260C	GC-MS-SIM	Trichloroethene
Aqueous	EPA 8260C	GC-MS-SIM	Vinyl chloride
Aqueous	EPA 8260C	GC-MS-SIM	Xylenes, total
Aqueous	EPA 8310	HPLC-UV/FLUOR	Acenaphthene
Aqueous	EPA 8310	HPLC-UV/FLUOR	Acenaphthylene
Aqueous	EPA 8310	HPLC-UV/FLUOR	Anthracene
Aqueous	EPA 8310	HPLC-UV/FLUOR	Benzo(a)antracene
Aqueous	EPA 8310	HPLC-UV/FLUOR	Benzo(a)pyrene

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Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous	EPA 8310	HPLC-UV/FLUOR	Benzo(b)fluoranthene
Aqueous	EPA 8310	HPLC-UV/FLUOR	Benzo(g,h,i)perylene
Aqueous	EPA 8310	HPLC-UV/FLUOR	Benzo(k)fluoranthene
Aqueous	EPA 8310	HPLC-UV/FLUOR	Chrysene
Aqueous	EPA 8310	HPLC-UV/FLUOR	Dibenzo(a,h)anthracene
Aqueous	EPA 8310	HPLC-UV/FLUOR	Fluoranthene
Aqueous	EPA 8310	HPLC-UV/FLUOR	Fluorene
Aqueous	EPA 8310	HPLC-UV/FLUOR	Indeno(1,2,3-cd)pyrene
Aqueous	EPA 8310	HPLC-UV/FLUOR	Naphthalene
Aqueous	EPA 8310	HPLC-UV/FLUOR	Phenanthrene
Aqueous	EPA 8310	HPLC-UV/FLUOR	Pyrene
Aqueous	EPA 9040B, C	POT	pH
Aqueous	EPA 9060, A	UV-VIS	Total organic carbon
Aqueous	EPA 9066	UV-VIS	Phenolics, total
Aqueous	RSK-175	GC-FID	Ethane
Aqueous	RSK-175	GC-FID	Ethylene
Aqueous	RSK-175	GC-FID	Methane
Aqueous	RSK-175	GC-FID	Propane
Aqueous	RSK-175	GC-FID	Acetylene
Aqueous	SM 2320B	Titration	Alkalinity, total, carbonate, and bicarbonate
Aqueous	SM 2340C	Titration	Hardness, total
Solids	(CAS SOP) GEN-351.2	UV-VIS	Nitrogen, total Kjeldahl
Solids	(CAS SOP) GEN-420.4/9066	UV-VIS	Phenolics, total
Solids	EPA Lloyd Kahn	UV-VIS	Total organic carbon
Solids	EPA 300.0	IC	Chloride
Solids	EPA 300.0	IC	Fluoride
Solids	EPA 300.0	IC	Nitrate
Solids	EPA 300.0	IC	Sulfate
Solids	EPA 7471B	CVAA	Mercury
Solids	EPA 8330A	HPLC-UV	1,3,5-Trinitrobenzene
Solids	EPA 8330A	HPLC-UV	1,3-Dinitrobenzene
Solids	EPA 8330A	HPLC-UV	2,4,6-Trinitrotoluene
Solids	EPA 8330A	HPLC-UV	2,4-Dinitrotoluene

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Matrix	Standard/Method	Technology	Analyte
Solids	EPA 8330A	HPLC-UV	2,6-Dinitrotoluene
Solids	EPA 8330A	HPLC-UV	2-Amino-4,6-dinitrotoluene
Solids	EPA 8330A	HPLC-UV	2-Nitrotoluene
Solids	EPA 8330A	HPLC-UV	3-Nitrotoluene
Solids	EPA 8330A	HPLC-UV	4-Amino-2,6-dinitrotoluene
Solids	EPA 8330A	HPLC-UV	4-Nitrotoluene
Solids	EPA 8330A	HPLC-UV	HMX
Solids	EPA 8330A	HPLC-UV	Nitrobenzene
Solids	EPA 8330A	HPLC-UV	RDX
Solids	EPA 8330A	HPLC-UV	Tetryl
Solids	EPA 9045C, D	POT	pH
Solids	SM 5220B	Titration	Chemical oxygen demand
Aqueous/Solids	EPA 1010A	Pensky Martin	Ignitability
Aqueous/Solids	EPA 353.2	UV-VIS	Nitrate/nitrite as N
Aqueous/Solids	EPA 6010C	ICP-AES	Aluminum
Aqueous/Solids	EPA 6010C	ICP-AES	Antimony
Aqueous/Solids	EPA 6010C	ICP-AES	Arsenic
Aqueous/Solids	EPA 6010C	ICP-AES	Barium
Aqueous/Solids	EPA 6010C	ICP-AES	Beryllium
Aqueous/Solids	EPA 6010C	ICP-AES	Boron
Aqueous/Solids	EPA 6010C	ICP-AES	Cadmium
Aqueous/Solids	EPA 6010C	ICP-AES	Calcium
Aqueous/Solids	EPA 6010C	ICP-AES	Chromium
Aqueous/Solids	EPA 6010C	ICP-AES	Cobalt
Aqueous/Solids	EPA 6010C	ICP-AES	Copper
Aqueous/Solids	EPA 6010C	ICP-AES	Iron
Aqueous/Solids	EPA 6010C	ICP-AES	Lead
Aqueous/Solids	EPA 6010C	ICP-AES	Magnesium
Aqueous/Solids	EPA 6010C	ICP-AES	Manganese
Aqueous/Solids	EPA 6010C	ICP-AES	Nickel
Aqueous/Solids	EPA 6010C	ICP-AES	Potassium
Aqueous/Solids	EPA 6010C	ICP-AES	Selenium
Aqueous/Solids	EPA 6010C	ICP-AES	Silver

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Matrix	Standard/Method	Technology	Analyte
Aqueous/Solids	EPA 6010C	ICP-AES	Sodium
Aqueous/Solids	EPA 6010C	ICP-AES	Thallium
Aqueous/Solids	EPA 6010C	ICP-AES	Tin
Aqueous/Solids	EPA 6010C	ICP-AES	Vanadium
Aqueous/Solids	EPA 6010C	ICP-AES	Zinc
Aqueous/Solids	EPA 6020A	ICP-MS	Arsenic
Aqueous/Solids	EPA 6020A	ICP-MS	Antimony
Aqueous/Solids	EPA 6020A	ICP-MS	Barium
Aqueous/Solids	EPA 6020A	ICP-MS	Beryllium
Aqueous/Solids	EPA 6020A	ICP-MS	Cadmium
Aqueous/Solids	EPA 6020A	ICP-MS	Chromium
Aqueous/Solids	EPA 6020A	ICP-MS	Cobalt
Aqueous/Solids	EPA 6020A	ICP-MS	Copper
Aqueous/Solids	EPA 6020A	ICP-MS	Lead
Aqueous/Solids	EPA 6020A	ICP-MS	Manganese
Aqueous/Solids	EPA 6020A	ICP-MS	Nickel
Aqueous/Solids	EPA 6020A	ICP-MS	Selenium
Aqueous/Solids	EPA 6020A	ICP-MS	Silver
Aqueous/Solids	EPA 6020A	ICP-MS	Thallium
Aqueous/Solids	EPA 6020A	ICP-MS	Vanadium
Aqueous/Solids	EPA 6020A	ICP-MS	Zinc
Aqueous/Solids	EPA 680	GC-MS	Monochlorobiphenyls, Total
Aqueous/Solids	EPA 680	GC-MS	Dichlorobiphenyls, Total
Aqueous/Solids	EPA 680	GC-MS	Trichlorobiphenyls, Total
Aqueous/Solids	EPA 680	GC-MS	Tetrachlorobiphenyls, Total
Aqueous/Solids	EPA 680	GC-MS	Pentachlorobiphenyls, Total
Aqueous/Solids	EPA 680	GC-MS	Hexachlorobiphenyls, Total
Aqueous/Solids	EPA 680	GC-MS	Heptachlorobiphenyls, Total
Aqueous/Solids	EPA 680	GC-MS	Octachlorobiphenyls, Total
Aqueous/Solids	EPA 680	GC-MS	Nonachlorobiphenyls, Total
Aqueous/Solids	EPA 680	GC-MS	Decachlorobiphenyls, Total
Aqueous/Solids	EPA 6850	HPLC-MS	Perchlorate

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Columbia Analytical Services

1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14609
Lisa Reyes Phone: 585-288-5380

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solids	EPA 7196A	UV-VIS	Chromium, hexavalent
Aqueous/Solids	EPA 7199	IC-UV	Chromium, hexavalent
Aqueous/Solids	EPA 8015C	GC-FID	Gasoline range organics
Aqueous/Solids	EPA 8015C	GC-FID	Diesel range organics
Aqueous/Solids	EPA 8081B	GC-ECD	4,4'-DDD
Aqueous/Solids	EPA 8081B	GC-ECD	4,4'-DDE
Aqueous/Solids	EPA 8081B	GC-ECD	4,4'-DDT
Aqueous/Solids	EPA 8081B	GC-ECD	Aldrin
Aqueous/Solids	EPA 8081B	GC-ECD	α-BHC
Aqueous/Solids	EPA 8081B	GC-ECD	Alpha-chlordane
Aqueous/Solids	EPA 8081B	GC-ECD	β-BHC
Aqueous/Solids	EPA 8081B	GC-ECD	Chlordane, technical
Aqueous/Solids	EPA 8081B	GC-ECD	δ-BHC
Aqueous/Solids	EPA 8081B	GC-ECD	Dieldrin
Aqueous/Solids	EPA 8081B	GC-ECD	Endosulfan I
Aqueous/Solids	EPA 8081B	GC-ECD	Endosulfan II
Aqueous/Solids	EPA 8081B	GC-ECD	Endosulfan sulfate
Aqueous/Solids	EPA 8081B	GC-ECD	Endrin
Aqueous/Solids	EPA 8081B	GC-ECD	Endrin aldehyde
Aqueous/Solids	EPA 8081B	GC-ECD	Endrin ketone
Aqueous/Solids	EPA 8081B	GC-ECD	γ-BHC (Lindane)
Aqueous/Solids	EPA 8081B	GC-ECD	γ-Chlordane
Aqueous/Solids	EPA 8081B	GC-ECD	Heptachlor
Aqueous/Solids	EPA 8081B	GC-ECD	Heptachlor epoxide
Aqueous/Solids	EPA 8081B	GC-ECD	Hexachlorobenzene
Aqueous/Solids	EPA 8081B	GC-ECD	Methoxychlor
Aqueous/Solids	EPA 8081B	GC-ECD	Toxaphene
Aqueous/Solids	EPA 8082A	GC-ECD	PCB 1016
Aqueous/Solids	EPA 8082A	GC-ECD	PCB 1221
Aqueous/Solids	EPA 8082A	GC-ECD	PCB 1232
Aqueous/Solids	EPA 8082A	GC-ECD	PCB 1242
Aqueous/Solids	EPA 8082A	GC-ECD	PCB 1248
Aqueous/Solids	EPA 8082A	GC-ECD	PCB 1254

Certificate of Accreditation: Supplement

ISO/IEC 17025:2005 and DoD-ELAP

Columbia Analytical Services

1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14609
Lisa Reyes Phone: 585-288-5380

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solids	EPA 8082A	GC-ECD	PCB 1260
Aqueous/Solids	EPA 8082A	GC-ECD	PCB 1268
Aqueous/Solids	EPA 8151A	GC-ECD	2,4-D
Aqueous/Solids	EPA 8151A	GC-ECD	Dicamba
Aqueous/Solids	EPA 8151A	GC-ECD	2,4,5-T
Aqueous/Solids	EPA 8151A	GC-ECD	2,4,5-TP
Aqueous/Solids	EPA 8151A	GC-ECD	Pentachlorophenol (PCP)
Aqueous/Solids	EPA 8260C	GC-MS	1,1,1,2-Tetrachloroethane
Aqueous/Solids	EPA 8260C	GC-MS	1,1,1-Trichloroethane
Aqueous/Solids	EPA 8260C	GC-MS	1,1,2,2-Tetrachloroethane
Aqueous/Solids	EPA 8260C	GC-MS	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)
Aqueous/Solids	EPA 8260C	GC-MS	1,1,2-Trichloroethane
Aqueous/Solids	EPA 8260C	GC-MS	1,1-Dichloroethane
Aqueous/Solids	EPA 8260C	GC-MS	1,1-Dichloroethene
Aqueous/Solids	EPA 8260C	GC-MS	1,1-Dichloropropene
Aqueous/Solids	EPA 8260C	GC-MS	1,2,3-Trichlorobenzene
Aqueous/Solids	EPA 8260C	GC-MS	1,2,3-Trichloropropane
Aqueous/Solids	EPA 8260C	GC-MS	1,2,4-Trichlorobenzene
Aqueous/Solids	EPA 8260C	GC-MS	1,2,4-Trimethylbenzene
Aqueous/Solids	EPA 8260C	GC-MS	1,2-Dibromo-3-chloropropane
Aqueous/Solids	EPA 8260C	GC-MS	1,2-Dibromoethane
Aqueous/Solids	EPA 8260C	GC-MS	1,2-Dichloro-1,1,2,2-tetrafluoroethane (Freon-114)
Aqueous/Solids	EPA 8260C	GC-MS	1,2-Dichloro-1,1,2-trifluoroethane (Freon 123a)
Aqueous/Solids	EPA 8260C	GC-MS	1,2-Dichlorobenzene
Aqueous/Solids	EPA 8260C	GC-MS	1,2-Dichloroethane
Aqueous/Solids	EPA 8260C	GC-MS	1,2-Dichloroethene, total
Aqueous/Solids	EPA 8260C	GC-MS	1,2-Dichloropropane
Aqueous/Solids	EPA 8260C	GC-MS	1,3,5-Trimethylbenzene
Aqueous/Solids	EPA 8260C	GC-MS	1,3-Dichlorobenzene
Aqueous/Solids	EPA 8260C	GC-MS	1,3-Dichloropropane
Aqueous/Solids	EPA 8260C	GC-MS	1,4-Dichlorobenzene
Aqueous/Solids	EPA 8260C	GC-MS	1,4-Dioxane

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Columbia Analytical Services

1565 Jefferson Road, Building 300, Suite 360, Rochester, NY 14609
Lisa Reyes Phone: 585-288-5380

Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solids	EPA 8260C	GC-MS	2,2-Dichloro-1,1,1-trifluoroethane (Freon 123)
Aqueous/Solids	EPA 8260C	GC-MS	2,2-Dichloropropane
Aqueous/Solids	EPA 8260C	GC-MS	2-Butanone (MEK)
Aqueous/Solids	EPA 8260C	GC-MS	2-Chloro-1,3-butadiene
Aqueous/Solids	EPA 8260C	GC-MS	2-Chloroethylvinyl ether
Aqueous/Solids	EPA 8260C	GC-MS	2-Chlorotoluene
Aqueous/Solids	EPA 8260C	GC-MS	2-Hexanone
Aqueous/Solids	EPA 8260C	GC-MS	2-Methyl-1-propanol (Isobutlyl alcohol)
Aqueous/Solids	EPA 8260C	GC-MS	2-Methyl-2-propanol (Tertbutyl alcohol)
Aqueous/Solids	EPA 8260C	GC-MS	2-Nitropropane
Aqueous/Solids	EPA 8260C	GC-MS	2-Propanol
Aqueous/Solids	EPA 8260C	GC-MS	3-Chloro-1-propene (Allyl chloride)
Aqueous/Solids	EPA 8260C	GC-MS	4-Chlorotoluene
Aqueous/Solids	EPA 8260C	GC-MS	4-Ethyltoluene
Aqueous/Solids	EPA 8260C	GC-MS	4-Isopropyltoluene
Aqueous/Solids	EPA 8260C	GC-MS	4-Methyl-2-pentanone (MIBK)
Aqueous/Solids	EPA 8260C	GC-MS	Acetone
Aqueous/Solids	EPA 8260C	GC-MS	Acetonitrile
Aqueous/Solids	EPA 8260C	GC-MS	Acrolein
Aqueous/Solids	EPA 8260C	GC-MS	Acrylonitrile
Aqueous/Solids	EPA 8260C	GC-MS	Benzene
Aqueous/Solids	EPA 8260C	GC-MS	Benzyl chloride
Aqueous/Solids	EPA 8260C	GC-MS	Bromobenzene
Aqueous/Solids	EPA 8260C	GC-MS	Bromochloromethane
Aqueous/Solids	EPA 8260C	GC-MS	Bromodichloromethane
Aqueous/Solids	EPA 8260C	GC-MS	Bromoform
Aqueous/Solids	EPA 8260C	GC-MS	Bromomethane
Aqueous/Solids	EPA 8260C	GC-MS	Carbon disulfide
Aqueous/Solids	EPA 8260C	GC-MS	Carbon tetrachloride
Aqueous/Solids	EPA 8260C	GC-MS	Chlorobenzene
Aqueous/Solids	EPA 8260C	GC-MS	Chloroethane
Aqueous/Solids	EPA 8260C	GC-MS	Chloroform
Aqueous/Solids	EPA 8260C	GC-MS	Chloromethane

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Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solids	EPA 8260C	GC-MS	cis-1,2-Dichloroethene
Aqueous/Solids	EPA 8260C	GC-MS	cis-1,3-Dichloropropene
Aqueous/Solids	EPA 8260C	GC-MS	Cyclohexane
Aqueous/Solids	EPA 8260C	GC-MS	Cyclohexanone
Aqueous/Solids	EPA 8260C	GC-MS	Dibromochloromethane
Aqueous/Solids	EPA 8260C	GC-MS	Dibromomethane
Aqueous/Solids	EPA 8260C	GC-MS	Dichlorodifluoromethane (Freon 12)
Aqueous/Solids	EPA 8260C	GC-MS	Dichlorofluoromethane (Freon 21)
Aqueous/Solids	EPA 8260C	GC-MS	Dichloromethane
Aqueous/Solids	EPA 8260C	GC-MS	Diethyl ether
Aqueous/Solids	EPA 8260C	GC-MS	Diisopropyl ether
Aqueous/Solids	EPA 8260C	GC-MS	Ethyl methacrylate
Aqueous/Solids	EPA 8260C	GC-MS	Ethyl tert-butyl ether
Aqueous/Solids	EPA 8260C	GC-MS	Ethylbenzene
Aqueous/Solids	EPA 8260C	GC-MS	Hexachlorobutadiene
Aqueous/Solids	EPA 8260C	GC-MS	Iodomethane
Aqueous/Solids	EPA 8260C	GC-MS	Isopropylbenzene
Aqueous/Solids	EPA 8260C	GC-MS	m- + p-Xylene
Aqueous/Solids	EPA 8260C	GC-MS	Methacrylonitrile
Aqueous/Solids	EPA 8260C	GC-MS	Methyl acetate
Aqueous/Solids	EPA 8260C	GC-MS	Methyl methacrylate
Aqueous/Solids	EPA 8260C	GC-MS	Methylcyclohexane
Aqueous/Solids	EPA 8260C	GC-MS	Methyl-tert-butyl ether (MTBE)
Aqueous/Solids	EPA 8260C	GC-MS	Napthalene
Aqueous/Solids	EPA 8260C	GC-MS	N-butylacetate
Aqueous/Solids	EPA 8260C	GC-MS	N-butylbenzene
Aqueous/Solids	EPA 8260C	GC-MS	N-heptane
Aqueous/Solids	EPA 8260C	GC-MS	N-propylbenzene
Aqueous/Solids	EPA 8260C	GC-MS	o-Xylene
Aqueous/Solids	EPA 8260C	GC-MS	Propionitrile
Aqueous/Solids	EPA 8260C	GC-MS	sec-butylbenzene
Aqueous/Solids	EPA 8260C	GC-MS	Styrene
Aqueous/Solids	EPA 8260C	GC-MS	tert-amyl methyl ether

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Matrix	Standard/Method	Technology	Analyte
Aqueous/Solids	EPA 8260C	GC-MS	tert-butylbenzene
Aqueous/Solids	EPA 8260C	GC-MS	Tetra hydrofuran
Aqueous/Solids	EPA 8260C	GC-MS	Tetrachloroethene
Aqueous/Solids	EPA 8260C	GC-MS	Toluene
Aqueous/Solids	EPA 8260C	GC-MS	trans-1,2-Dichloroethene
Aqueous/Solids	EPA 8260C	GC-MS	trans-1,3-Dichloropropene
Aqueous/Solids	EPA 8260C	GC-MS	trans-1,4-Dichloro-2-butene
Aqueous/Solids	EPA 8260C	GC-MS	Trichloroethene
Aqueous/Solids	EPA 8260C	GC-MS	Trichlorofluoromethane (Freon 11)
Aqueous/Solids	EPA 8260C	GC-MS	Vinyl acetate
Aqueous/Solids	EPA 8260C	GC-MS	Vinyl chloride
Aqueous/Solids	EPA 8260C	GC-MS	Xylenes, total
Aqueous/Solids	EPA 8270D	GC-MS	1,2,4,5-Tetrachlorobenzene
Aqueous/Solids	EPA 8270D	GC-MS	1,2,4-Trichlorobenzene
Aqueous/Solids	EPA 8270D	GC-MS	1,2-Dichlorobenzene
Aqueous/Solids	EPA 8270D	GC-MS	1,2-Diphenylhydrazine
Aqueous/Solids	EPA 8270D	GC-MS	1,3,5-Trinitrobenzene
Aqueous/Solids	EPA 8270D	GC-MS	1,3-Dichlorobenzene
Aqueous/Solids	EPA 8270D	GC-MS	1,3-Dinitrobenzene
Aqueous/Solids	EPA 8270D	GC-MS	1,4-Dichlorobenzene
Aqueous/Solids	EPA 8270D	GC-MS	1,4-Dioxane
Aqueous/Solids	EPA 8270D	GC-MS	1,4-Naphthoquinone
Aqueous/Solids	EPA 8270D	GC-MS	1-Methyl-2-pyrrolidinone
Aqueous/Solids	EPA 8270D	GC-MS	1-Methylnaphthalene
Aqueous/Solids	EPA 8270D	GC-MS	1-Naphthylamine
Aqueous/Solids	EPA 8270D	GC-MS	2,3,4,6-Tetrachlorophenol
Aqueous/Solids	EPA 8270D	GC-MS	2,4,5-Trichlorophenol
Aqueous/Solids	EPA 8270D	GC-MS	2,4,6-Trichlorophenol
Aqueous/Solids	EPA 8270D	GC-MS	2,4-Dichlorophenol
Aqueous/Solids	EPA 8270D	GC-MS	2,4-Dimethylphenol
Aqueous/Solids	EPA 8270D	GC-MS	2,4-Dinitrophenol
Aqueous/Solids	EPA 8270D	GC-MS	2,4-Dinitrotoluene
Aqueous/Solids	EPA 8270D	GC-MS	2,6-Dichlorophenol

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Columbia Analytical Services

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Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solids	EPA 8270D	GC-MS	2,6-Dinitrotoluene
Aqueous/Solids	EPA 8270D	GC-MS	2-Acetylaminofluorene
Aqueous/Solids	EPA 8270D	GC-MS	2-Chloronaphthalene
Aqueous/Solids	EPA 8270D	GC-MS	2-Chlorophenol
Aqueous/Solids	EPA 8270D	GC-MS	2-Methyl-5-nitroaniline (5-Nitro-o-toluidine)
Aqueous/Solids	EPA 8270D	GC-MS	2-Methylnaphthalene
Aqueous/Solids	EPA 8270D	GC-MS	2-Methylphenol
Aqueous/Solids	EPA 8270D	GC-MS	2-Naphthylamine
Aqueous/Solids	EPA 8270D	GC-MS	2-Nitroaniline
Aqueous/Solids	EPA 8270D	GC-MS	2-Nitrophenol
Aqueous/Solids	EPA 8270D	GC-MS	2-Picoline
Aqueous/Solids	EPA 8270D	GC-MS	3,3'-Dichlorobenzidine
Aqueous/Solids	EPA 8270D	GC-MS	3,3'-Dimethylbenzidine
Aqueous/Solids	EPA 8270D	GC-MS	3+4-Methylphenol
Aqueous/Solids	EPA 8270D	GC-MS	3-Methylcholanthrene
Aqueous/Solids	EPA 8270D	GC-MS	3-Nitroaniline
Aqueous/Solids	EPA 8270D	GC-MS	4,6-Dinitro-2-methylphenol
Aqueous/Solids	EPA 8270D	GC-MS	4-Aminobiphenyl
Aqueous/Solids	EPA 8270D	GC-MS	4-Bromophenyl-phenylether
Aqueous/Solids	EPA 8270D	GC-MS	4-Chloro-3-methylphenol
Aqueous/Solids	EPA 8270D	GC-MS	4-Chloroaniline
Aqueous/Solids	EPA 8270D	GC-MS	4-Chlorophenyl-phenylether
Aqueous/Solids	EPA 8270D	GC-MS	4-Nitroaniline
Aqueous/Solids	EPA 8270D	GC-MS	4-Nitrophenol
Aqueous/Solids	EPA 8270D	GC-MS	4-Nitroquinoline-1-oxide
Aqueous/Solids	EPA 8270D	GC-MS	7,12-Dimethylbenz(a)anthracene
Aqueous/Solids	EPA 8270D	GC-MS	α,α-Dimethylphenethylamine
Aqueous/Solids	EPA 8270D	GC-MS	Acenaphthene
Aqueous/Solids	EPA 8270D	GC-MS	Acenaphthylene
Aqueous/Solids	EPA 8270D	GC-MS	Acetophenone
Aqueous/Solids	EPA 8270D	GC-MS	Aniline
Aqueous/Solids	EPA 8270D	GC-MS	Anthracene
Aqueous/Solids	EPA 8270D	GC-MS	Aramite

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Columbia Analytical Services

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Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solids	EPA 8270D	GC-MS	Atrazine
Aqueous/Solids	EPA 8270D	GC-MS	Benzaldehyde
Aqueous/Solids	EPA 8270D	GC-MS	Benzidine
Aqueous/Solids	EPA 8270D	GC-MS	Benzo(a)anthracene
Aqueous/Solids	EPA 8270D	GC-MS	Benzo(a)pyrene
Aqueous/Solids	EPA 8270D	GC-MS	Benzo(b)fluoranthene
Aqueous/Solids	EPA 8270D	GC-MS	Benzo(g,h,i)perylene
Aqueous/Solids	EPA 8270D	GC-MS	Benzo(k)fluoranthene
Aqueous/Solids	EPA 8270D	GC-MS	Benzoic acid
Aqueous/Solids	EPA 8270D	GC-MS	Benzyl alcohol
Aqueous/Solids	EPA 8270D	GC-MS	Biphenyl
Aqueous/Solids	EPA 8270D	GC-MS	Bis(1-chloroisopropyl)ether
Aqueous/Solids	EPA 8270D	GC-MS	Bis(-2-chloroethoxy)methane
Aqueous/Solids	EPA 8270D	GC-MS	Bis(2-chloroethyl)ether
Aqueous/Solids	EPA 8270D	GC-MS	Bis(2-ethylhexyl)phthalate
Aqueous/Solids	EPA 8270D	GC-MS	Butyl benzyl phthalate
Aqueous/Solids	EPA 8270D	GC-MS	Caprolactam
Aqueous/Solids	EPA 8270D	GC-MS	Carbazole
Aqueous/Solids	EPA 8270D	GC-MS	Chlorobenzilate
Aqueous/Solids	EPA 8270D	GC-MS	Chrysene
Aqueous/Solids	EPA 8270D	GC-MS	Cyclohexane, isothiocyanato-
Aqueous/Solids	EPA 8270D	GC-MS	Diallate
Aqueous/Solids	EPA 8270D	GC-MS	Dibenzo(a,h)anthracene
Aqueous/Solids	EPA 8270D	GC-MS	Dibenzofuran
Aqueous/Solids	EPA 8270D	GC-MS	Diethylphthalate
Aqueous/Solids	EPA 8270D	GC-MS	Dimethoate
Aqueous/Solids	EPA 8270D	GC-MS	Dimethyl phthalate
Aqueous/Solids	EPA 8270D	GC-MS	Di-n-butylphthalate
Aqueous/Solids	EPA 8270D	GC-MS	Di-n-octyl phthalate
Aqueous/Solids	EPA 8270D	GC-MS	Dinoseb
Aqueous/Solids	EPA 8270D	GC-MS	Diphenylamine
Aqueous/Solids	EPA 8270D	GC-MS	Disulfoton
Aqueous/Solids	EPA 8270D	GC-MS	Ethyl methanesulfonate

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Accreditation is granted to the facility to perform the following testing:

Matrix	Standard/Method	Technology	Analyte
Aqueous/Solids	EPA 8270D	GC-MS	Fluoranthene
Aqueous/Solids	EPA 8270D	GC-MS	Fluorene
Aqueous/Solids	EPA 8270D	GC-MS	Hexachlorobenzene
Aqueous/Solids	EPA 8270D	GC-MS	Hexachlorobutadiene
Aqueous/Solids	EPA 8270D	GC-MS	Hexachlorocyclopentadiene
Aqueous/Solids	EPA 8270D	GC-MS	Hexachloroethane
Aqueous/Solids	EPA 8270D	GC-MS	Hexachlorophene
Aqueous/Solids	EPA 8270D	GC-MS	Hexachloropropene
Aqueous/Solids	EPA 8270D	GC-MS	Indeno(1,2,3-cd)pyrene
Aqueous/Solids	EPA 8270D	GC-MS	Isodrin
Aqueous/Solids	EPA 8270D	GC-MS	Isophorone
Aqueous/Solids	EPA 8270D	GC-MS	Isosafrole
Aqueous/Solids	EPA 8270D	GC-MS	Methapyrilene
Aqueous/Solids	EPA 8270D	GC-MS	Methyl methanesulfonate
Aqueous/Solids	EPA 8270D	GC-MS	Methyl parathion
Aqueous/Solids	EPA 8270D	GC-MS	Naphthalene
Aqueous/Solids	EPA 8270D	GC-MS	Nitrobenzene
Aqueous/Solids	EPA 8270D	GC-MS	N-nitrosodiethylamine
Aqueous/Solids	EPA 8270D	GC-MS	N-nitrosodimethylamine
Aqueous/Solids	EPA 8270D	GC-MS	N-nitrosodi-n-butylamine
Aqueous/Solids	EPA 8270D	GC-MS	N-nitroso-di-n-propylamine
Aqueous/Solids	EPA 8270D	GC-MS	N-nitrosodiphenylamine
Aqueous/Solids	EPA 8270D	GC-MS	N-nitrosomethylethylamine
Aqueous/Solids	EPA 8270D	GC-MS	N-nitrosomorpholine
Aqueous/Solids	EPA 8270D	GC-MS	N-nitrosopiperidine
Aqueous/Solids	EPA 8270D	GC-MS	N-nitrosopyrolidine
Aqueous/Solids	EPA 8270D	GC-MS	Octachlorostyrene
Aqueous/Solids	EPA 8270D	GC-MS	o,o,o-triethyl phosphorothioate
Aqueous/Solids	EPA 8270D	GC-MS	o-toluidine
Aqueous/Solids	EPA 8270D	GC-MS	Parathion (ethyl)
Aqueous/Solids	EPA 8270D	GC-MS	p-dimethylaminoazobenzene
Aqueous/Solids	EPA 8270D	GC-MS	Pentachlorobenzene
Aqueous/Solids	EPA 8270D	GC-MS	Pentachloroethane

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Matrix	Standard/Method	Technology	Analyte
Aqueous/Solids	EPA 8270D	GC-MS	Pentachloronitrobenzene
Aqueous/Solids	EPA 8270D	GC-MS	Pentachlorophenol
Aqueous/Solids	EPA 8270D	GC-MS	Phenacetin
Aqueous/Solids	EPA 8270D	GC-MS	Phenanthrene
Aqueous/Solids	EPA 8270D	GC-MS	Phenol
Aqueous/Solids	EPA 8270D	GC-MS	Phorate
Aqueous/Solids	EPA 8270D	GC-MS	Phthalimide
Aqueous/Solids	EPA 8270D	GC-MS	Pyrene
Aqueous/Solids	EPA 8270D	GC-MS	Pyridine
Aqueous/Solids	EPA 8270D	GC-MS	Safrole
Aqueous/Solids	EPA 8270D	GC-MS	Sulfotepp
Aqueous/Solids	EPA 8270D	GC-MS	Thionazin
Aqueous/Solids	EPA 8270D	GC-MS-LL	1,4-Dioxane
Aqueous/Solids	EPA 8270D	GC-MS-LL	1-Methylnaphthalene
Aqueous/Solids	EPA 8270D	GC-MS-LL	2-Methylnaphthalene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Acenaphthene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Acenaphthylene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Anthracene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Benzo(a)anthracene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Benzo(a)pyrene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Benzo(b)fluoranthene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Benzo(g,h,i)perylene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Benzo(k)fluoranthene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Bis(2-ethylhexyl)phthalate
Aqueous/Solids	EPA 8270D	GC-MS-LL	Butyl benzyl phthalate
Aqueous/Solids	EPA 8270D	GC-MS-LL	Carbazole
Aqueous/Solids	EPA 8270D	GC-MS-LL	Chrysene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Dibenzo(a,h)anthracene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Dibenzofuran
Aqueous/Solids	EPA 8270D	GC-MS-LL	Diethyl phthalate
Aqueous/Solids	EPA 8270D	GC-MS-LL	Dimethyl phthalate
Aqueous/Solids	EPA 8270D	GC-MS-LL	Di-n-butyl phthalate
Aqueous/Solids	EPA 8270D	GC-MS-LL	Di-n-octyl phthalate

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Matrix	Standard/Method	Technology	Analyte
Aqueous/Solids	EPA 8270D	GC-MS-LL	Fluoranthene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Fluorene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Hexachlorobenzene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Indeno(1,2,3-cd)pyrene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Naphthalene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Nitrobenzene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Octachlorostyrene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Phenanthrene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Pyrene
Aqueous/Solids	EPA 8270D	GC-MS-LL	Pyridine
Aqueous/Solids	EPA 9012A, B	UV-VIS	Cyanide, total
Aqueous/Solids	EPA 9034	Titration	Sulfide, acid soluble
Aqueous/Solids	EPA 9056A	IC	Bromide
Aqueous/Solids	EPA 9056A	IC	Chloride
Aqueous/Solids	EPA 9056A	IC	Fluoride
Aqueous/Solids	EPA 9056A	IC	Nitrate as Nitrogen
Aqueous/Solids	EPA 9056A	IC	Nitrite as Nitrogen
Aqueous/Solids	EPA 9056A	IC	Sulfate
Aqueous/Solids	GEN-AVS	Titrimetric	Acid Volatile Sulfide
Aqueous/Solids	EPA 8330B	HPLC	1,3,5-Trinitrobenzene
Aqueous/Solids	EPA 8330B	HPLC	1,3-Dinitrobenzene
Aqueous/Solids	EPA 8330B	HPLC	2,4,6-Trinitrotoluene (TNT)
Aqueous/Solids	EPA 8330B	HPLC	2,4-Dinitrotoluene
Aqueous/Solids	EPA 8330B	HPLC	2,6-Dinitrotoluene
Aqueous/Solids	EPA 8330B	HPLC	2-Amino 4,6-Dinitrotoluene
Aqueous/Solids	EPA 8330B	HPLC	2-Nitrotoluene
Aqueous/Solids	EPA 8330B	HPLC	3,5-Dinitroaniline
Aqueous/Solids	EPA 8330B	HPLC	3-Nitrotoluene
Aqueous/Solids	EPA 8330B	HPLC	4-Amino 2,6-Dinitrotoluene
Aqueous/Solids	EPA 8330B	HPLC	4-Nitrotoluene
Aqueous/Solids	EPA 8330B	HPLC	Hexahydro 1,3,5-Trinitro 1,3,5-Triazine
Aqueous/Solids	EPA 8330B	HPLC	Methyl 2,4,6 Trinitrophenylnitramine
Aqueous/Solids	EPA 8330B	HPLC	Nitrobenzene
Aqueous/Solids	EPA 8330B	HPLC	Nitroglycerin

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Matrix	Standard/Method	Technology	Analyte
Aqueous/Solids	EPA 8330B	HPLC	Octahydro 1.3.5.7 Tetranitro 1,3,5,7 Tetraz
Aqueous/Solids	EPA 8330B	HPLC	Pentaerythritol Tetranitrate (PETN)
Aqueous/Solids	HPLC-METACID	HPLC	Acetic Acid
Aqueous/Solids	HPLC-METACID	HPLC	Butanoic Acid (Butyric Acid)
Aqueous/Solids	HPLC-METACID	HPLC	Lactic Acid
Aqueous/Solids	HPLC-METACID	HPLC	Propionic Acid
Aqueous/Solids	HPLC-METACID	HPLC	Pyruvic Acid

Matrix	Standard/Method	Technology	Analyte
Aqueous	EPA 3010A	Acid Digestion	Metals prep
Aqueous	EPA 3510C	SF Extraction	Semivolatiles, pesticides, PCBs, DRO
Aqueous	EPA 5030B	P&T	Volatiles
Solids	EPA 3050B	Acid Digestion	Metals prep
Solids	EPA 3060A	Digestion	Hexavalent chromium digestion
Solids	EPA 3541	SOX Extraction	Semivolatiles, pesticides, PCBs, DRO
Solids	EPA 5035	P&T closed	Volatiles
Aqueous/Solids	EPA 1311	TCLP	Physical Extraction
Aqueous/Solids	EPA 1312	SPLP	Physical Extraction
Aqueous/Solids	EPA 3620B	Florisil Cleanup	Semivolatiles, pesticides, PCBs
Aqueous/Solids	EPA 3660B	Sulfur Cleanup	Semivolatiles, pesticides, PCBs
Aqueous/Solids	EPA 3665A	Sulfuric Acid Cleanup	PCBs
Aqueous/Solids	EPA 9012A, B	Distillation	Cyanide
Aqueous/Solids	EPA 9030B	Distillation	Sulfide, acid soluble

Responses to Comments

From: Haug.Susanne@epamail.epa.gov [mailto:Haug.Susanne@epamail.epa.gov]
Sent: Wednesday, October 31, 2012 11:32 AM
To: Scott Park; Ivester, Marlene/VBO; Sawyer, Stephanie/VBO; Wade.Smith@deq.virginia.gov
Subject: AOC 6 TNT Subareas comments 1 of 2

Hi Everyone,

I was planning on sending these comments on Monday but we were shut down for 2 days. These are only partial comments on the AOC 6 TNT Subareas SAP. I haven't yet received BTAG comments. I've sent a reminder email to the BTAG and will send you their comments as soon as I get them. A lot of people are still without power and we have a "liberal leave policy" in effect. I am working from home today and am having trouble sending attachments so I pasted the comments below. I'll send it in letter form tomorrow when I'm in the office.

Let me know if you have any questions.

Sue

1. PAGES 18 and 26. For soil and gw samples collected during the RI, limited analysis is proposed (SVOCs, explosives and metals). In 2008, for the Site Inspection conducted in this area, the analysis was also limited (per page 21 of the report). Either justification for deviating from a full suite analysis of RI samples should be provided or complete analysis should be performed.

2. PAGE 24. In the third and seventh bullets, please clarify the text to indicate that maximum on-site concentrations will be compared to 95th percent UTL levels in the bg population. In the sixth bullet, please clarify that exposure point concentrations for gw will be based on the 95th percent UCL of the mean for wells in the most contaminated portion of the plume.

3. PAGE 25. According to the last paragraph on this page, 13 "co-located surface (0 to 6 inches) and subsurface (6 to 24 inches) soil samples will be collected" for the RI. Typically, subsurface soil samples are collected at intervals much deeper than a maximum of 24 inches. Are the top 24 inches at this site comprised of original soil (as compared to fill placed after operations)? If so, if contamination is observed in this interval, the full extent of contamination will have to be characterized at some point. If not, samples should be collected at a depth where contamination might be expected to be found based on historical site activities.

4. FIGURE 4. The final step of this flow chart states that if maximum bg concentrations are not exceeded, then no further investigation or action is warranted. After many discussions on this topic, I believe the team agreed that this step (which has been consistently opposed by EPA) would be used as a single line of evidence and in conjunction with other information to help characterize sites, and not as a screen to eliminate sites. The Decision Tree should be modified to reflect this.

5. In an effort to completely and comprehensively characterize the contamination at this Site, it is highly recommended the laboratories performing the analyses report Tentatively Identified Compounds (TICs). TIC reporting is very useful in preventing chemical contaminants not previously screened for from being overlooked.

6. If any samples are split between laboratories, it is strongly recommended each laboratory perform the exact same method for the split sample analysis. It is also recommended each split sample be accompanied by blind Performance Evaluation (PE) samples.

7. Laboratory accreditation should be reviewed to ensure each is up to date.

8. Note: United States Environmental Protection Agency Region III has made the National Functional Guidelines for performing Data Validation the standard.

Sue

Susanne Haug, P.E.
Remedial Project Manager
US EPA Region III (3HS11)
215-814-3394 (ph

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

November 6, 2012

Mr. Scott Park
NAVFAC MIDLANT, Building N-26, Room 3208
Attention: Code OPHE3, Mr. Scott Park
9742 Maryland Avenue
Norfolk, VA 23511-3095

Subject: Draft Tier II Sampling and Analysis Plan, AOC 6 – TNT Graining House Sump and TNT Catch Box Ruins Subareas - Remedial Investigation, Naval Weapons Station Yorktown Cheatham Annex, Williamsburg, Virginia, September 2012

Mr. Park:

Thank you for the opportunity to review the subject document. On October 31, 2012 EPA submitted a partial list of comments. The comments below are in addition to those previously submitted. This completes the review on this draft version of the document.

1. Page 18, Numbers 1 and 2: The text needs to clearly state why the groundwater sample analysis (metals) is not the same as the soil sample analysis (SVOCs, explosives, and metals). Because soil constituents can migrate to groundwater, analysis for soil and groundwater should be for the same constituents.

2. Page 18, Number 5: The text states "The Team agreed not to include the groundwater data in the ERA in this RI." It is not clear if adequate sediment and surface water data from Penniman Lake have been collected to identify contaminant migration from this site to Penniman Lake in order to address ecological risk in Penniman Lake. The text needs to clearly state that data in Penniman Lake is limited and additional sampling will be needed as part of the Penniman Lake RI to assess impacts from this site.

3. Section 2.2.1 on page 21 states that a Final Site Inspection (SI) Narrative Report for the Penniman Shell Loading Plant was prepared in 1999 and found that one explosive and several metals exceeded the 1999 EPA Region 3 risk-based concentrations. Based on these results, it appears that the sample analysis in the 2008 SI was limited to SVOCs, explosives, metals, and cyanide; and pesticides and PCBs were not analyzed. Additional justification needs to be provided for eliminating these analytes in the 2008 SI and the

current investigation as the original results in 1999 were only compared to human health criteria and did not consider exceedances of ecological criteria.

4. Section 2.2.1 on page 21 states that since no potential human health or ecological risks were identified for sediment and surface water and a remedial investigation for Penniman Lake is planned, no further action was recommended for these media as part of AOC 6. A similar statement is made in Section 2.2.3 on page 22. It is unclear how the conclusion of no ecological risk was reached since screening levels were exceeded in sediment for explosives and metals and in surface water for metals. Since only one sediment sample was collected, the extent of the contamination and potential risk in Penniman Lake is undefined. This area of Penniman Lake should be further evaluated as part of the Penniman Lake remedial investigation.

5. Page 22, Section 2.2.3 Distribution of Contamination: The text indicates that the soil in the western and northeastern portions of the site was not sampled. Therefore additional soil samples are required to fill this data gap. While the existing SI data may suggest a limited number of contaminants, this is based on a very limited number of samples. All of the contaminants included in the original SI analyses need to be included in the subsequent RI sampling analysis because of the uncertainty with limiting the analyte list based on limited sampling.

6. Section 2.2.2 on page 22 states that surficial runoff from the AOC 6 TNT subareas flows primarily east toward Penniman Lake and southeast toward King Creek. The section further states that groundwater is expected to flow east to Penniman Lake and southeast toward King Creek. Based on the migration pathway, it is unclear why no samples have been collected and none are proposed for collection in King Creek. This represents a data gap that will need to be addressed as part of this or another investigation. This issue should be discussed.

7. Section 2.2.6 on page 23 states that due to the small size of the potentially impacted area, potential exposures for upper trophic level receptors (e.g., birds and mammals) are not likely to be significant. Therefore, no food chain modeling will be performed as part of the ecological risk assessment. BTAG does not support this approach particularly since the extent of contamination is not well defined. BTAG recommends addressing potential risk to upper trophic level receptors, particularly those with smaller home ranges (e.g., American robin [*Turdus migratorius*] and short-tailed shrew [*Blarina brevicauda*]). Because of their small home range, small body size, and high ingestion rates, these receptors would be sensitive to contaminants found at the site.

8. Page 24, Section 2.3.2 Data Quality Objectives: In order to know that analytes are undetected, the quantitation levels (QLs) need to be lower than the respective ecological screening values. If this is not the case, then those contaminants will need to be retained as contaminants of potential concern.

9. Section 2.3.2.2 on page 25 states that to evaluate potential ecological risk, mean soil concentrations will be compared with soil ecological screening values (ESVs). If soil concentrations are below soil ESVs, the chemical will not be considered a contaminant of potential concern. The magnitude of the maximum hazard quotient will also be considered when making this determination. This approach is unacceptable. Because soil invertebrates and plants have limited or no mobility, potential risk from individual hot spots should also be evaluated. Any soil samples with concentrations exceeding ESVs present potential risk to plants and soil invertebrates.

10. Page 26, Section 2.3.3: The first bullet indicates 6 permanent monitoring wells will be installed. Figure 5 shows the locations of these wells and there is no well located on the west side of these former structures. An adequate explanation for this potential data gap needs to be included in this section or else another permanent monitoring well needs to be added.

11. Section 2.5 on page 33 states that during meetings, the Partnering Team discussed and agreed to the proposed sampling rationale for the this site. Figure 5 presents the proposed sample locations for each medium to be evaluated. Within the boundaries of the former graining house sump (no samples) and catch box ruins (1 sample) sampling is too limited. A minimum of three soil samples should be taken within the footprint of each of the ruins of the TNT Graining House and the Catch Box ruins.

12. Section 2.3.4 on page 27 states that literature-based ESVs for plants and soil invertebrates will be used as project action limits to identify contaminants of potential concern for ecological receptors. The specific values are provided in Tables A1-1 and A1-2 in Appendix A-1. However, the basis for the values is not provided. BTAG strongly recommends that the EPA Eco-SSLs be used when available to assess ecological risk to invertebrates and plants. Other similarly conservative screening levels from the literature can be used if Eco-SSLs are not available.

13. Page 27, Section 2.3.4: The text states "Identified COPCs will be used in a quantitative…ERA (through Step 3a) to identify the COPCs for each medium." This sentence is confusing. Please re-write to clarify how the first set of COPCs differs from the second set of COPCs.

If you have any questions, please contact me at 215-814-3394.

Sincerely,

Susanne Haug

Susanne Haug, P.E.
NPL/BRAC Federal Facilities Branch

cc: Wade Smith, VDEQ

From: Smith, Wade (DEQ) [mailto:Wade.Smith@deq.virginia.gov]
Sent: Wednesday, December 12, 2012 1:19 PM
To: scott.park@navy.mil
Cc: Ivester, Marlene/VBO; Sawyer, Stephanie/VBO; Haug.Susanne@epamail.epa.gov
Subject: CAX: AOC 6 SAP - DEQ Comments

Thank you for giving the DEQ the opportunity to comment on the September 2012 Draft SAP for AOC 6 at CAX.

The Draft SAP was received by the DEQ on September 27, 2012.

Based on the scoping sessions associated with this Draft SAP, the DEQ concurs with the Sampling Design and Rationale and has two additional minor comments on the document:

Please replace John Burchette with Susanne Haug, EPA RPM, throughout document as appropriate; and

Please revise Figure 2 to indicate that the Ammonia Settling Pits are part of the AOC 6 Approximate Study Area Boundary and not included in the Approximate AOC 6 TNT Subareas Study Boundary.

Upon your submittal of the Draft Final SAP, the DEQ will issue an official letter for your files.

Please let me know if you have any questions.

Sincerely,

Wade M. Smith
Remediation Project Manager
Virginia Department of Environmental Quality
Office of Remediation Programs
Phone: (804) 698-4125
wade.smith@deq.virginia.gov

Response to Comments
Draft Tier II Sampling and Analysis Plan
AOC 6 – TNT Graining House Sump and TNT Catch Box Ruins Subareas
Remedial Investigation

Naval Weapons Station Yorktown Cheatham Annex
Williamsburg, VA
March 18, 2013

Comments received by email on October 31, 2012 and letter dated November 6, 2012 from Sue Haug, U. S. Environmental Protection Agency (USEPA) Region 3, and by email on December 12, 2012 from Wade Smith, Virginia Department of Environmental Protection (VDEQ), following review of the draft remedial investigation (RI) Uniform Federal Policy Sampling and Analysis Plan (SAP) submitted September 26, 2012.

Comments received from USEPA via email dated October 31, 2012

EPA RPM Comment 1: *PAGES 18 and 26. For soil and gw samples collected during the RI, limited analysis is proposed (SVOCs, explosives and metals). In 2008, for the Site Inspection conducted in this area, the analysis was also limited (per page 21 of the report). Either justification for deviating from a full suite analysis of RI samples should be provided or complete analysis should be performed.*

Response: The AOC 6 TNT subareas waste source samples were analyzed for VOCs, SVOCs, pesticides/PCBs, explosives, and inorganics. However, the only contaminants that exceeded the USEPA Region III risk-based concentrations (RBCs) included inorganics and explosives. Specifically, **Table 1** of the 1999 Site Inspection (SI) Report (Weston, 1999) identified these contaminants as 2,4,6-TNT, arsenic, cadmium, lead, and manganese and the analytical results are included in **Table A-1** in the **Attachments** to these RTCs. Therefore, during the development of the recent SI UFP-QAPP (CH2M HILL, 2008), the Partnering Team agreed that full suite analyses were not necessary and the samples would be analyzed for SVOCs, explosives, and inorganics (including cyanide) (SVOCs added at the request of USEPA). The Final SI Report (CH2M HILL, 2012) concluded that the COPCs consisted of one SVOC, six explosives, and 10 inorganics in surface soil; one SVOC, three explosives, and seven inorganics in subsurface soil; and 13 total and 10 dissolved inorganics in groundwater. Note also that the one SVOC that exceeded screening criteria for surface soil and subsurface soil during the 2008 SI is 2,4-dinitrotoluene, which can also be classified as an explosive constituent for the purposes of laboratory analysis and human health and ecological risk screenings. Therefore, the Team discussed and agreed that this constituent will be captured as part of the explosives analysis, and separate SVOC analysis is not needed.

As stated in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA, 1988), Section 2.2.2,

> "Before the activities necessary to conduct an RI/FS can be planned, it is important to compile the available data that have previously been collected for a site. These data can be used to determine the additional work that needs to be conducted both in the field and within the community. A thorough search of existing data should help avoid duplication of previous efforts and lead to a remedial investigation that is more focused and, therefore, more efficient in its expenditure of resources."

Following this guidance, the RI should include analysis of a focused list of analytes based on the SI exceedances. One of the primary purposes of the proposed RI soil and groundwater sampling is to fill relatively minor spatial data gaps in areas that were previously investigated with a reasonable degree of spatial coverage. As a result, upon evaluation of the recent SI analytical results, the CAX Partnering Team agreed during the three scoping sessions (documented in WS #9 of the SAP) that it was appropriate to limit the RI soil sample analyses to explosives and inorganics, and groundwater analyses to inorganics in order to fulfill this purpose.

Since VOCs, pesticides, and PCBs were not potential constituents of concern following the 1999 SI and were not carried forward for the recent SI conducted in 2008, these analyses have not been included in the RI SAP. For clarification, text will be added to Section 2.2.1, fourth paragraph, as follows:

> In 2008, SI field activities were conducted and included surface and subsurface soil sampling, temporary groundwater well installation activities, groundwater well development and sampling, temporary groundwater well abandonment activities, and surface water and sediment (surface and subsurface) sampling. The soil and sediment samples were analyzed for SVOCs, explosives, inorganics, and cyanide; the groundwater and surface water samples were analyzed for SVOCs, explosives, inorganics (total and dissolved), cyanide (total and dissolved), and hardness (surface water only). Since VOCs, SVOCs, pesticides, and PCBs were not found to be potential constituents of concern during the 1999 SI, these analyses were not carried forward in the recent SI conducted in 2008, except for SVOCs, which were added at the request of the USEPA. The results were evaluated as part of the SI Report (CH2M HILL, 2012) and indicated that potentially unacceptable human health and/or ecological risks were associated with exposure to explosives and inorganics in soil, and inorganics in groundwater, and an RI was recommended. Additionally, since no potential human health or ecological risks were identified for sediment and surface water and an RI for Penniman Lake is planned, no further action was recommended for these media as part of AOC 6 (CH2M HILL, 2012).

EPA RPM Comment 2: *PAGE 24. In the third and seventh bullets, please clarify the text to indicate that maximum on-site concentrations will be compared to 95th percent UTL levels in the bg population. In the sixth bullet, please clarify that exposure point concentrations for gw will be based on the 95th percent UCL of the mean for wells in the most contaminated portion of the plume.*

Response: The text will be clarified on page 24 as follows:

(third bullet)

- If potentially unacceptable risks are identified associated with inorganics, the maximum detected inorganics concentrations will be compared to the base background 95 percent upper tolerance limits (UTLs) (CH2M HILL, 2011) to determine if the risks are associated with the site or background conditions. If risks are associated with background conditions, no further action or assessment based on human health will be required for inorganics in soil. If risks are not associated with base background conditions, the constituent will be identified as a constituent of concern (COC).

(seventh bullet)

- If potentially unacceptable risks are identified associated with inorganics, the maximum detected inorganics concentrations will be compared to the base background 95 percent UTLs to determine if the risks are associated with the site or background conditions. If all risks are associated with background conditions, no further action or assessment based on human health will be required for inorganics in groundwater. If risks are not associated with base background conditions, the constituent will be identified as a COC.

(sixth bullet)

- If COPCs are identified, human health risks will be evaluated for exposure to the COPCs indentified in groundwater for future industrial workers, residents, and construction workers. The 95 percent UCL of the mean for wells from the most contaminated portion of the groundwater plume (if a plume is identified) will be used as the exposure concentration for the risk calculations. If all risks are within acceptable USEPA risk levels, no further action/assessment based on human health will be required for groundwater.

EPA RPM Comment 3: *PAGE 25. According to the last paragraph on this page, 13 "co-located surface (0 to 6 inches) and subsurface (6 to 24 inches) soil samples will be collected" for the RI. Typically, subsurface soil samples are collected at intervals much deeper than a maximum of 24 inches. Are the top 24 inches at this site comprised*

of original soil (as compared to fill placed after operations)? If so, if contamination is observed in this interval, the full extent of contamination will have to be characterized at some point. If not, samples should be collected at a depth where contamination might be expected to be found based on historical site activities.

Response: It is assumed that the top 24 inches of soil at the AOC 6 TNT subareas consists of "original" soil, which may have been disturbed during construction and dismantling of the TNT Graining House and TNT Catch Boxes. It is also assumed that the top 24 inches of soil are more likely to be contaminated than deeper soil, and would be more likely to have higher site-related concentrations. While it is typically assumed for Ecological Risk Assessment (ERA) purposes that there are no significant ecological exposures to soil below 24 inches below ground surface (bgs), for Human Health Risk Assessment (HHRA) purposes, there is a potential for human exposure associated with soil contamination deeper than 24 inches bgs.

To address the potential for contamination at depths below 24 bgs, collection of a continuous soil core to the depth of the water table is proposed at SI sample location CAA06-SO01. This location is where the highest detections of explosives and inorganics were observed in surface and subsurface soil during the SI (see **Figure 5-14** (surface soil) and **Figure 5-15** (subsurface soil)**,** included in the **Attachments**). It is proposed that soil samples be collected from the continuous soil core at each 2-foot interval from 24 inches bgs to just above the water table depth (anticipated to be around 8-9.5' bgs). A graduated approach for analyzing the soil samples for explosives and inorganics will be conducted, beginning with the 24-48 inches bgs subsurface soil sample. If the detection(s) of explosives and/or inorganics exceed the current Residential Soil (Adjusted) Levels in the 24-48-inch sample, then the 48-72-inch sample will be analyzed for explosives and/or inorganics, and so on. This step-wise comparison of explosives and inorganics detections and soil analyses will continue until no exceedances of current Residential Soil (Adjusted) Levels are observed or the deepest subsurface soil sample collected at this location is analyzed. In addition to explosives and inorganics, these deeper soil samples will be analyzed for hexavalent chromium if hexavalent chromium is detected, and the concentration is above the RSL, in the sample interval above to determine whether or not the human health evaluation assumption that the chromium is in the hexavalent form is appropriate.

EPA RPM Comment 4: *FIGURE 4. The final step of this flow chart states that if maximum bg concentrations are not exceeded, then no further investigation or action is warranted. After many discussions on this topic, I believe the team agreed that this step (which has been consistently opposed by EPA) would be used as a single line of evidence and in conjunction with other information to help characterize sites, and not as a screen to eliminate sites. The Decision Tree should be modified to reflect this.*

Response: As discussed with the team as part of resolving the comments on the CAX Site 4 UFP-SAP, the intention of the Decision Tree (**Figure 4**) presented in the UFP-SAP is that comparison of COPC/COC concentrations to background 95% UTL data (or any other background-related criteria) will be conducted independently of the evaluation of potential risk through the completion of the human health and ecological risk assessments. Only in cases where potential human health or ecological risk is identified *and* comparison of site data to the background 95% UTLs indicates UTL exceedances, would further evaluation of the data with respect to consistency with background conditions be considered. In other words, should further evaluation methods (such as evaluating the magnitude of the 95% UTL exceedance and/or comparing to maximum background concentrations) be employed, they would only be utilized following the completion of the risk assessments. Therefore, the final step in the decision logic will be revised as follows:

(Section 2.3.2.1, last bullet under "Human Health Decision Logic")

(Section 2.3.2.2, last bullet under "Ecological Decision Logic")

- If the COC concentrations exceed the background 95 percent UTLs, further evaluation will be conducted to consider whether the COC concentrations are consistent with background conditions or if they represent a release such that further action is warranted.

The 2nd to last box in the decision logic (**Figure 4**) will be revised to state:

"Conduct further evaluation to consider whether the COC concentrations are consistent with background conditions or if they represent a release such that further action is warranted." In addition, the text label for the arrow from this box directed to the left will be revised to read "COC concentrations not indicative of a CERCLA-related release" and the arrow directed to the right to read "COC concentrations indicative of a CERCLA-related release."

EPA RPM Comment 5: *In an effort to completely and comprehensively characterize the contamination at this Site, it is highly recommended the laboratories performing the analyses report Tentatively Identified Compounds (TICs). TIC reporting is very useful in preventing chemical contaminants not previously screened for from being overlooked.*

Response: The Navy does not agree with EPA's recommendation to include reporting for TICs as part of the RI. When employed, TIC reporting is generally conducted during the initial phase of investigation when a site has not been characterized at all and when there is reason to believe that unconventional pollutants may have been released. At the CAX AOC 6 TNT subareas, multiple earlier phases of investigation have included full scan or an extensive variety of analytes likely to have been released, such that preliminary lists of COPCs by media have already been determined. As a result, the objectives of the current RI are collecting limited additional data to refine the spatial dataset to complete the characterization of the site and to refine the assessment of risks to human health and the environment. Moreover, experience has shown that generating TIC data at this stage of investigation will provide a very small likelihood of ultimately providing actionable information while creating substantial additional costs to analyze, report, tabulate, interpret, and manage TIC data. TIC results are fraught with uncertainty in nearly every aspect. Very often with TIC reporting, only the class of compound can be identified (e.g., "unidentified alkane"). In the event that a specific TIC can be identified by name, there is typically very little chance that any regulatory standards associated with the compound exist. The accuracy of reported TIC concentrations is also highly suspect, as the analytical instruments have not been calibrated with respect to these compounds. Finally, experience has shown that many reported TICs are not actually associated with the environmental samples, but are laboratory or sampling artifacts. In summary, it is the Navy's judgment that including TIC reporting as part of the RI would not be a cost-effective use of resources and would detract from the RI effort by creating additional and unnecessary uncertainty associated with the RI results.

EPA RPM Comment 6: *If any samples are split between laboratories, it is strongly recommended each laboratory perform the exact same method for the split sample analysis. It is also recommended each split sample be accompanied by blind Performance Evaluation (PE) samples*.

Response: Split sampling is not proposed as part of the CAX AOC 6 TNT subareas RI. As outlined in Section 3.3, Table 8, all soil and groundwater samples will be shipped to TriMatrix Labs in Grand Rapids, MI, with the exception of hexavalent chromium samples. All hexavalent samples will be shipped directly to Columbia Analytical Services, Inc. in Rochester, NY, due to the short hold time for this analyte. Explosives analyses will be performed at CAS-Rochester (8330) or CAS-Kelso (Nitroguanidine); however, because the hold time for explosives is not short, CH2M HILL will not ship directly to the subcontracted labs. TriMatrix will receive the explosives samples and then ship them to the other laboratories. There will be no duplication of analytical results among the respective laboratories. No changes were made to the SAP.

EPA RPM Comment 7: *Laboratory accreditation should be reviewed to ensure each is up to date.*

Response: As requested, prior to submittal of the Final SAP, laboratory accreditation will be reviewed by a CH2M HILL chemist to ensure that each is up to date.

EPA RPM Comment 8: *Note: United States Environmental Protection Agency Region III has made the National Functional Guidelines for performing Data Validation the standard.*

Response: The data validator may take guidance from the National Functional Guidelines (NFGs) when the guidance is relevant to the EPA and lab methods used for this RI. Note that the NFGs are specific to the evaluation of Contract Laboratory Program (CLP) methods; since no CLP methods are to be used for this RI, the validation

criteria specified in the NFGs are not directly applicable and may not be followed strictly. No changes were made to the SAP.

Comments received from USEPA via letter dated November 6, 2012

EPA RPM Comment 1: *Page 18, Numbers 1 and 2: The text needs to clearly state why the groundwater sample analysis (metals) is not the same as the soil sample analysis (SVOCs, explosives, and metals). Because soil constituents can migrate to groundwater, analysis for soil and groundwater should be for the same constituents.*

Response: Page 18, numbers 1 and 2, document the comments and decisions that were made by the CAX Partnering Team during the November 16, 2011 scoping session and should not be modified. The environmental questions being addressed during the RI and the sampling approach are presented in Section 2.3.3, and groundwater is addressed in this section starting on page 26. To clarify why SVOCs and explosives analyses are not proposed for the groundwater samples, the first bullet on page 26 will be revised as follows:

> ***The following work is proposed to answer this environmental question:*** Six permanent monitoring wells (**Figure 5**) will be installed in the AOC 6 TNT subareas and six groundwater samples will be collected and analyzed for inorganics (total and dissolved). The six groundwater samples will also be analyzed for natural attenuation parameters (wet chemistry parameters – alkalinity, chloride, nitrate, nitrite, sulfate, sulfide, methane, TOC, and pH) to support a natural attenuation evaluation, if necessary.
>
> Although the RI soil samples will be analyzed for SVOCs and explosives, the groundwater samples will not be analyzed for these parameters since none of these constituents were detected in groundwater at similar locations during the recent SI (see **Figure 5-16** included in the **Attachments**). In addition, the release occurred nearly 100 years ago, such that if soil contaminants were present at concentrations sufficient to allow significant migration from soil to groundwater, the SI results would have provided evidence of that result given that groundwater is only approximately 8-9.5 feet bgs and the matrix is sandy. Furthermore, the water solubility of 2,4,6-TNT, the explosive constituent with the highest concentrations in soil in October 2008, is relatively low and "in the case of impact areas, the majority of the TNT may be degraded in the surface soil, but small quantities can reach shallow ground water" (*Technical Fact Sheet – 2,4,6-Trinitrotouene (TNT)*, EPA 505-F-11-011, May 2012, included in the **Attachments**).
>
> In addition, the monitoring wells will be gauged and slug tests will be conducted in order to determine the groundwater flow direction and velocity.

EPA RPM Comment 2: *Page 18, Number 5: The text states "The Team agreed not to include the groundwater data in the ERA in this RI." It is not clear if adequate sediment and surface water data from Penniman Lake have been collected to identify contaminant migration from this site to Penniman Lake in order to address ecological risk in Penniman Lake. The text needs to clearly state that data in Penniman Lake is limited and additional sampling will be needed as part of the Penniman Lake RI to assess impacts from this site.*

Response: Page 18, number 5, documents the comments and decisions that were made by the CAX Partnering Team during the November 16, 2011 scoping session and should not be modified. Although the text included in the last paragraph of Section 2.2.3 does state that additional surface water and sediment sampling will occur during the Penniman Lake RI, this text will be revised as follows:

> The SI data indicate that exposure to surface water and sediment in Penniman Lake adjacent to the AOC 6 TNT subareas would not be expected to result in any unacceptable human health or ecological risks. However, based on the limited surface water and sediment data from the AOC 6 TNT subareas and per Team agreement (November 2011 scoping session), any future investigation of Penniman Lake surface water and sediment will be evaluated as part of a separate Penniman Lake RI and these media will not be sampled during this RI.

EPA RPM Comment 3: *Section 2.2.1 on page 21 states that a Final Site Inspection (SI) Narrative Report for the Penniman Shell Loading Plant was prepared in 1999 and found that one explosive and several metals exceeded the*

1999 EPA Region 3 risk-based concentrations. Based on these results, it appears that the sample analysis in the 2008 SI was limited to SVOCs, explosives, metals, and cyanide; and pesticides and PCBs were not analyzed. Additional justification needs to be provided for eliminating these analytes in the 2008 SI and the current investigation as the original results in 1999 were only compared to human health criteria and did not consider exceedances of ecological criteria.

Response: As reported in the *Final Site Inspection Narrative Report, Penniman Shell Loading Plant, Williamsburg, Virginia* (Weston, 1999), the AOC 6 TNT subareas waste source contaminants that exceeded the Region III RBCs included inorganics and explosives. Specifically, **Table 1** of the 1999 Site Inspection (SI) Report (Weston, 1999) identified these contaminants as 2,4,6-TNT, arsenic, cadmium, lead, and manganese and the analytical results are included in **Table A-1** in the **Attachments** to these RTCs. As listed in **Table A-1**, the 1999 soil sample results included low, estimated detections of pesticides and no detections for PCBs. Therefore, during the development of the recent SI UFP-QAPP (CH2M HILL, 2008), the Partnering Team agreed that full suite analyses were not necessary and the samples would be analyzed for SVOCs, explosives, and inorganics (including cyanide) (SVOCs were added at the request of USEPA).

Since the low, estimated concentrations of detected pesticides in the 1999 soil samples are typical of pesticides being used as intended and were not considered to represent a CERCLA release. PCBs were not detected in the 1999 soil samples. Consequently, analyses for pesticides and PCBs were eliminated for the recent SI and are not proposed for this RI.

EPA RPM Comment 4: *Section 2.2.1 on page 21 states that since no potential human health or ecological risks were identified for sediment and surface water and a remedial investigation for Penniman Lake is planned, no further action was recommended for these media as part of AOC 6. A similar statement is made in Section 2.2.3 on page 22. It is unclear how the conclusion of no ecological risk was reached since screening levels were exceeded in sediment for explosives and metals and in surface water for metals. Since only one sediment sample was collected, the extent of the contamination and potential risk in Penniman Lake is undefined. This area of Penniman Lake should be further evaluated as part of the Penniman Lake remedial investigation.*

Response: As documented in the Final SI Report (CH2M HILL, 2012), no refined COPCs were identified based on the ecological risk evaluation conducted for Penniman Lake surface water and sediment adjacent to AOC 6. Thus, no unacceptable ecological risks are associated with these media based upon the data set utilized in the Final SI report. Nonetheless, this area of Penniman Lake will be further evaluated as part of the Penniman Lake RI. See also the response to EPA RPM Comment 2 above.

EPA RPM Comment 5: *Page 22, Section 2.2.3 Distribution of Contamination: The text indicates that the soil in the western and northeastern portions of the site was not sampled. Therefore additional soil samples are required to fill this data gap. While the existing SI data may suggest a limited number of contaminants, this is based on a very limited number of samples. All of the contaminants included in the original SI analyses need to be included in the subsequent RI sampling analysis because of the uncertainty with limiting the analyte list based on limited sampling.*

Response: The 2008 soil sample locations are shown in **Figure 5-7** (from the SI report, which has been attached to these RTCs for reference purposes) in the **Attachments**. In order to address the 2008 SI sampling data gaps in the western and northeastern portions of the site, surface and subsurface soil samples are proposed during the RI field activities, as shown on **Figure 5 (Revised)** in the **Attachments**.

The original SI soil analyses conducted in 2008 included SVOCs, explosives, and inorganics. The SI constituents analyzed for in 2008 are included in the proposed RI analyses with the exception of SVOCs.

Only one SVOC, 2,4-dinitrotoluene (DNT), was detected in the 2008 SI soil samples at concentrations that exceeded HHRA screening values; ERA screening values were also not exceeded. As agreed to by the CAX Partnering Team during the March 2012 scoping session, SVOC analysis for soil samples was removed from the RI UFP-SAP since:

- 2,4-DNT was the only SVOC constituent that exceeded any risk screening criteria (HHRA, but not ERA) in the soil samples
- the exceedance occurred at only one sample location, and
- 2,4-DNT is included as an analyte in the explosives analysis proposed for the RI

No changes were made to the SAP.

EPA RPM Comment 6: *Section 2.2.2 on page 22 states that surficial runoff from the AOC 6 TNT subareas flows primarily east toward Penniman Lake and southeast toward King Creek. The section further states that groundwater is expected to flow east to Penniman Lake and southeast toward King Creek. Based on the migration pathway, it is unclear why no samples have been collected and none are proposed for collection in King Creek. This represents a data gap that will need to be addressed as part of this or another investigation. This issue should be discussed.*

Response: As stated in Section 2.2.2, page 22, groundwater is expected to flow east toward Penniman Lake and southeast toward King Creek. However, the expected groundwater flow directions have not been demonstrated, nor has a pathway for the migration of contaminants to King Creek via groundwater been confirmed. Therefore, the collection of samples from King Creek is premature and not proposed as part of the RI.

As documented in Section 2.1.1, page 18, number 2, data will be collected during the RI to allow for the determination of the groundwater flow directions and flow velocities at the AOC 6 TNT subareas. Presently, based on the results of the recent SI, there is not enough information to conclude that significant groundwater contamination is present at the AOC 6 TNT subareas. Until the nature and extent of significant contamination in groundwater, if any, is delineated and the potential risk to human health and ecological receptors is evaluated during the RI, it is premature to collect samples from King Creek.

EPA RPM Comment 7: *Section 2.2.6 on page 23 states that due to the small size of the potentially impacted area, potential exposures for upper trophic level receptors (e.g., birds and mammals) are not likely to be significant. Therefore, no food chain modeling will be performed as part of the ecological risk assessment. BTAG does not support this approach particularly since the extent of contamination is not well defined. BTAG recommends addressing potential risk to upper trophic level receptors, particularly those with smaller home ranges (e.g., American robin [Turdus migratorius] and short-tailed shrew [Blarina brevicauda]). Because of their small home range, small body size, and high ingestion rates, these receptors would be sensitive to contaminants found at the site.*

Response: This is the same approach that was used in the Final SI report. Specifically, no food web modeling was conducted during the SI for this site, as explained and documented in Appendix B of the Final SI Report, as part of the ecological risk assessment (ERA) methodology and conceptual site model (CSM). Because the basic ecological conceptual model for the site has not changed, nor has the size of the site (less than 1 acre), this approach has also been retained for the RI. No changes were made to the SAP in response to this comment.

EPA RPM Comment 8: *Page 24, Section 2.3.2 Data Quality Objectives: In order to know that analytes are undetected, the quantitation levels (QLs) need to be lower than the respective ecological screening values. If this is not the case, then those contaminants will need to be retained as contaminants of potential concern.*

Response: The Project Action Limits (PALs), Quantitation Limits (QLs), and laboratory limits are provided in Appendix A, Table A1-1 of the SAP. Undetected constituents whose maximum sample-specific reporting limit exceeds an ecological screening value will be retained as a COPC in Step 2 of the ERA for that medium. In Step 3A, these constituents will be evaluated further as part of the uncertainty evaluation.

EPA RPM Comment 9: *Section 2.3.2.2 on page 25 states that to evaluate potential ecological risk, mean soil concentrations will be compared with soil ecological screening values (ESVs). If soil concentrations are below soil ESVs, the chemical will not be considered a contaminant of potential concern. The magnitude of the maximum*

hazard quotient will also be considered when making this determination. This approach is unacceptable. Because soil invertebrates and plants have limited or no mobility, potential risk from individual hot spots should also be evaluated. Any soil samples with concentrations exceeding ESVs present potential risk to plants and soil invertebrates.

Response: The text of the first bullet in this subsection will be modified to indicate that both the mean and 95% UCL of the mean will be calculated and used in the evaluation, with the 95% UCL used as the primary decision EPC in Step 3A of the ERA (with consideration of the mean and maximum concentrations, as appropriate). This is consistent with Navy ERA guidance and also appropriate for population-based assessment endpoints.

EPA RPM Comment 10: *Page 26, Section 2.3.3: The first bullet indicates 6 permanent monitoring wells will be installed. Figure 5 shows the locations of these wells and there is no well located on the west side of these former structures. An adequate explanation for this potential data gap needs to be included in this section or else another permanent monitoring well needs to be added.*

Response: In order to address this potential data gap, the locations of the proposed northern-most monitoring well and western-most co-located surface and subsurface soil sample within the yellow AOC 6 TNT subareas boundary will be switched, as shown on the revised **Figure 5** in the **Attachments**.

EPA RPM Comment 11: *Section 2.5 on page 33 states that during meetings, the Partnering Team discussed and agreed to the proposed sampling rationale for the this site. Figure 5 presents the proposed sample locations for each medium to be evaluated. Within the boundaries of the former graining house sump (no samples) and catch box ruins (1 sample) sampling is too limited. A minimum of three soil samples should be taken within the footprint of each of the ruins of the TNT Graining House and the Catch Box ruins.*

Response: The footprint of the former Catch Box Ruins is approximately 21 feet long (parallel to Penniman Lake) and 9 feet wide on the shorter side (perpendicular to Penniman Lake), and consists of an earthen, brick-lined depression. The depth of this depression varies depending on where one stands within it, from approximately two feet deep (along the short side closest to Garrison Road) to approximately 5.5 feet deep (along the opposite short side). Based on the small area, one sample in the center of the depression is adequate. In addition, this sample will be collected from the lowest point of the depression where the highest concentrations of potential contaminants are most likely.

The remains of the former TNT Graining House consist of a concrete-lined, open-top pit believed to be the sump pit of the former TNT Graining House. This open-top pit is 42 feet, 2 ½ inches long (perpendicular to Penniman Lake) and 20 feet, 1 inch wide (parallel to Penniman Lake). Collection of any soil samples within this concrete-lined pit consists of organic debris that has collected in this area and does not represent native soil conditions. As such, additional sampling within the footprint of the former TNT Graining House is not possible. The proposed RI samples, in conjunction with the SI samples, adequately characterize the site.

During the recent SI, soil samples were collected to the southeast and adjacent to the former TNT Graining House where the greatest potential for contaminant migration exists. The proposed RI soil sample locations shown on **Figure 5 (Revised)** have been positioned to address any data gaps in potential contaminant migration directly south, southwest, and west of the former TNT Graining House. No changes were made to the SAP

EPA RPM Comment 12: *Section 2.3.4 on page 27 states that literature-based ESVs for plants and soil invertebrates will be used as project action limits to identify contaminants of potential concern for ecological receptors. The specific values are provided in Tables A1-1 and A1-2 in Appendix A-1. However, the basis for the values is not provided. BTAG strongly recommends that the EPA Eco-SSLs be used when available to assess ecological risk to invertebrates and plants. Other similarly conservative screening levels from the literature can be used if Eco-SSLs are not available.*

Response: A table showing the specific reference for each ESV will be added to the SAP as an attachment to Appendix A. For soil, the lower of the plant and soil invertebrate Eco-SSLs will be used as the ESV for chemicals with such values.

EPA RPM Comment 13: *Page 27, Section 2.3.4: The text states "Identified COPCs will be used in a quantitative…ERA (through Step 3a) to identify the COPCs for each medium." This sentence is confusing. Please re-write to clarify how the first set of COPCs differs from the second set of COPCs.*

Response: Because the PALs are derived from risk-based screening values, the comparison to PALs specified in the first sentence of this subsection constitutes a screening-level comparison (e.g., Step 2 of the ERA process) that results in a set of COPCs. The sentence referenced in the comment will be revised as follows:

> Identified COPCs from the screening-level comparison to PALs will be used in a quantitative HHRA (in accordance with USEPA guidance) and an ERA (through Step 3A) to calculate potential risks to human and ecological receptors, and to identify baseline COPCs for each medium.

Comments received from VDEQ via email dated December 12, 2012

VDEQ Comment 1: *Please replace John Burchette with Susanne Haug, EPA RPM, throughout document as appropriate.*

Response: The SAP will be revised to list the current USEPA RPM, Susanne Haug, where appropriate.

VDEQ Comment 2: *Please revise Figure 2 to indicate that the Ammonia Settling Pits are part of the AOC 6 Approximate Study Area Boundary and not included in the Approximate AOC 6 TNT Subareas Study Boundary.*

Response: To indicate that the Ammonia Settling Pits subarea are a subarea of AOC 6, and not included as part of the TNT Subareas Study Boundary, **Figure 2** will be revised by removing the yellow hash marks within the Ammonia Settling Pits boundary.

Attachments

TABLE A-1
AOC 6 - 1999 Soil Sampling Results
Cheatham Annex
Williamsburg, Virginia

Sample Location Area	TNT Graining House Sump	TNT Graining House Sump	TNT Catch Box Ruins
Sample ID	PEN1-SO-03[2]	PEN1-SO-03A[1,2]	PEN1-SO-04[2]
Sample Date	01/12/99	01/12/99	01/12/99
Chemical Name			
Volatile Organic Compounds (UG/KG)			
Chloroform	3 B	**10 J**	12 U
Styrene	**2.66666667 J**	20 UJ	12 U
Xylene (total)	20 U	20 UJ	12 U
Semi-volatile Organic Compounds (UG/KG)			
Naphthalene	660 U	670 U	400 U
2-Methylnaphthalene	660 U	670 U	400 U
Dibenzofuran	660 U	670 U	400 U
2,4-Dinitrotoluene	660 U	670 U	**111.76 J**
Diethyl phthalate	660 U	670 U	400 U
Phenanthrene	**42 J**	**34 J**	**2.8 J**
Di-n-butyl phthalate	660 U	670 U	400 U
Fluoranthene	**42 J**	**48 J**	**25 J**
Pyrene	**1300**	**1500**	**510**
Benzo(a)anthracene	**97.67 J**	**125.58 J**	**21.86 J**
Chrysene	**740**	**840 J**	**30.23 J**
Benzo(b)fluoranthene	**33 J**	**38 J**	**3.6 J**
Benzo(k)fluoranthene	**31 J**	**37 J**	**4.5 J**
Benzo(a)pyrene	**47 J**	**55 J**	400 U
Ideno(1,2,3-cd)pyrene	**22.47 J**	**22.47 J**	400 U
Dibenz(a,h)anthracene	**15.73 J**	**19.1 J**	400 U
Benzo(g,h,i)perylene	**26 J**	**35 J**	400 U
Nitroaromatics (MG/KG)			
2,4,6-Trinitrotoluene	**26**	**28**	**620**
2-Amino-4,6-dinitrotoluene	**1.8 J**	1.8 U	18 U
Pesticide/Polychlorinated Biphenyls (UG/KG)			
Endosulfan I	**16 J**	**14 J**	**11 J**
Dieldrin	66 U	**1.35 J**	80 U
4,4'-DDE	**0.9 J**	**1.2 J**	**0.48 J**
Endrin	**4 J**	67 U	80 U
Endosulfan II	**0.43 J**	67 U	80 U
4,4'-DDD	**0.72 J**	67 U	80 U
Endrin ketone	**1.2 J**	**1.8 J**	80 U
Endrin aldehyde	66 U	67 U	80 U
alpha-Chlordane	34 U	35 U	41 U
Inorganics (MG/KG)			
Aluminum	**2150**	**2730**	**7760**
Antimony	2.9 B	2.2 B	**UL**
Arsenic	**12.5**	**15.5**	**11**
Barium	**283**	**203**	**34.5**
Beryllium	**0.18**	**0.17**	**0.36**
Cadmium	**4**	**4**	UL
Calcium	**7983.33 J**	**7633.33 J**	**768.33 J**
Chromium	**14.8**	**22.7**	**15.1**
Cobalt	**5.3**	**6.4**	**2.4**
Copper	**27.9**	**32.1**	**4.09 J**
Iron	**70800**	**101000**	**20000**
Lead	**7580**	**7750**	**813**
Magnesium	**605 J**	**900 J**	**648**
Manganese	**705**	**886**	**65.42 J**
Mercury	**0.49**	**0.6**	**0.07**
Nickel	**15.6**	**17.4**	**5.4**
Potassium	**485**	**570**	**722**
Selenium	**3.9**	**3.7 L**	U
Silver	**2.7**	**4**	**0.76**
Sodium	**147**	**168**	**74.7**
Vanadium	**28**	**31.8**	**22.5**
Zinc	**1010**	**1150**	**87.69 J**
Cyanide	**0.57**	**1.2**	**0.07 L**

NOTES:

Detections of a chemical are indicated in bold font.

[1]Duplicate of PEN-SO-03

[2]Data as reported in the *Final Site Inspection Narrative Report, Penniman Shell Loading Plant, Williamsburg, Virginia* by Roy F. Weston, Inc., August 9, 1999.

U = Compound not detected.

J = Analyte present. Reported value may or may not be accurate or precise.

L = Analyte present. Reported value may be biased low. Actual value is expected to be higher.

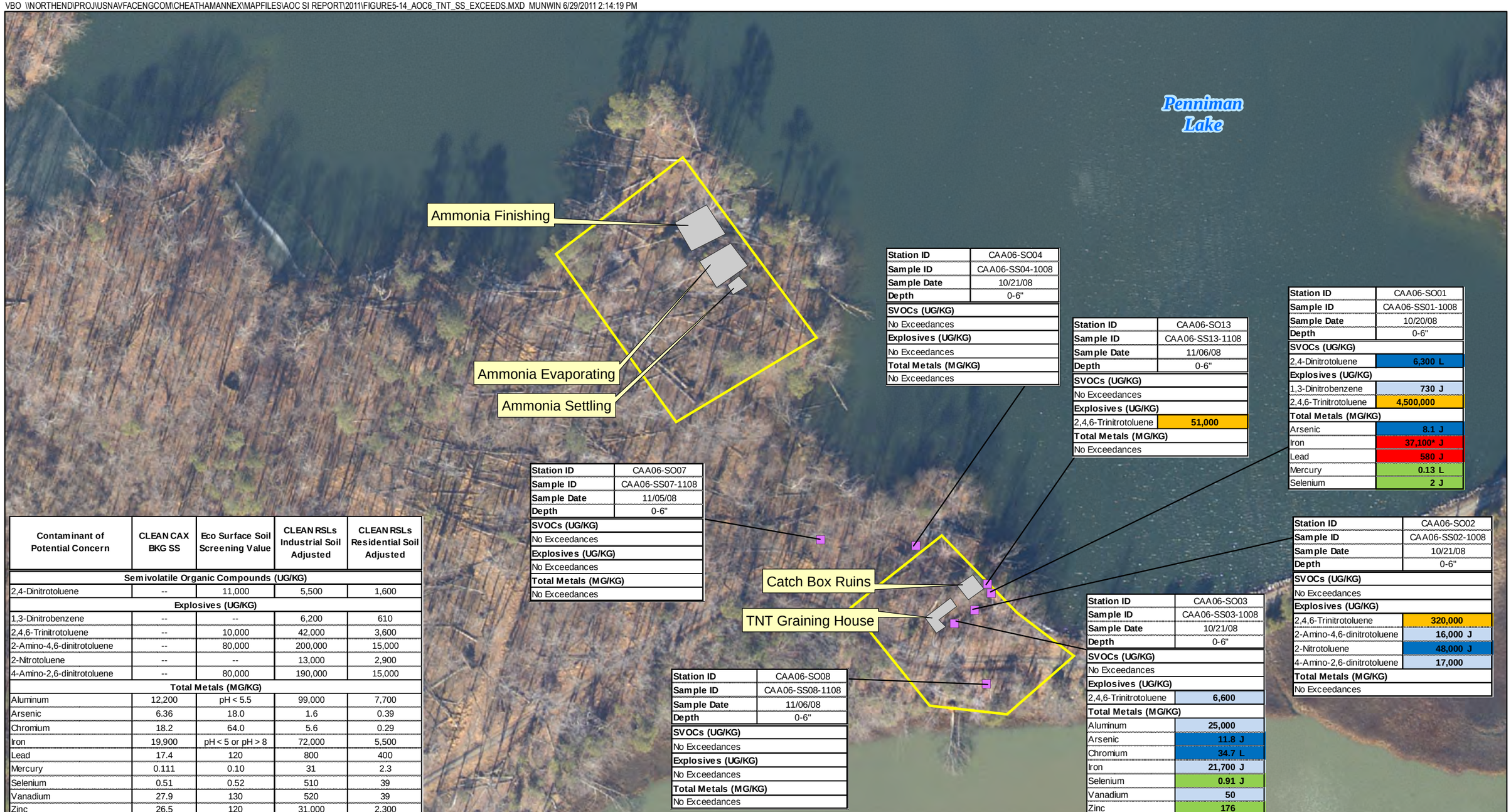
UL = Not detected, quantitation limit is probably higher.

B = Not detected substantially above the level reported in laboratory or field blanks.

K = Analyte present. Reported value may be biased high. Actual value is expected to be lower.

UJ = Not detected, quantitation limit may be inaccurate or imprecise.

VBO \\NORTHEND\PROJ\USNAVFACENGCOM\CHEATHAMANNEX\MAPFILES\AOC SI REPORT\2011\FIGURE5-14_AOC6_TNT_SS_EXCEEDS.MXD MUNWIN 6/29/2011 2:14:19 PM



Station ID	CAA06-SO04
Sample ID	CAA06-SS04-1008
Sample Date	10/21/08
Depth	0-6"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
No Exceedances	
Total Metals (MG/KG)	
No Exceedances	

Station ID	CAA06-SO13
Sample ID	CAA06-SS13-1108
Sample Date	11/06/08
Depth	0-6"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
2,4,6-Trinitrotoluene	51,000
Total Metals (MG/KG)	
No Exceedances	

Station ID	CAA06-SO01
Sample ID	CAA06-SS01-1008
Sample Date	10/20/08
Depth	0-6"
SVOCs (UG/KG)	
2,4-Dinitrotoluene	6,300 L
Explosives (UG/KG)	
1,3-Dinitrobenzene	730 J
2,4,6-Trinitrotoluene	4,500,000
Total Metals (MG/KG)	
Arsenic	8.1 J
Iron	37,100* J
Lead	580 J
Mercury	0.13 L
Selenium	2 J

Station ID	CAA06-SO07
Sample ID	CAA06-SS07-1108
Sample Date	11/05/08
Depth	0-6"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
No Exceedances	
Total Metals (MG/KG)	
No Exceedances	

Station ID	CAA06-SO02
Sample ID	CAA06-SS02-1008
Sample Date	10/21/08
Depth	0-6"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
2,4,6-Trinitrotoluene	320,000
2-Amino-4,6-dinitrotoluene	16,000 J
2-Nitrotoluene	48,000 J
4-Amino-2,6-dinitrotoluene	17,000
Total Metals (MG/KG)	
No Exceedances	

Station ID	CAA06-SO03
Sample ID	CAA06-SS03-1008
Sample Date	10/21/08
Depth	0-6"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
2,4,6-Trinitrotoluene	6,600
Total Metals (MG/KG)	
Aluminum	25,000
Arsenic	11.8 J
Chromium	34.7 L
Iron	21,700 J
Selenium	0.91 J
Vanadium	50
Zinc	176

Station ID	CAA06-SO08
Sample ID	CAA06-SS08-1108
Sample Date	11/06/08
Depth	0-6"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
No Exceedances	
Total Metals (MG/KG)	
No Exceedances	

Contaminant of Potential Concern	CLEAN CAX BKG SS	Eco Surface Soil Screening Value	CLEAN RSLs Industrial Soil Adjusted	CLEAN RSLs Residential Soil Adjusted
Semivolatile Organic Compounds (UG/KG)				
2,4-Dinitrotoluene	--	11,000	5,500	1,600
Explosives (UG/KG)				
1,3-Dinitrobenzene	--	--	6,200	610
2,4,6-Trinitrotoluene	--	10,000	42,000	3,600
2-Amino-4,6-dinitrotoluene	--	80,000	200,000	15,000
2-Nitrotoluene	--	--	13,000	2,900
4-Amino-2,6-dinitrotoluene	--	80,000	190,000	15,000
Total Metals (MG/KG)				
Aluminum	12,200	pH < 5.5	99,000	7,700
Arsenic	6.36	18.0	1.6	0.39
Chromium	18.2	64.0	5.6	0.29
Iron	19,900	pH < 5 or pH > 8	72,000	5,500
Lead	17.4	120	800	400
Mercury	0.111	0.10	31	2.3
Selenium	0.51	0.52	510	39
Vanadium	27.9	130	520	39
Zinc	26.5	120	31,000	2,300

Legend

- Soil Sample Location
- Approximate AOC 6 Study Area
- Buildings

Notes:

- Exceeds BKG & ECO
- Exceeds BKG & Res RSL
- Exceeds BKG, ECO & Res RSL
- Exceeds BKG, Res & Ind RSLs
- Exceeds BKG, ECO, Res & Ind RSLs

*Eco exceedance due to pH value
-- - No value available
J - Analyte present, value may or may not be accurate or precise
L - Analyte present, value may be biased low, actual value may be higher
UG/KG - Micrograms per kilogram
MG/KG - Milligrams per kilogram

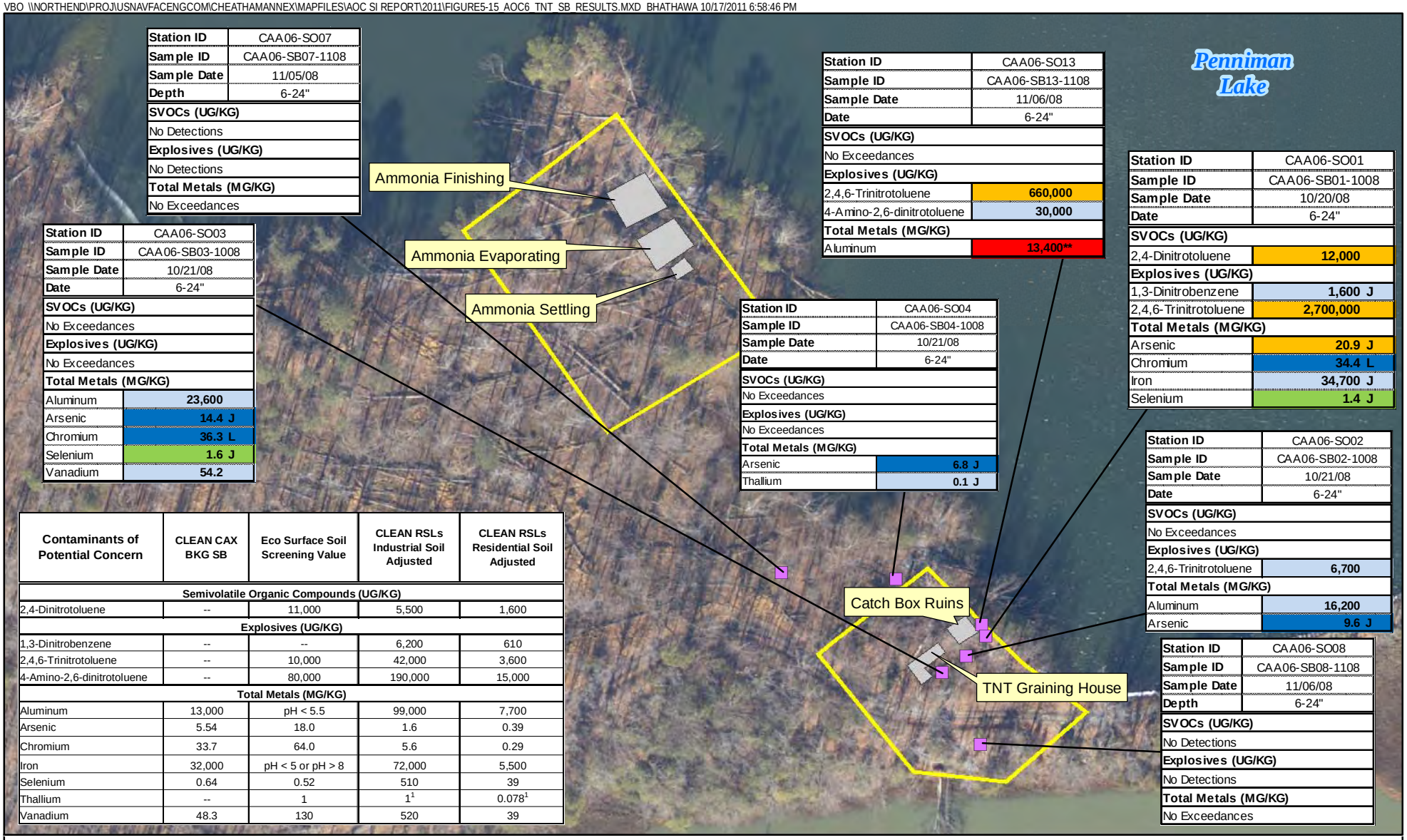
N W E S

0 100 200 Feet

Figure 5-14
AOC 6 Surface Soil Exceedance Results
TNT Graining House and Catch Box Ruins Subarea
Site Inspection Report
Areas of Concern 1, 2, 6, 7, and 8
Cheatham Annex
Williamsburg, Virginia

CH2MHILL

VBO \\NORTHEND\PROJ\USNAVFACENGCOM\CHEATHAMANNEX\MAPFILES\AOC SI REPORT\2011\FIGURE5-15_AOC6_TNT_SB_RESULTS.MXD BHATHAWA 10/17/2011 6:58:46 PM



Station ID	CAA06-SO07
Sample ID	CAA06-SB07-1108
Sample Date	11/05/08
Depth	6-24"
SVOCs (UG/KG)	
No Detections	
Explosives (UG/KG)	
No Detections	
Total Metals (MG/KG)	
No Exceedances	

Station ID	CAA06-SO03
Sample ID	CAA06-SB03-1008
Sample Date	10/21/08
Date	6-24"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
No Exceedances	
Total Metals (MG/KG)	
Aluminum	23,600
Arsenic	14.4 J
Chromium	36.3 L
Selenium	1.6 J
Vanadium	54.2

Station ID	CAA06-SO13
Sample ID	CAA06-SB13-1108
Sample Date	11/06/08
Date	6-24"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
2,4,6-Trinitrotoluene	660,000
4-Amino-2,6-dinitrotoluene	30,000
Total Metals (MG/KG)	
Aluminum	13,400**

Station ID	CAA06-SO04
Sample ID	CAA06-SB04-1008
Sample Date	10/21/08
Date	6-24"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
No Exceedances	
Total Metals (MG/KG)	
Arsenic	6.8 J
Thallium	0.1 J

Station ID	CAA06-SO01
Sample ID	CAA06-SB01-1008
Sample Date	10/20/08
Date	6-24"
SVOCs (UG/KG)	
2,4-Dinitrotoluene	12,000
Explosives (UG/KG)	
1,3-Dinitrobenzene	1,600 J
2,4,6-Trinitrotoluene	2,700,000
Total Metals (MG/KG)	
Arsenic	20.9 J
Chromium	34.4 L
Iron	34,700 J
Selenium	1.4 J

Station ID	CAA06-SO02
Sample ID	CAA06-SB02-1008
Sample Date	10/21/08
Date	6-24"
SVOCs (UG/KG)	
No Exceedances	
Explosives (UG/KG)	
2,4,6-Trinitrotoluene	6,700
Total Metals (MG/KG)	
Aluminum	16,200
Arsenic	9.6 J

Station ID	CAA06-SO08
Sample ID	CAA06-SB08-1108
Sample Date	11/06/08
Depth	6-24"
SVOCs (UG/KG)	
No Detections	
Explosives (UG/KG)	
No Detections	
Total Metals (MG/KG)	
No Exceedances	

Contaminants of Potential Concern	CLEAN CAX BKG SB	Eco Surface Soil Screening Value	CLEAN RSLs Industrial Soil Adjusted	CLEAN RSLs Residential Soil Adjusted
Semivolatile Organic Compounds (UG/KG)				
2,4-Dinitrotoluene	--	11,000	5,500	1,600
Explosives (UG/KG)				
1,3-Dinitrobenzene	--	--	6,200	610
2,4,6-Trinitrotoluene	--	10,000	42,000	3,600
4-Amino-2,6-dinitrotoluene	--	80,000	190,000	15,000
Total Metals (MG/KG)				
Aluminum	13,000	pH < 5.5	99,000	7,700
Arsenic	5.54	18.0	1.6	0.39
Chromium	33.7	64.0	5.6	0.29
Iron	32,000	pH < 5 or pH > 8	72,000	5,500
Selenium	0.64	0.52	510	39
Thallium	--	1	1[1]	0.078[1]
Vanadium	48.3	130	520	39

Legend

- Soil Sample Location
- Approximate AOC 6 Study Area
- Buildings

Notes:

[1]Adjusted June 2011 RSL value
* Indicates duplicate sample was collected at this location. Values presented are the higher of the two.
**Eco exceedance due to pH value
-- - No value available
J - Analyte present, value may or may not be accurate or precise
L - Analyte present, value may be biased low, actual value may be higher

UG/KG - Micrograms per kilogram
MG/KG - Milligrams per kilogram

- Exceeds BKG & ECO
- Exceeds BKG & Res RSL
- Exceeds BKG, ECO & Res RSL
- Exceeds BKG, Res & Ind RSLs
- Exceeds BKG, ECO, Res & Ind RSLs

N W E S

0 60 120 Feet

Figure 5-15
AOC 6 Subsurface Soil Exceedance Results
TNT Graining House and Catch Box Ruins Subarea
Site Inspection Report
Areas of Concern 1, 2, 6, 7, and 8
Cheatham Annex
Williamsburg, Virginia

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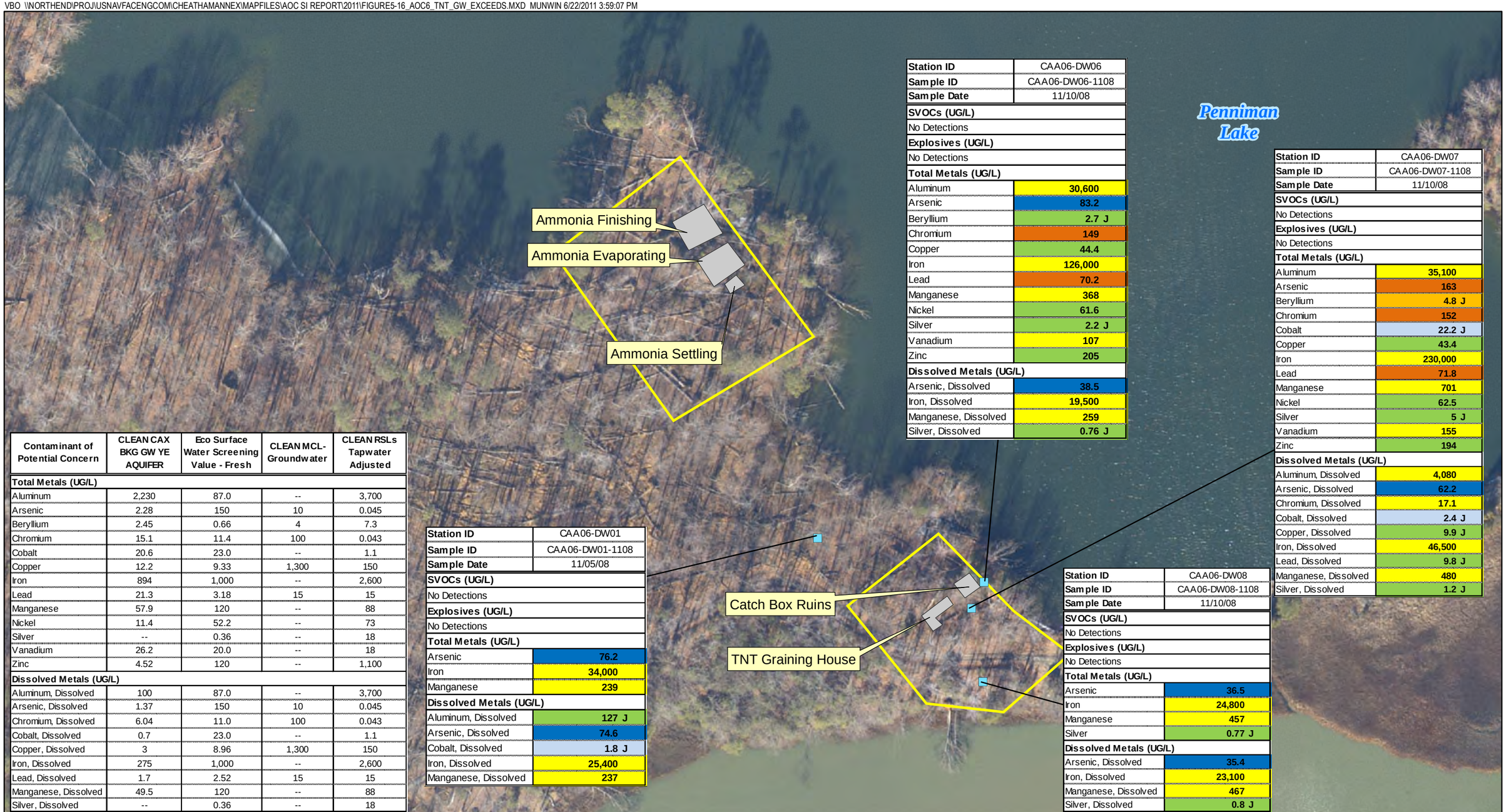
VBO \\NORTHEND\PROJ\USNAVFACENGCOM\CHEATHAMANNEX\MAPFILES\AOC SI REPORT\2011\FIGURE5-16_AOC6_TNT_GW_EXCEEDS.MXD MUNWIN 6/22/2011 3:59:07 PM



Station ID	CAA06-DW06
Sample ID	CAA06-DW06-1108
Sample Date	11/10/08
SVOCs (UG/L)	
No Detections	
Explosives (UG/L)	
No Detections	
Total Metals (UG/L)	
Aluminum	30,600
Arsenic	83.2
Beryllium	2.7 J
Chromium	149
Copper	44.4
Iron	126,000
Lead	70.2
Manganese	368
Nickel	61.6
Silver	2.2 J
Vanadium	107
Zinc	205
Dissolved Metals (UG/L)	
Arsenic, Dissolved	38.5
Iron, Dissolved	19,500
Manganese, Dissolved	259
Silver, Dissolved	0.76 J

Station ID	CAA06-DW07
Sample ID	CAA06-DW07-1108
Sample Date	11/10/08
SVOCs (UG/L)	
No Detections	
Explosives (UG/L)	
No Detections	
Total Metals (UG/L)	
Aluminum	35,100
Arsenic	163
Beryllium	4.8 J
Chromium	152
Cobalt	22.2 J
Copper	43.4
Iron	230,000
Lead	71.8
Manganese	701
Nickel	62.5
Silver	5 J
Vanadium	155
Zinc	194
Dissolved Metals (UG/L)	
Aluminum, Dissolved	4,080
Arsenic, Dissolved	62.2
Chromium, Dissolved	17.1
Cobalt, Dissolved	2.4 J
Copper, Dissolved	9.9 J
Iron, Dissolved	46,500
Lead, Dissolved	9.8 J
Manganese, Dissolved	480
Silver, Dissolved	1.2 J

Station ID	CAA06-DW01
Sample ID	CAA06-DW01-1108
Sample Date	11/05/08
SVOCs (UG/L)	
No Detections	
Explosives (UG/L)	
No Detections	
Total Metals (UG/L)	
Arsenic	76.2
Iron	34,000
Manganese	239
Dissolved Metals (UG/L)	
Aluminum, Dissolved	127 J
Arsenic, Dissolved	74.6
Cobalt, Dissolved	1.8 J
Iron, Dissolved	25,400
Manganese, Dissolved	237

Station ID	CAA06-DW08
Sample ID	CAA06-DW08-1108
Sample Date	11/10/08
SVOCs (UG/L)	
No Detections	
Explosives (UG/L)	
No Detections	
Total Metals (UG/L)	
Arsenic	36.5
Iron	24,800
Manganese	457
Silver	0.77 J
Dissolved Metals (UG/L)	
Arsenic, Dissolved	35.4
Iron, Dissolved	23,100
Manganese, Dissolved	467
Silver, Dissolved	0.8 J

Contaminant of Potential Concern	CLEAN CAX BKG GW YE AQUIFER	Eco Surface Water Screening Value - Fresh	CLEAN MCL-Groundwater	CLEAN RSLs Tapwater Adjusted
Total Metals (UG/L)				
Aluminum	2,230	87.0	--	3,700
Arsenic	2.28	150	10	0.045
Beryllium	2.45	0.66	4	7.3
Chromium	15.1	11.4	100	0.043
Cobalt	20.6	23.0	--	1.1
Copper	12.2	9.33	1,300	150
Iron	894	1,000	--	2,600
Lead	21.3	3.18	15	15
Manganese	57.9	120	--	88
Nickel	11.4	52.2	--	73
Silver	--	0.36	--	18
Vanadium	26.2	20.0	--	18
Zinc	4.52	120	--	1,100
Dissolved Metals (UG/L)				
Aluminum, Dissolved	100	87.0	--	3,700
Arsenic, Dissolved	1.37	150	10	0.045
Chromium, Dissolved	6.04	11.0	100	0.043
Cobalt, Dissolved	0.7	23.0	--	1.1
Copper, Dissolved	3	8.96	1,300	150
Iron, Dissolved	275	1,000	--	2,600
Lead, Dissolved	1.7	2.52	15	15
Manganese, Dissolved	49.5	120	--	88
Silver, Dissolved	--	0.36	--	18

Legend

- Groundwater/Soil Sample Location
- Approximate AOC 6 Study Area
- Buildings

Notes:

- Exceeds BKG & ECO
- Exceeds BKG & Tapwater RSL
- Exceeds BKG, Tapwater RSL & MCL
- Exceeds BKG, ECO & Tapwater RSL
- Exceeds BKG, ECO & MCL
- Exceeds BKG, ECO, Tapwater RSL & MCL

-- - No value available
J - Analyte present, value may or may not be accurate or precise
UG/L - Micrograms per liter

N
W E
S

0 100 200 Feet

Figure 5-16
AOC 6 Groundwater Exceedance Results
TNT Graining House and Catch Box Ruins Subarea
Site Inspection Report
Areas of Concern 1, 2, 6, 7, and 8
Cheatham Annex
Williamsburg, Virginia

CH2MHILL

Technical Fact Sheet – 2,4,6-Trinitrotoluene (TNT)

May 2012

At a Glance

- Highly explosive, yellow, odorless solid.
- Synthetic product that does not occur naturally in the environment.
- Has been used extensively in the manufacture of explosives and accounts for a large part of the explosives contamination at active and former U.S. military installations.
- Sorbed by most soils, limiting its migration to water.
- Not expected to persist for a long period of time in surface waters because of transformation processes.
- Classified as a Group C (possible human) carcinogen.
- Primarily damages the liver and blood systems if inhaled or ingested.
- SW8515 is a field screening method used to detect TNT in soil by colorimetric screening.
- The primary laboratory methods include liquid and gas chromatography.
- Potential treatment technologies include in situ bioremediation, granular activated carbon treatment, composting, and incineration.

Introduction

This fact sheet, developed by the U.S. Environmental Protection Agency (EPA) Federal Facilities Restoration and Reuse Office (FFRRO), provides a brief summary of 2,4,6-trinitrotoluene (TNT), including its physical and chemical properties; environmental and health impacts; existing federal and state guidelines; detection and treatment methods; and additional sources of information. This fact sheet is intended for use by site managers and field personnel who may address TNT contamination at cleanup sites or in drinking water supplies.

Major manufacturing of TNT began in the U.S. in 1916 at the beginning of World War I. It was produced in enormous quantities both commercially and at government ammunition plants for use in military munitions in World War I and World War II (Steen 2007). During the 1940s through the 1970s, Department of Defense (DoD) ammunitions plants and depots demilitarized off-specification, unserviceable, and obsolete munitions based on steam-out and melt-out processes to recover TNT and TNT-containing explosive fillers such as Composition B (TNT/ hexahydro-1,3,5-trinitro-1,3,5-triazine [RDX] mixture). These processes often generated significant quantities of explosives-contaminated wastewaters. The untreated wastewater was discharged into unlined impoundments, lagoons, ditches and playas, which resulted in significant levels of soil and ground water contamination. Ground water contamination from TNT was first reported in the late 1980s (Spalding and Fulton 1988).

TNT is still widely used in U.S. military munitions and accounts for a large part of the explosives contamination at active and former U.S. military installations. With its manufacturing impurities and environmental transformation products, TNT presents various health and environmental concerns.

What is TNT?

- TNT is a yellow, odorless solid that does not occur naturally in the environment. It is made by combining toluene with a mixture of nitric and sulfuric acids (ATSDR 1995).
- Effluent from TNT manufacturing was a major source of munitions constituent contamination in soils, ground water, and occasionally surrounding surface water and sediment at Army ammunition plants. TNT production ended in the mid-1980s in the United States; however, contamination of soils and ground water remains in some areas (EPA 2005; MMR 2001).
- It is a highly explosive, single-ring nitroaromatic compound that is a crystalline solid at room temperature (CRREL 2006).

What is TNT? (continued)

- TNT is one of the most widely used military high explosives, partly because of its insensitivity to shock and friction. It has been used extensively in the manufacture of explosives since the beginning of the 20th century and is used in military cartridge casings, bombs, and grenades (ATSDR 1995).
- It has been used either as a pure explosive or in binary mixtures. The most common binary mixtures of TNT are cyclotols (mixtures with RDX) and octols (mixtures with High Melting Explosive [HMX]) (ATSDR 1995; MMR 2001).
- In addition to military use, small amounts of TNT may be used for industrial explosive applications, such as deep well and underwater blasting. Other industrial uses include chemical manufacturing as an intermediate in the production of dyestuffs and photographic chemicals (MMR 2001).
- TNT is commonly found at hand grenade ranges, antitank rocket ranges, artillery ranges, bombing ranges, munitions testing sites, and open burn/open detonation (OB/OD) sites (CRREL 2006).

Exhibit 1: Physical and Chemical Properties of TNT
(ATSDR 1995; EPA 1999)

Property	Value
CAS Number	118-96-7
Physical Description (physical state at room temperature)	yellow, odorless solid
Molecular weight (g/mol)	227
Water solubility (mg/L at 20°C)	130
Octanol-water partition coefficient (K_{OW})	1.6
Soil organic carbon-water coefficient (K_{OC})	300
Boiling point (°C)	240 (Explodes)
Melting point (°C)	80.1
Vapor pressure at 25°C (mm Hg)	1.99×10^{-4}
Specific gravity	1.654
Henry's Law Constant (atm-m^3/mol at 20°C)	4.57×10^{-7}

Abbreviations: g/mol – grams per mole; mg/L – milligrams per liter; °C – degrees Celsius; mm Hg – millimeters of mercury; atm-m^3/mol – atmosphere time cubic meter per mole.

What are the environmental impacts of TNT?

- TNT can be released to the environment through spills, firing of munitions, disposal of ordnance, and OB/OD of ordnance, leeching from inadequately sealed impoundments, and demilitarization of munitions. The compound can also be released from manufacturing and munitions processing facilities (ATSDR 1995).
- TNT has been identified in at least 20 of the 1,338 hazardous waste sites that have been proposed for inclusion on the National Priorities List (NPL) (ASTDR 1995).
- TNT is a crystalline solid at room temperature and TNT's water solubility (approximately 130 milligrams per liter [mg/L] at 20°C) and vapor pressure are relatively low, but greater than those of RDX and HMX (CRREL 2006).
- Partition coefficients reported by most investigators indicate soils have a high capacity for rapid sorption of TNT. TNT not sorbed into soil is usually transformed rapidly under anaerobic conditions but may persist under aerobic conditions (CRREL 2006; USACE 1997).
- In the case of impact areas, the majority of the TNT may be degraded in the surface soil, but small quantities can reach shallow ground water (CRREL 2006).
- Once released to surface water, TNT undergoes rapid photolysis to a number of degradation products. 1,3,5-Trinitrobenzene (1,3,5-TNB) is the primary photodegradation product of TNT in environmental systems (ATSDR 1995; CRREL 2006).

What are the environmental impacts of TNT? (continued)

- TNT is one of the most widely used military high explosives, partly because of its insensitivity to shock and friction. It has been used extensively in the manufacture of explosives since the beginning of the 20th century and is used in military cartridge casings, bombs, and grenades (ATSDR 1995).
- Products of photolysis of TNT have been observed as a coating on TNT particles and as a fine powdered residue surrounding TNT particles on ranges that receive limited rainfall (CRREL 2007a).
- Generally, dissolved-phase TNT is broken down by biodegradation in water but at rates much slower than photolysis (ATSDR 1995; CRREL 2006).
- Biological degradation products of TNT in water, soil, or sediments include 2-amino-4,6-dinitrotoluene, 2,6-diamino-4-nitrotoluene, 4-amino-2,6-dinitrotoluene, and 2,4-diamino-6-nitrotoluene (CRREL 2007b; EPA 1999).
- TNT does not seem to bioaccumulate in animals, but can be taken up by plants (CRREL 2006).

What are the health effects of TNT?

- The toxicity of TNT to humans was well documented in the 20th century, with more than 475 fatalities and more than 17,000 cases of TNT poisoning during World War I and World War II manufacturing operations (Bodeau 1993).
- The primary routes of exposure in manufacturing environments are inhalation of dust and ingestion and dermal sorption of TNT particulates, and significant health effects were liver necrosis and aplastic anemia (ATSDR 1995).
- The highest exposures to TNT have been found in areas around Army ammunition plants where these explosives are manufactured, packed, loaded, or released through the demilitarization of munitions (ATSDR 1995).
- Potential exposure to TNT could occur by dermal contact or inhalation exposure, and the likely route is exposure to contaminated soils. However, exposure to contaminated ground water is also likely at sites with high infiltration rates such as washout lagoons or OB/OD areas (MMR 2001).
- EPA has assigned TNT a weight-of-evidence carcinogenic classification of C (possible human carcinogen) (IRIS 1993; OSHA 1999).
- The oral slope factor for carcinogenic risk is 3×10^{-2} milligrams per kilogram per day (mg/kg/day) (IRIS 1993).
- EPA assigned TNT a reference dose (RfD) of 5×10^{-4} mg/kg/day (IRIS 1993).
- Animal study results indicated that inhalation or ingestion of high levels of TNT may cause liver, blood, immune system, and reproductive damage (EPA 2005; MMR 2001).
- When TNT reaches the liver, it breaks down into several different substances. Not all of these substances have been identified (ATSDR 1995).
- At high levels in air, workers involved in the production of TNT experienced anemia and abnormal liver tests. After long-term exposure to skin and eyes, some people developed skin irritation and cataracts (MMR 2001).
- There is no information indicating that TNT causes birth defects in humans. However, male animals treated with high doses of TNT have developed serious reproductive system effects (ATSDR 1995b; MMR 2001).

Are there any federal and state guidelines and health standards for TNT?

- A Minimal Risk Level (MRL) of 0.0005 mg/kg/day has been derived for intermediate oral exposure to TNT (ATSDR 1995).
- The EPA has established a Lifetime Health Advisory guidance level of 2 parts per billion (ppb) for TNT in drinking water. The health advisory for a cancer risk of 10-4 is 0.1 mg/L (ATSDR 1995; EPA 2011a).
- EPA has calculated a resident soil screening level of 19 milligrams per kilogram (mg/kg) and an industrial soil screening level of 79 mg/kg (EPA 2011b).
- The EPA has not established an ambient air level for TNT (MMR 2001).
- Since TNT is explosive, flammable, and toxic, EPA has designated it as a hazardous waste and EPA regulations for disposal must be followed (EPA 2012).

Are there any federal and state guidelines and health standards for TNT? (continued)

- The Occupational Safety and Health Administration (OSHA) set a general industry permissible exposure limit (PEL) of 1.5 milligrams per cubic meter (mg/m^3) of workplace air for an 8-hour workday for a 40-hour work week (OSHA 2010).
- The National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit (REL) for TNT during an 8-hour workday, 40-hour work week is 0.5 mg/m^3 (OSHA 2010).
- The American Conference of Governmental Industrial Hygienists (ACGIH) has set a threshold limit value (TLV) of 0.1 mg/m^3 (OSHA 2010).
- TNT in bulk and in cased munitions is a United Nations Hazard Division 1.1 Explosive, not a flammable solid, and a Resource Conservation and Recovery Act ((RCRA) D003 (reactive) waste for waste military munitions containing TNT (DOT 1989).

What detection and site characterization methods are available for TNT?

- High performance liquid chromatography (HPLC) and high-resolution gas chromatography (HRGC) have been paired with several types of detectors, including mass spectrometry (MS), electrochemical detection (ED), electron capture detector (ECD), and ultraviolet detector (UV) (ATSDR 1995).
- Laboratory Method 8330 is the most widely used analytical approach for detecting TNT in soil. The method specifies using HPLC with a UV. It has been used to detect TNT and some of its breakdown products at levels in the low ppb range (EPA 2006).
- Another method commonly used is Method 8095, which employs the same sample-processing steps as Method 8330 but uses HRGC with an ECD for determination (EPA 2005).
- SW8515 is a specific field screening method used to detect TNT in soil by a colorimetric screening method (USACE 2005; Army 2009).
- Tested field-screening instruments for TNT include GC-IONSCAN, which uses ion mobility spectrometry (IMS), and the Spreeta Sensor, which uses surface plasma resonance (SPR) (EPA 2000; 2001).

What technologies are being used to treat TNT?

- In situ bioremediation is an emerging technology for the treatment of explosives (including TNT)-contaminated ground water. Biological treatment methods such as bioreactors, bioslurry treatment, and passive subsurface biobarriers have been proven successful in reducing TNT concentrations (EPA 2005; CRREL 2006; ESTCP 2010).
- Composting has been proven in achieving cleanup goals for TNT at field demonstrations (EPA 2005).
- Incineration can be used on soil containing low concentrations of TNT (EPA 2005).
- Granular activated carbon (GAC) is the primary method to treat explosives-contaminated ground water and waste waters. Ultrafiltration and resin adsorption have not been used at full scale to treat ground water contaminated with TNT or related explosives co-contaminants such as trinitrobenzene (TNB), dinitrotoluene (DNT), tetryl, RDX, or HMX (FRTR 2007).
- Fenton oxidation and treatment with iron metal (FeO) has been used to remediate TNT-contaminated soil and water but has not been used as standalone full-scale treatment technology (NCER 2010; EPA 2005).

Where can I find more information about TNT?

- Agency for Toxic Substances and Disease Registry (ATSDR). 1995. Toxicological Profile for TNT. www.atsdr.cdc.gov/toxprofiles/TP.asp?id=677&tid=125
- Bodeau, D. 1993. Occupational Health: The Soldier and the Industrial Base. Chapter 9. Military Energetic Materials: Explosives and Propellant.

Where can I find more information about TNT? (continued)

- Cold Regions Research and Engineering Laboratory (CRREL). 2006. Conceptual Model for the Transport of Energetic Residues from Surface Soil to Groundwater by Range Activities. ERDC/CRREL TR-06-18. www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA472270
- CRREL. 2007a. Photochemical Degradation of Composition B and Its Components. ERDC/EL TR-07-16. www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA472238
- CRREL. 2007b. Protocols for Collection of Surface Soil Samples at Military Training and Testing Ranges for the Characterization of Energetic Munitions Constituents. ERDC/CRREL TR-07-10. www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA471045.
- Environmental Security Technology Certification Program (ESTCP). 2010. Passive Biobarrier for Treating Comingled Perchlorate and RDX in Groundwater at an Active Range (ER-1028).
- Federal Remediation Technologies Roundtable (FRTR). 2007. Remediation Technologies Screening Matrix and Reference Guide, Version 4.0. Section 2.10.2 Common Treatment Technologies for Explosives in Ground Water, Surface Water, and Leachate.
- Massachusetts Military Reservation (MMR) 2001. Impact Area Groundwater Study Program. Chemical Fact Sheet – TNT. Fact Sheet 2001-05. http://imc2.army.mil/wastewater/community/facts/tnt.pdf
- Occupational Safety & Health Administration (OSHA). 1999. 2,4,6-Trinitrotoluene. http://www.osha.gov/dts/chemicalsampling/data/CH_274100.html
- Spalding, R. and J. Fulton. 1988. Groundwater Munition Residues and Nitrate near Grand Island, Nebraska, USA. Journal of Contaminant Hydrology. Volume 2 (2), Pages 139-153.
- Steen, K. 2007. Technical Expertise and U.S. Mobilization, 1917-18: High Explosives and War Gases. Frontline and Factory: Comparative Perspectives on the Chemical Industry at War, 1914-1924. Pages 103 –122.
- U.S. Army. 2009. Military Munitions Response Program. Munitions Response Remedial Investigation/Feasibility Study Guidance.
- U.S. Army Corps of Engineers (USACE). 1997. Review of Fate and Transport Processes of Explosives. Installation Restoration Research Program. Technical Report IRRP-92-2. March 1997. http://el.erdc.usace.army.mil/elpubs/pdf/trirrp97-2.pdf
- USACE. 2005. Military Munitions Center of Expertise. Technical Update. Munitions Constituent (MC) Sampling.
- U.S. Department of Transportation (DOT). 1989. Hazardous materials table and hazardous materials communications regulations. Code of Federal Regulations. 49 CFR 172.101.
- U.S. Environmental Protection Agency (EPA). 1999. Office of Research and Development. Federal Facilities Forum Issue. Field Sampling and Selecting On-site Analytical Methods for Explosives in Water. EPA 600-S-99-002.
- EPA. 2000. Office of Research and Development. Barringer Instruments. GC-IONSCAN. Environmental Technology Verification Report. EPA 600-R-00-046.
- EPA. 2001. Office of Research and Development. Research International, Inc. TNT Detection Technology. Texas Instruments Spreeta Sensor. Environmental Technology Verification Report. EPA/600/R-01/064. August 2001.
- EPA. 2005. EPA Handbook on the Management of Munitions Response Actions. EPA 505-B-01-001 http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100304J.txt
- EPA. 2006. 8330b. Nitroaromatics, Nitramines, and Nitrate esters by High Performance Liquid Chromatography (HPLC) Revision 2.
- EPA. 2011a. 2011 Edition of the Drinking Water Standards and Health Advisories. http://water.epa.gov/action/advisories/drinking/upload/dwstandards2011.pdf
- EPA. 2011b. Regions 3, 6, and 9. Regional Screening Levels Table. www.epa.gov/reg3hwmd/risk/human/index.htm
- EPA. 2012. Listed Wastes- Hazardous Wastes. www.epa.gov/osw/hazard/wastetypes/listed.htm

Where can I find more information about TNT? (continued)

- EPA. Integrated Risk Information System (IRIS). 1993. 2,4,6-Trinitrotoluene (TNT) (CASRN 118-96-7). Last Revised 1993. www.epa.gov/iris/subst/0269.htm
- EPA. National Center for Environmental Research (NCER). 2010. Final Report: Fate and Transport of Munitions Residues in Contaminated Soil. Website accessed on July 2, 2010.

Contact Information

If you have any questions or comments on this fact sheet, please contact: Mary Cooke, FFRRO, by phone at (703) 603-8712 or by email at cooke.maryt@epa.gov.

VBO \\NORTHEND\PROJ\USNAVFACENGCOM\CHEATHAMANNEX\MAPFILES\AOC SI REPORT\2011\FIGURE5-7_AOC6_TNT_AREA_LOCATIONS.MXD BHATHAWA 10/7/2011 4:05:46 PM

Legend

- Groundwater/Soil Sample Location
- Soil Sample Location
- Surface Water/Sediment Sample Location
- Approximate AOC 6 Study Areas
- Buildings
- Topographic Surface Contour (feet above mean sea level)

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0 50 100
Feet

Figure 5-7
AOC 6 Comprehensive Investigation Locations; Ammonia Settling Pit, TNT Graining House and Catch Box Ruins Subareas
Site Inspection Report
Areas of Concern 1, 2, 6, 7, and 8
Cheatham Annex
Williamsburg, Virginia

CH2MHILL

R:\USNAVFACENGCOM405450\CHEATHAMANNEX\MAPFILES\387443_AOC6_RI_UFPSAP\FIGURE 5 - PROPOSED SAMPLE LOCATIONS.MXD JCROCKETT 3/18/2013 7:54:28 AM

Legend

- Proposed Surface/Subsurface Soil Samples for Total and Hexavalent Chromium Analysis
- Proposed Subsurface Soil Sample for Total and Hexavalent Chromium Analysis (6-24" bgs), and additional Subsurface Soil Samples (24" bgs and below) for Explosives and/or Inorganics Analyses, plus Hexavalent Chromium, (as necessary)
- Proposed Surface/Subsurface Soil Samples
- Proposed Surface/Subsurface Soil Samples Co-Located with Groundwater Samples
- Approximate AOC 6 TNT Subarea Study Boundary
- Former TNT Graining House Sump/Former Catch Boxes Boundary

N W E S

0 37.5 75 Feet

Figure 5 (Revised)
Proposed Sample Locations
AOC 6 TNT Subareas Remedial Investigation UFP-SAP
Cheatham Annex
Williamsburg, Virginia

CH2MHILL

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

April 29, 2013

Mr. Scott Park
NAVFAC MIDLANT, Building N-26, Room 3208
Attention: Code OPHE3, Mr. Scott Park
9742 Maryland Avenue
Norfolk, VA 23511-3095

Subject: Response to Comments, Draft Tier II Sampling and Analysis Plan, AOC 6 – TNT Graining House Sump and TNT Catch Box Ruins Subareas - Remedial Investigation, Naval Weapons Station Yorktown Cheatham Annex, Williamsburg, Virginia, March 18, 2013

Mr. Park:

Thank you for the opportunity to review the subject document. The responses are acceptable except for the following which require further discussion.

<u>Comments received from USEPA via email dated October 31, 2012</u>

1. The response to EPA RPM comment 1 states, in part, "…the proposed RI soil and groundwater sampling is to fill relatively minor spatial data gaps…." According to another response, the size of the sump was approximately 42 feet by 20 feet. The size of the sump relative to the size of the TNT Graining House Ruins should be clarified. Please explain why sampling in the TNT Graining House is only proposed within the sump.

2. The response to EPA RPM comment 4 states, in part, "If the COC concentrations exceed the background 95 percent UTLs, further evaluation will be conducted to consider whether the COC concentrations are consistent with background conditions or if they represent a release such that further action is warranted." Please detail what "further evaluation" means. Also, please explain why the interpretation of site COC concentrations exceeding the respective background 95 percent UTLs would not mean that site concentrations are more than background and therefore, are a concern.

Comments received from USEPA via letter dated November 6, 2012

3. EPA comment 7 recommended that food chain modeling be performed to address risk to upper trophic level receptors, particularly those with smaller home ranges (e.g., American robin [*Turdus migratorius*] and short-tailed shrew [*Blarina brevicauda*]). The RTC states that because no food chain modeling was performed as part of the Site Inspection, no food chain modeling will be performed as part of the Remedial Investigation. BTAG still does not support this position. A Remedial Investigation is intended to be a more comprehensive evaluation and performing food chain modeling is warranted, even if the site is small. Even if area use is not 100% because of the small size of the site, food chain modeling should be performed on receptors with small home ranges to assess this exposure pathway. This approach would also be consistent with the recent agreement to perform food chain modeling at AOC 8.

4. The response to EPA RPM comment 9 states, in part, "…with consideration of the mean and maximum concentrations, as appropriate…." Please confirm that maximum concentrations will be used in the ecological risk assessment for plants and invertebrates since these receptors have limited or no mobility.

5. The response to EPA RPM comment 10 refers to Figure 5 in the attachments. When this figure is compared to Figure 5 in the Draft Tier II Sampling and Analysis Plan for AOC 6 TNT Graining House Sump and TNT Catch Box Ruins Subareas Remedial Investigation (September 2012), the location of the Catch Box Ruins has changed. Please verify that the new location is correct. In addition, the revised Figure 5 shows one or more roads, paths, washouts to the south of Garrison Road leading to King Creek. Please explain these areas and any need for them to be investigated in relationship to this site.

6. EPA comment 11 stated that within the boundaries of the TNT Graining House Sump (no samples) and Catch Basin Ruins (1 sample) sampling is too limited and a minimum of three samples should be taken within the footprint of each of the ruins. The RTC states that based on the small area of the Catch Basin Ruins (21 feet long by 9 feet wide), one sample is adequate. Regardless of the size of this brick lined depression or how it bottom elevation varies (2 feet to 5.5 feet deep), one sample will not be sufficient to account for the potential variability of contaminant concentrations that might be present in this depression. Without knowing this information, either a minimum of three discrete samples or a composite sample should be collected within the Catch Basin Ruins.

7. EPA comment 11 stated that within the boundaries of the TNT Graining House Sump (no samples) sampling is too limited and a minimum of three samples should be taken within the footprint of the ruins. The response indicates, in part, that sampling within the former footprint of the Graining House sump is not possible and would consist of organic debris and does not represent native soil. If there is material within this sump or the building footprint, it should be sampled to verify that there is no residual contamination present, even if it is not native soil.

If you have any questions, please contact me at 215-814-3394.

Sincerely,

Susanne Haug, P.E.
NPL/BRAC Federal Facilities Branch

cc: Wade Smith, VDEQ

Additional Response to Comments
Remedial Investigation
Sampling and Analysis Plan
AOC 6 TNT Subareas
Naval Weapons Station Yorktown Cheatham Annex
Williamsburg, VA
August 6, 2013

Additional comments provided by the U.S. Environmental Protection Agency (EPA) Region 3 in a letter dated April 29, 2013, following their review of the responses to their original comments (responses submitted March 18, 2013). The CAX Partnering Team held a conference call to discuss and resolve the comments listed below on June 4, 2013. The call included EPA technical support (BTAG) and CH2M HILL technical support (senior human health and ecological risk assessors). All comments were resolved during the call, except Comment 2, which was tabled at the request of the EPA RPM to allow time for an internal EPA discussion.

[*Comments 1 and 2 below are in reference to the comments received from EPA via an email dated October 31, 2012 (refer to the original Response to Comments letter dated March 18, 2013).*]

EPA RPM Comment 1: *The response to EPA RPM comment 1 states, in part, "…the proposed RI soil and groundwater sampling is to fill relatively minor spatial data gaps…." According to another response, the size of the sump was approximately 42 feet by 20 feet. The size of the sump relative to the size of the TNT Graining House Ruins should be clarified. Please explain why sampling in the TNT Graining House is only proposed within the sump.*

Navy Response: Per the discussion and agreement related to EPA Comment 7 (below) during the June 4, 2013 conference call, John McCloskey with EPA BTAG said this comment was resolved, since the Navy agreed to field check for and sample, if present, any residual material (from the former plant process and not organic material) within the TNT Graining House Sump. Refer also to the response to EPA Comment 7 (below) for more detail on the discussion and noted section changes to the SAP.

EPA RPM Comment 2: *The response to EPA RPM comment 4 states, in part, "If the COC concentrations exceed the background 95 percent UTLs, further evaluation will be conducted to consider whether the COC concentrations are consistent with background conditions or if they represent a release such that further action is warranted." Please detail what "further evaluation" means. Also, please explain why the interpretation of site COC concentrations exceeding the respective background 95 percent UTLs would not mean that site concentrations are more than background and therefore, are a concern.*

Navy Response: During the June 4, 2013 conference call, discussion of this comment was tabled per the EPA RPM's request. In a subsequent email from EPA dated June 12, 2013, the EPA commented: "We still disagree with the response, but you can move forward as you planned. When the time comes, EPA will do our own analysis and revisit this issue then, if necessary." Therefore, this comment is resolved and no changes to the SAP are needed.

[Comments 3 through 7 below are in reference to the comments received from EPA via a letter dated November 6, 2012 (refer to the original Response to Comments letter dated March 18, 2013).]

EPA RPM Comment 3: *EPA comment 7 recommended that food chain modeling be performed to address risk to upper trophic level receptors, particularly those with smaller home ranges (e.g., American robin [Turdus migratorius] and short-tailed shrew [Blarina brevicauda]). The RTC states that because no food chain modeling was performed as part of the Site Inspection, no food chain modeling will be performed as part of the Remedial Investigation. BTAG still does not support this position. A Remedial Investigation is intended to be a more comprehensive evaluation and performing food chain modeling is warranted, even if the site is small. Even if area use is not 100% because of the small size of the site, food chain modeling should be performed on receptors with small home ranges to assess this exposure pathway. This approach would also be consistent with the recent agreement to perform food chain modeling at AOC 8.*

Navy Response: During the June 4, 2013 conference call, agreement was reached that food web modeling will be added to the ecological risk assessment. However, appropriate Area Use Factors may be applied to account for the small size of the site.

A fourth bullet was added to Section 2.3.2.2 of the SAP as follows:

- Food web exposures (for detected bioaccumulative constituents in surface soil) for upper trophic level receptors will also be modeled for terrestrial habitats at the AOC 6 TNT Subareas. Terrestrial receptors may include: (1) meadow vole; (2) short-tailed shrew; (3) white-footed mouse; (4) red fox; (5) American robin; and (6) red-tailed hawk. If maximum exposure doses (calculated using maximum surface soil concentrations) exceed NOAEL-based ingestion toxicity reference values (TRVs), the chemical will be identified as an initial COPC. Mean and 95% UCL-based exposure doses (for bioaccumulative chemicals) will also be calculated and compared with NOAEL, LOAEL, and Maximum Acceptable Toxicant Concentration (MATC)-based TRVs. If the MATC-based HQ equals or exceeds one based upon the mean soil concentration, the chemical will be identified as a refined COPC. Appropriate Area Use Factors [AUFs] may be applied when selecting refined COPCs.

EPA RPM Comment 4: *The response to EPA RPM comment 9 states, in part, "…with consideration of the mean and maximum concentrations, as appropriate…." Please confirm that maximum concentrations will be used in the ecological risk assessment for plants and invertebrates since these receptors have limited or no mobility.*

Navy Response: During the June 4, 2013 conference call, agreement was reached that no changes to the SAP were necessary if the SAP acknowledges factors other than the mean will be considered. As stated in the March 18, 2013 response, the text in the first bullet of Section 2.3.2.2 was revised to state that the mean and maximum concentrations will be considered, as appropriate; however, the 95% UCL will be used as the primary decision EPC in Step 3A of the ERA. Therefore, no additional changes to the SAP are needed. [It should be noted that the Screening Ecological Risk Assessment (SERA) (Steps 1 and 2 of the ERA process) is a very conservative assessment that does use maximum concentrations.]

EPA RPM Comment 5: *The response to EPA RPM comment 10 refers to Figure 5 in the attachments. When this figure is compared to Figure 5 in the Draft Tier II Sampling and Analysis Plan for AOC 6 TNT Graining House Sump and TNT Catch Box Ruins Subareas Remedial Investigation (September 2012), the location of the Catch Box Ruins has changed. Please verify that the new location is correct. In addition, the revised Figure 5 shows one or more roads, paths, washouts to the south of Garrison Road leading to King Creek. Please explain these areas and any need for them to be investigated in relationship to this site.*

Navy Response: The location of the Catch Box Ruins was verified during the CAX Partnering Team site visit conducted on November 15, 2012; thus, the figure was updated to reflect the correct location. During the June 4, 2013 conference call, it was determined that the "roads, paths, and washouts to the south of Garrison Road"

were shadows on the aerial photograph in the figure. Agreement was reached to continue with the current sampling plan since there is no evidence that contamination has reached Garrison Road and there is no obvious pathway. Per EPA request, Figure 5 was revised to include the outlines of the berms located in the vicinity of the former structures at the CAX AOC 6 TNT subareas, as well as the topographic high points along Garrison Road. No changes to the SAP, other than to Figure 5, were necessary.

EPA RPM Comment 6: *EPA comment 11 stated that within the boundaries of the TNT Graining House Sump (no samples) and Catch Basin Ruins (1 sample) sampling is too limited and a minimum of three samples should be taken within the footprint of each of the ruins. The RTC states that based on the small area of the Catch Basin Ruins (21 feet long by 9 feet wide), one sample is adequate. Regardless of the size of this brick lined depression or how it bottom elevation varies (2 feet to 5.5 feet deep), one sample will not be sufficient to account for the potential variability of contaminant concentrations that might be present in this depression. Without knowing this information, either a minimum of three discrete samples or a composite sample should be collected within the Catch Basin Ruins.*

Navy Response: During the June 4, 2013 conference call, the Navy proposed collection of surface and subsurface 3-point composite samples from the Catch Box Ruins, and agreement was reached. The 3-point composite samples will be collected from the lowest portion and center of the Catch Box Ruins to account for the potential variability of contaminant concentrations within this depression, with the vicinity of SI location CAA06-SO01 as the center point and a location to the north and south of it as the other two points. The composite samples will be collected from the surface (0-6 inches below ground surface [bgs]) and from the subsurface at two-foot intervals (except for the first interval at 6 to 24 inches bgs) until groundwater is reached (anticipated to be around 10 feet bgs) to address the potential for contamination at depths below 24 inches bgs. The samples will be analyzed for explosives and metals (and hexavalent chromium, pH, TOC, and grain size, as appropriate). In the March 18, 2013 response to EPA's October 31, 2012 Comment 3, the Navy had proposed discrete samples from a single soil boring within the Catch Box Ruins and a graduated approach to analyzing the subsurface soil samples starting with the 2 to 4-foot interval samples, meaning it would be analyzed and if any detection(s) of explosives and/or inorganics exceeded the current Residential Soil (Adjusted) Levels, the next two-foot interval (4-6') would be analyzed and so on. However, composites will now be collected and ALL of the composite samples will be analyzed instead of a graduated approach to analysis since this approach may result in the inability to meet laboratory holding times. In summary, the SAP was revised to reflect 3-point composite samples will be collected from the Catch Box Ruins from the surface to groundwater, and all samples will be analyzed. The specific revisions to the SAP occur within the first bullet of Section 2.3.3, as follows:

- **What is the nature and extent of contamination in soil?** There are seven existing surface soil samples and seven existing subsurface soil samples that were collected and evaluated in the 2008 SI (CH2M HILL, 2012). These data will be used to aid in determining the nature and extent of contamination at the site. However, additional soil data are necessary for expanded spatial coverage to adequately characterize this medium.

  The following work is proposed to answer this environmental question: To supplement the existing soil data, thirteen co-located surface (0 to 6 inches) and subsurface (6 to 24 inches) soil samples ~~(**Figure 5**)~~ will be collected from the AOC 6 TNT subareas at soil sample locations CAA06-SO28 through CAA06-SO34 and from the soil borings for monitoring well locations CAA06-MW01 through CAA06-MW06 (**Figure 5**) and analyzed for explosives and metals. The surface samples also will be analyzed for pH, TOC and sieve grain size, and the subsurface samples also will be analyzed for pH and TOC to assist in completing the ERA. At soil sample location CAA06-SO27, a surface (0 to 6 inches) and a subsurface (6 to 24 inches) soil sample will be collected and analyzed for total and hexavalent chromium to assist with the HHRA. ~~and one surface soil and two subsurface soil samples from two additional sampling locations will be analyzed for hexavalent chromium to supplement the existing soil data. In addition, the 13 co-located surface soil and subsurface soil samples will be analyzed for pH, TOC, and sieve grain size (surface soil samples only) to assist in completing the ERA. Six of the proposed monitoring well locations will be co-located with six of the 13 co-located surface and subsurface soil sample locations.~~

To account for the potential variability of contaminant concentrations within the Catch Box Ruins and to address the potential for contamination at depths below 24 inches, 3-point composite soil samples will be collected from the surface of the depression (0-6 inch interval) and from the subsurface at two-foot intervals (except for the first interval at 6 to 24 inches bgs) until groundwater is reached (anticipated to be around 10 feet bgs). The 3-point composite samples will be collected from the lowest portion and center of the Catch Box Ruins, with the vicinity of SI location CAA06-SO01 as the center point and a location to the north and south of it as the other two points (location CAA06-SO01 is where the highest detections of explosives and metals were observed in surface and subsurface soil during the SI). All of the composite samples will be field composited and analyzed for explosives and metals. The surface composite sample also will be analyzed for pH, TOC and sieve grain size, and the subsurface composite sample from the 6 to 24-inch interval also will be analyzed for pH and TOC to assist with the ERA. In addition, at the center point (vicinity of SI location CAA06-SO01), a discrete surface (0 to 6 inches) and a discrete subsurface (6 to 24 inches) soil sample will be collected and analyzed for total and hexavalent chromium to assist with the HHRA.

EPA RPM Comment 7: *EPA comment 11 stated that within the boundaries of the TNT Graining House Sump (no samples) sampling is too limited and a minimum of three samples should be taken within the footprint of the ruins. The response indicates, in part, that sampling within the former footprint of the Graining House sump is not possible and would consist of organic debris and does not represent native soil. If there is material within this sump or the building footprint, it should be sampled to verify that there is no residual contamination present, even if it is not native soil.*

Navy Response: During the June 4, 2013 conference call, John McCloskey (EPA BTAG) clarified this comment, stating he wondered if there was any actual residual material (from the former plant process and not organic material) within the Graining House Sump. If present, he feels it should be sampled, because if the sump compartments can hold water, they can be used by receptors (e.g., insects, amphibians). Agreement was reached that during the RI field activities, the sump will be field checked for residual material, and if present, a 3-point composite sample will be collected. The Navy assumes the analytical parameters for this sample will be the same as for the soil (i.e., explosives and metals, plus the physical parameters pH and TOC). The screening values will depend upon the environmental conditions encountered and the nature of the collected material, but will likely, and are assumed to be freshwater sediment values for the ERA and the adjusted residential soil RSLs for the HHRA. The SAP was revised to reflect the sampling and analyses of this contingent sample from the Graining House Sump [see Sections 2.1.4, 2.2.6, 2.3.1, 2.3.2.1, 2.3.2.2, 2.3.3 (2nd to last bullet), 2.3.4, 2.3.5, 2.5, 3.2.9, and 3.3, Figure 3 (CSM), and Appendix A Tables A1-8 to A1-10,Tables A3-1 to A3-5, and Tables A3-7 to A3-8].

Lower Trophic Level Aquatic Receptors (i.e., aquatic/wetland plants, benthic/aquatic invertebrates, fish, amphibians, and reptiles): Exposure from ingestion of, and/or direct contact with, contaminants in surface water* and/or sediment*.

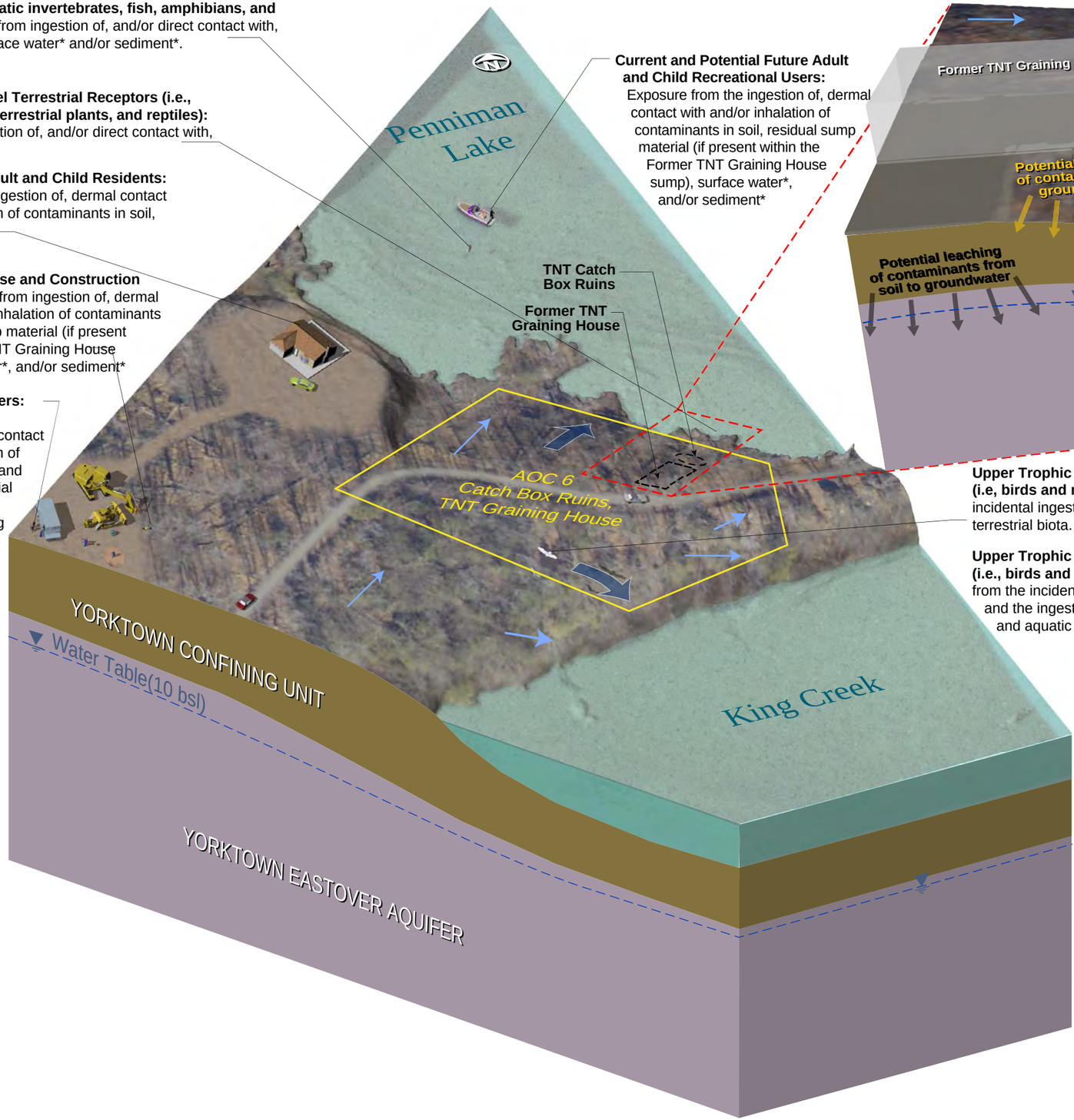
Lower Trophic Level Terrestrial Receptors (i.e., soil invertebrates, terrestrial plants, and reptiles): Exposure from ingestion of, and/or direct contact with, contaminants in soil.

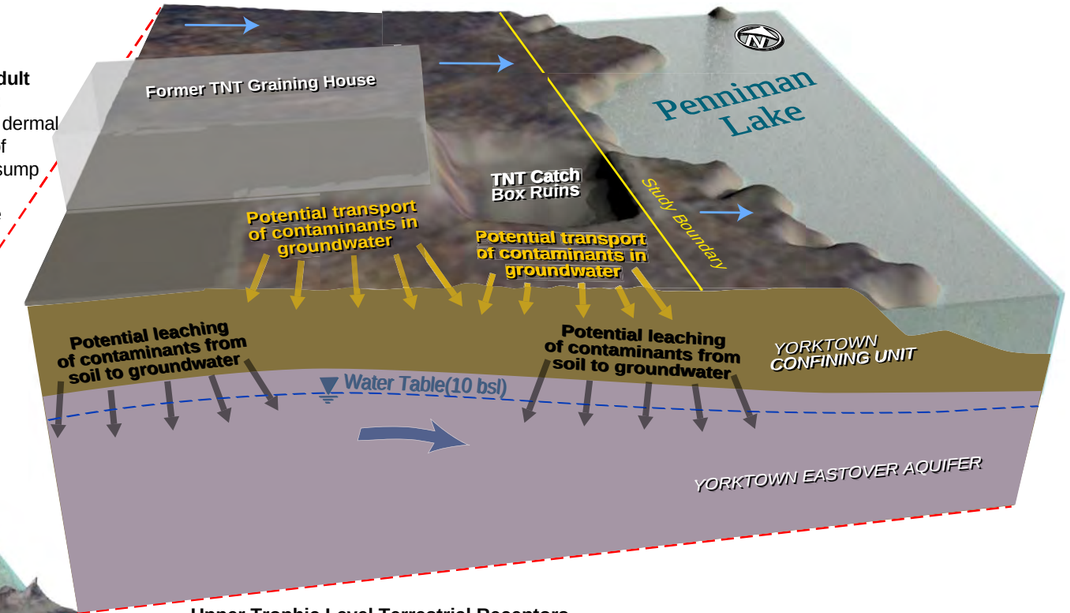
Potential Future Adult and Child Residents: Exposure from the ingestion of, dermal contact with and/or inhalation of contaminants in soil, and/or sediment*

Potential Future Base and Construction Workers: Exposure from ingestion of, dermal contact with and/or inhalation of contaminants in soil, residual sump material (if present within the Former TNT Graining House sump), surface water*, and/or sediment*

Current Base Workers: Exposure from the ingestion of, dermal contact with and/or inhalation of contaminants in soil and residual sump material (if present within the Former TNT Graining House sump)

Current and Potential Future Adult and Child Recreational Users: Exposure from the ingestion of, dermal contact with and/or inhalation of contaminants in soil, residual sump material (if present within the Former TNT Graining House sump), surface water*, and/or sediment*





Upper Trophic Level Terrestrial Receptors (i.e, birds and mammals): Exposure from the incidental ingestion of soil and the ingestion of terrestrial biota.

Upper Trophic Level Aquatic Receptors (i.e., birds and mammals): Exposure from the incidental ingestion of sediment*, and the ingestion of surface water* and aquatic biota*.

LEGEND

- Approximate Study Area
- Yorktown Confining Unit
- Yorktown Eastover Aquifer
- Anticipated Overland Surface Water Flow Direction
- Water Table
- Inferred Groundwater Flow Direction
- Contaminate Transport
- Contaminate Leaching

* Surface water, aquatic biota and sediment will be evaluated as part of the Penniman Lake Remedial Investigation.

FIGURE 3
AOC 6 TNT Subareas Conceptual Site Model
Cheatham Annex
Williamsburg, Virginia

CH2MHILL

R:\USNAVFACENGCOM405450\CHEATHAMANNEX\MAPFILES\387443_AOC6_RI_UFPSAP\FIGURE 5 - PROPOSED SAMPLE LOCATIONS.MXD JCROCKETT 7/29/2013 12:23:45 PM

Legend

- Proposed Surface/Subsurface Soil Samples for Total and Hexavalent Chromium Analyses only
- Proposed 3-point composite Surface (0-6") and Subsurface [6" to groundwater table (~10')] Soil Samples from within the Catch Box Ruins. Also the location of discrete Surface/Subsurface Soil Samples from the center point for Total and Hexavalent Chromium analyses only.
- Proposed Surface/Subsurface Soil Samples
- Proposed Surface/Subsurface Soil Samples Co-Located with Groundwater Samples
- Topographic High Point (dashed where approximated)
- Approximate AOC 6 TNT Subarea Study Boundary
- Berm Boundary
- Former TNT Graining House Sump/Former Catch Boxes boundary

N W E S

0 37.5 75 Feet

Figure 5
Proposed Sample Locations
AOC 6 TNT Subareas Remedial Investigation UFP-SAP
Cheatham Annex
Williamsburg, Virginia

CH2MHILL

Regulatory Acceptance

COMMONWEALTH of VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY
Street address: 629 East Main Street, Richmond, Virginia 23219
Mailing address: P.O. Box 1105, Richmond, Virginia 23218
TDD (804) 698-4021
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Douglas W. Domenech
Secretary of Natural Resources

David K. Paylor
Director

(804) 698-4000
1-800-592-5482

September 24, 2013

Mr. Scott Park
NAVFAC MIDLANT, Building N-26
Hampton Roads Restoration Product Line, Code OPHREV4
9742 Maryland Avenue
Norfolk, VA 23511-3095

Tier II Sampling and Analysis Plan
AOC 6 TNT Graining House Sump and TNT Catch Box Ruins Subareas
Naval Weapons Station Yorktown
Cheatham Annex
Williamsburg, Virginia

Dear Mr. Park:

The Virginia Department of Environmental Quality (DEQ) has received the *Redline Final Tier II Sampling and Analysis Plan* (SAP) for AOC 6 Subareas at Naval Weapons Station Yorktown, Cheatham Annex, Williamsburg, Virginia. The SAP, prepared by CH2M HILL, was received by the DEQ (electronically) on September 16, 2013.

Thank you for providing the DEQ's Office of Remediation Programs the opportunity to review the above-referenced SAP. Subsequent to DEQ's internal review, this office concurs with the proposed text revisions and recommends submittal of the *Final Tier II Sampling and Analysis Plan*.

Please contact me at (804) 698-4125 or wade.smith@deq.virginia.gov with any additional questions.

Sincerely,

Wade M. Smith
Remediation Project Manager
Office of Remediation Programs

cc: Jerry Hoover, EPA

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

September 25, 2013

Mr. Scott Park
NAVFAC MIDLANT, Building N-26, Room 3208
Attention: Code OPHE3, Mr. Scott Park
9742 Maryland Avenue
Norfolk, VA 23511-3095

Subject: Tier II Remedial Investigation Sampling and Analysis Plan for AOC 6 TNT Graining House Sump and TNT Catch Box Ruins Subareas, Naval Weapons Station Yorktown Cheatham Annex, Williamsburg, Virginia

Mr. Park:

EPA has reviewed the Responses to Comments (RTCs) and the Red-line Text for the subject document submitted via email from CH2M Hill on September 16, 2013. EPA has no comments on either the RTCs or the Red-line Text. Please submit a final copy of the subject document for our records.

If you have any questions, please contact me at 215-814-2077.

Sincerely,

Gerald F. Hoover

Gerald F. Hoover, RPM
NPL/BRAC Federal Facilities Branch

cc: Wade Smith, VDEQ