QUALITY ASSURANCE PROJECT PLAN - FINAL

JANUARY 2016

Former Port Mobil Terminal

4101 Arthur Kill Road
Staten Island, New York

KINDER MORGAN TERMINALS

SUBMITTED TO:
United States Environmental Protection Agency
EPA ID No. NYD000824516

Louis Berger

FINAL

QUALITY ASSURANCE PROJECT PLAN
for the Kinder Morgan Staten Island Site
(former Port Mobil Terminal)

Staten Island, New York

Prepared for:

United States of Environmental Protection Agency Region 2
Hazardous Waste Facilities Branch
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Version: 01

January 2016

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Attachment 1:	Revised MNA Monitoring Program Schedule
Attachment 2:	Summary of EPA Deadlines
Attachment 3:	Field and Equipment Standard Operating Procedures
Attachment 4:	Field Modification Form (template)
Attachment 5:	Non-Conformance Quality Control Report (template)

QAPP Worksheet 1
Title and Approval Page

Site Name/Project Name: Kinder Morgan Staten Island Site (former Port Mobil Terminal)

Document Title: Quality Assurance Project Plan (QAPP) for the Kinder Morgan Staten Island Site (Staten Island, New York)

Lead Organization: United States Environmental Protection Agency (USEPA)

Name of Document Preparer and Company Affiliation: Louis Berger
Preparer's Address, Telephone Number, and E-mail Address: 412 Mount Kemble Avenue, Morristown, New Jersey 07960
Preparation Date (Day/Month/Year): January 2016

Investigative Organization's Technical Manager:

Susan Fund for E.G.
Erik Gustafson, CHMM (Louis Berger)

Investigative Organization's Quality Assurance Officer:

Michael McCloskey, PG (Louis Berger)

Investigative Organization's Quality Control Officer:

Scott J. Thompson (Louis Berger)

USEPA Project Coordinator (Approval Authority):

Wilfredo Palomino (United States Environmental Protection Agency)

QAPP Worksheet 2
QAPP Identifying Information

Site Name/Project Name: Kinder Morgan Staten Island Site (former Port Mobil Terminal)
Site Location: Staten Island, New York
Site Number/Code: NYD000824516
Operable Unit: Not Applicable
Contractor Name: Louis Berger under contract to Kinder Morgan
Work Assignment Number: Not Applicable

Title: Quality Assurance Project Plan for the Kinder Morgan Staten Island Site
Version Number: 01
Version Date: January 2016

1. Identify regulatory program:
   United States Environmental Protection Agency (USEPA) Hazardous Waste Facility Branch; Resource Conservation and Recovery Act (RCRA). QAPP prepared following the "Uniform Federal Policy for Quality Assurance Project Plans" (USEPA Document No. 505-B-04-900A, Final Version 1. March 2005).

2. Identify approval entity: USEPA

3. The QAPP is (select one): ☐Generic ☒Project Specific

4. Refer to Worksheet 9 for scoping discussions held in October 2015 on preparation of the QAPP.

5. List dates and titles of QAPP documents written for previous site work, if applicable:

Title	Submittal Date
Previous QAPP developed for the Facility (as referenced in the Woodard & Curran, January 2011 QAPP)	November 1995
Woodard & Curran, January 2011. "Quality Assurance Project Plan for the Former Port Mobil Terminal at 4101 Arthur Kill Road, Staten Island, New York." Final Revision 0, Document Number 206923.	January 2011

6. List organizational partners (stakeholders) and connection with lead organization:
   - United States Environmental Protection Agency (USEPA) has listed the Kinder Morgan Staten Island (Former Port Mobil) Site as a RCRA Administrative Order of Consent (the Order). Kinder Morgan is a respondent on the Order and is conducting an investigative work in response to the Order. Exxon Mobil is an additional respondent on the Order.
   - Regulatory oversight of the facility is shared jointly by USEPA and New York State Department of Environmental Conservation (NYSDEC). Both agencies review and provide comments on the project.
   - Louis Berger will be providing consulting services under contract to Kinder Morgan and will implement environmental investigations and/or prepare select RCRA–related reports for activities conducted at the Kinder Morgan Staten Island Site.
   - Tetra Tech and laboratory (TestAmerica) are under separate contract to Kinder Morgan.

7. List data users: Kinder Morgan, USEPA, NYSDEC, and other stakeholders.

8. If any required QAPP elements and required information are not applicable to the project, then circle the omitted QAPP elements and required information on the attached table. Provide an explanation for their exclusion below:
   - No QAPP Worksheets are omitted.

QAPP Worksheet 3
Distribution List

QAPP Recipients	Title	Organization	Telephone Number	E-mail Address	Document Control Number
Wilfredo Palomino	USEPA Project Coordinator	USEPA	212-637-4179	Palomino.Wilfredo@epa.gov	Electronic copy of Document Control No. KM-SI-001
Adolph Everett	USEPA Chief RCRA Programs Branch	USEPA	212-637-4109	Everett.Adolph@epa.gov	Electronic copy of Document Control No. KM-SI-001
James Moras	NYSDEC – RCRA Case Manager	NYSDEC	518-402-9767	jamoras@gw.dec.state.ny.us	Electronic copy of Document Control No. KM-SI-001
Richard (RJ) Sherman	Kinder Morgan Remediation Manager	Kinder Morgan	731-541-5161	richard_sherman@kindermorgan.com	Electronic copy of Document Control No. KM-SI-001
Steve Trifiletti	ExxonMobil (Additional AOC Respondent)	ExxonMobil	718-404-0652	steve.p.trifiletti@exxonmobil.com	Electronic copy of Document Control No. KM-SI-001
Joseph Dempsey	Louis Berger Project Director	Louis Berger	973-407-1372	jdempsey@louisberger.com	Electronic copy of Document Control No. KM-SI-001
Erik Gustafson	Louis Berger Technical Manager	Louis Berger	212-612-7973	egustafson@louisberger.com	Electronic copy of Document Control No. KM-SI-001
Susan Ferrel	Louis Berger Project Manager	Louis Berger	973-407-1424	SFerrel@louisberger.com	Electronic copy of Document Control No. KM-SI-001
Tavis Lloyd	Louis Berger Project Manager	Louis Berger	973-407-1390	tlloyd@louisberger.com	Electronic copy of Document Control No. KM-SI-001
Michael McCloskey	Louis Berger Quality Assurance Officer	Louis Berger	973-407-1395	mmccloskey@louisberger.com	Electronic copy of Document Control No. KM-SI-001
Scott J. Thompson	Louis Berger Quality Control Officer	Louis Berger	609-510-3245	sjthomspon@louisberger.com	Electronic copy of Document Control No. KM-SI-001
Joseph Thurm	Louis Berger Health and Safety Manager (CMI program)	Louis Berger	610-280-5397	jthurm@louisberger.com	Electronic copy of Document Control No. KM-SI-001
Nevin Diehl	Louis Berger Field Team Leader (CMI program)	Louis Berger	973-407-1626	ndiehl@louisberger.com	Electronic copy of Document Control No. KM-SI-001
Danielle Kearsley	Tetra Tech Project Manager	Tetra Tech	908-534-2303	Danielle.Kearsley@tetratech.com	Electronic copy of Document Control No. KM-SI-001
Michelle Gillie	Tetra Tech Corporate Health and Safety Director	Tetra Tech	832-251-5189	michelle.gillie@tetratech.com	Electronic copy of Document Control No. KM-SI-001

QAPP Recipients	Title	Organization	Telephone Number	E-mail Address	Document Control Number
Gloria Switalski	Data Validation (MNA program)	Data Check Inc. (under contract to Louis Berger)	603-859-8979	datachck@tds.net	Electronic copy of Document Control No. KM-SI-001
Joseph Carabillo	Data Validation (CMI program)	Louis Berger	973-407-1083	jcarabillo@louisberger.com	Electronic copy of Document Control No. KM-SI-001
Patricia Grieco	TestAmerica Inc. Laboratory Project Manager	TestAmerica (under contract to Kinder Morgan)	732-593-2507	Patricia.Grieco@testamericainc.com	Electronic copy of Document Control No. KM-SI-001

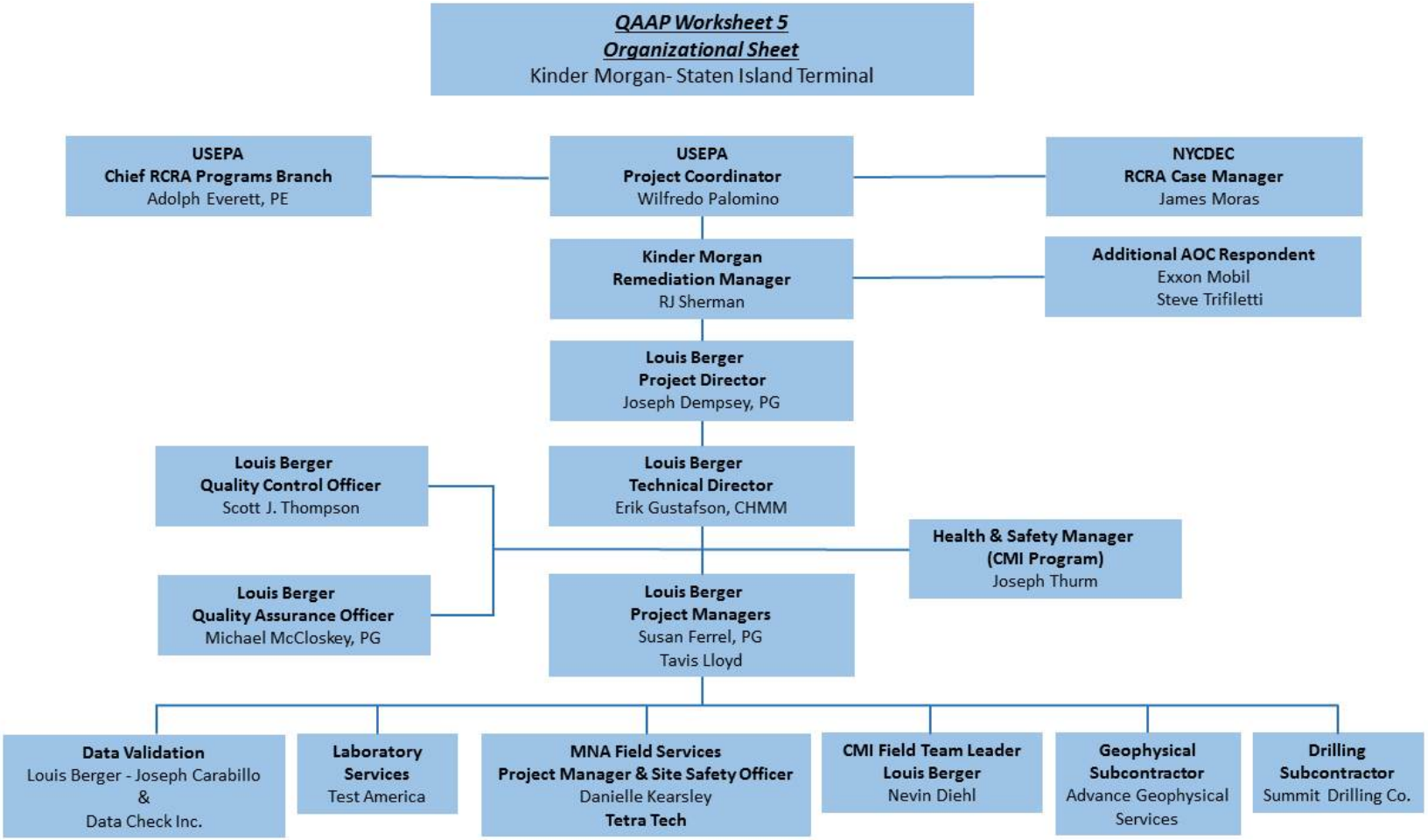
Document Control No. KM-SI-01 corresponds to “QAPP for the Kinder Morgan Staten Island Site” submitted in January 2016. Tetra Tech will collect samples for MNA program, and Louis Berger will participate in future field programs (as needed).

MNA = Monitored Natural Attenuation
CMI = Corrective Measures Implementation

QAPP Worksheet 4
Project Personnel Sign-Off Sheet

Project Personnel		Telephone Number		Date QAPP Read
Wilfredo Palomino	USEPA Project Coordinator	212-637-4179	Wilfredo Palomino	1-11-2016
Richard (RJ) Sherman	Kinder Morgan Remediation Manger	731-541-5161		1-8-2016
Erik Gustafson	Louis Berger Technical Manger	212-612-7973	Susan Ferrell for E.G.	1-7-2016
Michael McCloskey	Louis Berger Quality Assurance Officer	973-407-1395	Michael J. McCloskey	1-6-2016
Danielle Kearsley	Tetra Tech Project Manager	908-534-2303	Danielle Kearsley	1-7-2016
Scott J. Thompson	Louis Berger Quality Control Officer	609-510-3245	Scott J. Thompson	01/06/2016

QAPP Worksheet 5
Project Organization Chart



MNA = Monitored Natural Attenuation
CMI = Corrective Measures Implementation

QAPP Worksheet 6
Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathways, etc.)
Primary point of contact with USEPA for Kinder Morgan	Kinder Morgan Remediation Manager	RJ Sherman (Kinder Morgan)	731-541-5161	Materials and information about the project will be forwarded to USEPA Project Coordinator and NYSDEC (if directed) by Kinder Morgan Remediation Manager.
Primary point of contact with Kinder Morgan Remediation Manager	Consultant (Louis Berger) Project Director	Joseph Dempsey (Louis Berger)	973-407-1372	Consultant Project Director will be primary liaison to Kinder Morgan Remediation Manager and will provide project information directly to USEPA on request from Kinder Morgan.
Technical Implementation of Projects	Consultant (Louis Berger) Technical Manager	Erik Gustafson (Louis Berger)	212-612-7973	Responsible for implementation of project. Notify Consultant Project Director of any project issues or significant developments by phone, e-mail, or in-person by close of next business day.
Management of Project	Consultant (Louis Berger) Project Managers	Susan Ferrel Tavis Lloyd (Louis Berger)	973-407-1424 973-407-1390	Responsible for managing project. Notify Consultant Technical Manager of any project issues or significant developments by phone, e-mail, or in-person by close of next business day.
Field Work Progress	Field Team Leaders	Nevin Diehl (Louis Berger) Danielle Kearsley (Tetra Tech)	973-407-1626 908-534-2303	Responsible for daily field activities. Notify Consultant Project Managers of field progress and results by phone or e-mail within 2 business days; any field or laboratory issues or QAPP changes by phone or e-mail by close of next business day; and provide field work documentation within one week.
Reporting Laboratory Data Quality Issues	Primary Laboratory Client Representative	Patricia Grieco (TestAmerica)	732-593-2507	Laboratory Client Representative will notify Consultant Project Managers and/or Field Team Leaders of any laboratory QA/QC issues requiring guidance or corrective action within 2 business days. Turnaround time for analytical data will be 10 business days.

QAPP Worksheet 6
Communication Pathways

Reporting of Analytical Data Validation	Data Validator	Joseph Carabillo (Louis Berger) Gloria J. Switalski (Data Check, Inc.)	973-407-1083 603-859-8979	Data Validator will report in writing the results of data validation, as applicable, to Consultant Project Managers within 30 business days of receiving data package. Significant issues with data quality identified during data validation will be reported by e-mail within 2 business days.
Field and Analytical Corrective Actions	Consultant (Louis Berger) Project Managers and QC Officer	Susan Ferrel/Tavis Lloyd (Louis Berger) Scott J. Thompson (Louis Berger)	973-407-1424/973-407-1390 609-510-3245	The need for Corrective action for field and analytical issues will be determined by Consultant Project Managers and QC Officer with input from Field Team Leader or Laboratory Client Representative, as applicable.
Release of Analytical Data	Consultant (Louis Berger) QC Officer	Scott J. Thompson (Louis Berger)	609-510-3245	No analytical data will be released for use until verification and/or validation is completed as applicable, and QC Officer has approved the release.
Approval of Field Modifications	USEPA Project Coordinator	Wilfredo Palomino (USEPA)	212-637-4179	Any significant changes to the QAPP and/or work plans must be approved by the USEPA Project Coordinator before the changes can be implemented.

QAPP Worksheet 7
Personnel Responsibilities and Qualification Table

Name	Title	Organizational Affiliation	Responsibilities	Education and Experience Qualifications
Wilfredo Palomino	USEPA Project Coordinator	USEPA	USEPA Project Coordinator	Not applicable
Adolph Everett	USEPA Chief RCRA Programs Branch	USEPA	USEPA Chief RCRA Programs Branch	Not applicable
James Moras	NYSDEC – RCRA Case Manager	NYSDEC	NYSDEC – RCRA Case Manager	Not applicable
RJ Sherman	Kinder Morgan Remediation Manager	Kinder Morgan	Overall project oversight for Lead Organization, coordination, and compliance with the Order. Leads communication with USEPA.	Not applicable
Joseph Dempsey	Consultant (Louis Berger) Project Director	Louis Berger	Overall project direction for primary consultant (Louis Berger)	BS, Geology/Water Resources Professional Geologist
Erik Gustafson	Consultant (Louis Berger) Technical Manager	Louis Berger	Overall Technical Management for primary consultant (Louis Berger)	BS, Environmental Science; MS, Environmental and Waste Management; CHMM
Susan Ferrel	Project Manager	Louis Berger	Day-to-day technical lead; oversees and coordinates data collection; lead in data interpretation and preparation of deliverables.	BS, Geoscience; Professional Geologist
Tavis Lloyd	Project Manager	Louis Berger	Day-to-day technical lead; oversees and coordinates data collection; lead in data interpretation and preparation of deliverables.	BS, Geology; MS, Sedimentary Stratigraphy
Michael McCloskey	Quality Assurance Officer	Louis Berger	Quality Assurance Officer	BS, Geoscience Professional Geologist
Scott J. Thompson	Quality Control Officer	Louis Berger	Quality Control Officer	BS, Chemistry, MBA
Nevin Diehl	Field Team Leader	Louis Berger	Day-to-day technical scientist directing the collection of field data;	BS, Geology

Name	Title	Organizational Affiliation	Responsibilities	Education and Experience Qualifications
			laboratory subcontractor contact; Louis Berger Site Safety Officer.	
Joseph Thurm	Louis Berger Health and Safety Manager	Louis Berger	Responsible for health and safety of field team members and safety implementation of the field program	Principle Industrial Hygienist (CIH, CSP, CHMM)
Danielle Kearsley	Tetra Tech Project Manager	Tetra Tech	Day-to-day technical scientist directing the collection of field data; laboratory subcontractor contact.	BS, Environmental Science
Michelle Gillie	Tetra Tech Corporate Health and Safety Director	Tetra Tech	Responsible for health and safety for the field crew and safety implementation of the field program.	Certified Industrial Hygienist (CIH, CPEA, FAIHA)
Patricia Grieco	Laboratory Client Representative	TestAmerica	Reporting laboratory procedures, progress, and QA/QC issues; overseeing overall laboratory project.	Not applicable
Gloria J. Switalski	Data Validator	Data Check, Inc.	Performs data validation	Not applicable

Notes:
1. Resumes and copies of certifications are on file at Louis Berger office in Morristown, New Jersey for Louis Berger staff.
2. Tetra Tech will collect samples for MNA program, and Louis Berger will participate in future field programs (as needed).

QAPP Worksheet 8
Special Personnel Training Requirements Table

Project Function	Specialized Training Title or Description of Course	Training Provider	Training Date	Personnel and Groups Receiving Training	Personnel Titles and Organizational Affiliation	Location of Training Records/Certificates
Field investigation and on-site personnel	OSHA and First Aid training as specified in the Site-Specific Health and Safety Plan (refer to Note 1)	Kinder Morgan, Tetra Tech, and Louis Berger	Training dates kept in Kinder Morgan, Tetra Tech, or Louis Berger training records. Copies of OSHA HAZWOPER Certificates will be available on-site.	All field team members working on-site	Kinder Morgan, Tetra Tech, and Louis Berger	Kinder Morgan, Tetra Tech, and Louis Berger project files. Copies of OSHA HAZWOPER Certificates will be available on-site.

Notes:
1. The Site-specific Health and Safety plan has been prepared by Tetra Tech to support field activities and submitted under separate cover (dated August 2014). Tetra Tech will collect samples for MNA program, and Louis Berger will participate in future field programs (as needed).
2. A Transportation Workers Identification Card (TWIC) will be required for security access to the Facility.

QAPP Worksheet 9
Project Scoping Session Participants Sheet

Project Name: Kinder Morgan Staten Island Site **Projected Date(s) of Sampling:** Proposed Field Work: 2016 through 2021 **Project Managers**: Erik Gustafson (Technical Manager) and Susan Ferrel and Tavis Lloyd (Project Managers)	**Site Name**: Kinder Morgan Staten Island Site **Site Location**: Staten Island, New York
Date of Session: April 8, 2015 Scoping Session Purpose: Scoping meeting for QAPP.	

Name	Title	Affiliation	Phone #	E-mail Address
Susan Ferrel	Project Manager	Louis Berger	973-407-1424	sferrel@louisberger.com
Erik Gustafson	Technical Manager	Louis Berger	212-612-7973	egustafson@louisberger.com
RJ Sherman	Kinder Morgan Remediation Manager	Kinder Morgan	731-541-5161	richard_sherman@kindermorgan.com

Comments/Decisions:
Communication between Kinder Morgan and Louis Berger to begin preparation of QAPP for MNA sampling.

QAPP Worksheet 9
Project Scoping Session Participants Sheet

Project Name: Kinder Morgan Staten Island Site **Projected Date(s) of Sampling:** Proposed Field Work: 2016 through 2021 **Project Managers**: Erik Gustafson (Technical Manager) and Susan Ferrel and Tavis Lloyd (Project Managers)	**Site Name**: Kinder Morgan Staten Island Site **Site Location**: Staten Island, New York

Date of Session: October 9 through October 21, 2015 multiple meeting sessions
Scoping Session Purpose: Scoping meeting for QAPP preparation.

Name	Title	Affiliation	Phone #	E-mail Address
Susan Ferrel	Project Manager	Louis Berger	973-407-1424	sferrel@louisberger.com
AmyMarie Accardi-Dey	Chemist	Louis Berger	914-798-3712	aaccardidey@louisberger.com
Xiulan Wang	Chemist	Louis Berger	914-798-3719	xwang@louisberger.com

Comments/Decisions:
During the multiple meetings, the project team discussed preparation of the QAPP, including sample matrixes, target compound lists, achievable laboratory QLs, project-specific cleanup criteria, potential laboratory issues, and potential field program logistics. Deliverable is QAPP Version 01 (dated January 2016).

QAPP Worksheet 10
Problem Definition

The problem to be addressed by the project:

BACKGROUND
The Facility is located in Staten Island, New York (**Figure 1**) and is a petroleum bulk storage terminal designed for the distribution of gasoline and distillate fuels. The nominal storage capacity at the Facility is 125 million gallons with an annual throughput of approximately 1.4 billion gallons. Operations at the Facility has included above ground tank storage, storm water management and treatment, and material transfer activities. Additionally, the Facility has an above ground piping network to transfer petroleum products throughout the operating portion of the Facility. In 2005, the Facility was purchased from ExxonMobil by Kinder Morgan Liquids Terminals, LLC (Kinder Morgan). Operation and remediation of the facility currently continues through Kinder Morgan. A Site Plan is provided as **Figure 2**.

Regulatory oversight of the Facility is shared jointly by the New York State of Environmental Conservation (NYSDEC) and the USEPA. At this time, two (2) permits/monitoring programs and two (2) regulatory orders are in force. These regulatory programs are:

- Monthly New York State, State Pollutant Discharge Elimination System (SPDES) monitoring for the storm water outfall*;
- Monthly New York State Major Oil Storage Facility (MOSF) monitoring well gauging and annual monitoring well sampling*;
- Monthly Monitoring of selected wells as required by an Order on Consent with the NYSDEC dated March 17, 1986 (as part of MOSF monthly well gauging)*; and
- **Completion of a facility-wide Corrective Measures Implementation (CMI) as required by a 3008(h) of the Resource Conservation and Recovery Act (RCRA) Administrative Order on Consent (the Order) issued by the USEPA on September 10, 2009 (Docket No. RCRA-02-2009-7306) to Exxon Mobil and the property owner, Kinder Morgan Liquids Terminals, LLC. (performance of these activities are represented under this QAPP)**

** Maintained outside of the QAPP by Kinder Morgan*

This QAPP and subsequent Field Modifications will address activities associated with the CMI as required by the Order. Both Kinder Morgan and Exxon Mobil are respondents to the Order, and currently Kinder Morgan is responsible for implementing investigations and remedial actions associated with the Order.

Past Investigations
Investigations completed at the Facility under the RCRA Corrective Action Program have been conducted since the early 1990s are on-going. The findings of the investigations were presented in reports listed in Worksheet 13.

Most recently the findings were presented in the CMS Report by Woodard & Curran (Revised June 14, 2013), and a draft Corrective Measure Implementation (CMI) Workplan was submitted to the USEPA by Woodard & Curran in June 2014. A revised CMI Workplan was submitted to the EPA by Louis Berger in November 2015to address EPA's comments to the draft CMI Workplan.

On-Going Activities

QAPP Worksheet 10
Problem Definition

CMI activities are being performed to design, construct, operate, and maintain, and monitor the performance of the corrective measures selected. The Order also requires that all current Interim Corrective Measures (ICMs) continue to operate and the Monitored Natural Attenuation (MNA) program continue to be performed at the Facility while the CMI Workplan is being implemented. MNA sampling has been conducted under the Woodard & Curran January 2011 QAPP, which will expire in 2016.

This QAPP (which replaces the January 2011 QAPP) provides the rationale, field SOPs, analytical methods, and reporting of data to support the MNA program and the CMI program.

MNA Program - Overview
Kinder Morgan has contracted an outside consultant, currently Tetra Tech, to perform monthly ICM Monitoring events (groundwater and product measurements) and ICM system operation checks, consisting of manual product recovery and absorbent sock removal/replacement. Currently, operation and Maintenance (O&M) activities are being performed on the active product recovery system in operation at well MW-100 (North Beach Area); no other recovery system are active at this time. Tetra Tech also conducts quarterly groundwater sampling of wells specified in **Attachment 1**. The groundwater samples are analyzed for benzene, toluene, ethylbenzene and xylene (BTEX) and methyl tertiary-butyl ether (MTBE) on a quarterly basis, and indicator parameter (listed on Attachment 1) are included in the suite of analytical parameters for the 4th quarter sampling round. Data validation, and the preparation and submittal of quarterly Progress Reports and Annual Reports are currently performed by Louis Berger in accordance with the schedule in **Attachment 2.**

The Order specified that remedial goals for groundwater at perimeter monitoring wells bordering the Arthur Kill River must be protective of surface water standards presented in the NYSDEC Technical and Operational Guidance Series (TOGS) 1.1.1. To account for the significant mixing and dilution of groundwater that would occur as it discharges to the Arthur Kill River, the surface water criteria were multiplied by a conservative dilution factor of 10 to obtain the Groundwater Cleanup Objectives (GCO) for each chemical of concern. These remediation goals have been developed as required by the Order and are presented in Revised Corrective Measures Study (CMS) Report by Woodard and Curran, June 14, 2013. The Facility perimeter is defined as the downgradient portion of the Facility within 150 feet of the Arthur Kill River Shoreline. For the purpose of groundwater monitoring, MNA monitoring wells located within this downgradient perimeter area of the Facility include: ICM-1, ICM-3, ICM-5, ICM-7, ICM-9, ICM-10, L-8, MH-1, N-42, RFI-8R, RFI-9, RFI-11 and I-3. Non-perimeter areas are defined as any portion of the Facility not identified as a downgradient perimeter area of the facility. **Figures 3A, 3B and 3C** show the perimeter and non-perimeter areas and the monitoring wells that are sampled for each quarter with respect to these areas. The MNA Program is being performed in conjunction with the CMI Program.

CMI Program - Overview
Future Field Modifications will provide the rationale, field SOPs, analytical method and reporting of data to support the CMI Wok Plan and field program. For the general purposes of investigation and remediation activities conducted under the CMI program, the Facility has been categorized into the following seven (7) investigation areas, also known as Remediation Areas as shown **Figure 2**:

- Area 1: Tank 41 Berm
- Area 2: Tank 50
- Area 3: North Beach/Monitoring Well MW-100 Area
- Area 4: Bulkhead Recovery Area

QAPP Worksheet 10
Problem Definition

- Area 5: Boiler House
- Area 6: Former Lube Tanks
- Area 7: Siphon Building

The most recent activities conducted under the CMI program are summarized in the documents identified on Worksheet 13.
It is anticipated that supplemental area-specific workplans will be prepared by the Respondent and submitted to the USEPA in the form of a Field Modification (refer to Attachment 4 for template).

The environmental questions being asked:
The performance goals for the continuing RCRA Corrective Action Program at the Facility are outlined in the Order and the investigation, monitoring and remedial actions are developed such that the following questions are considered:

- Is there continued reduction or eventual elimination in the concentration of BTEX and MTBE on-site through MNA, enhanced remediation, direct source removals and LNAPL recovery operation?
- Is there reduction or elimination of human and environmental exposures in the future through the accelerated reduction and/or eventual elimination of chemicals of concern?
- Have the GCOs along perimeter areas of the Facility protective of the surface water of the Arthur Kill River?

Specifically, for each of the programs the following questions are relevant:

MNA Program
- Are the historical contaminant concentrations showing decreasing trends in groundwater samples?
- What is the estimated time frame for contaminant degradation for various wells?
- Are increasing trends in groundwater contaminant concentrations adequately addressed?
- Are increasing volumes of product thickness in wells adequately addressed?

CMI Program
- Is there adequate delineation of soil contamination, LNAPL, and groundwater for the known areas of concern?
- Are there any upgradient sources affecting areas of elevated contamination?
- Are there any new areas of concern?

In addition, are the programs incorporating the USEPA Stabilization and Green Clean Up Initiatives?
- Limiting soil excavation to higher concentration “hot Spots”
- When possible liquid petroleum recovery without groundwater pumping
- Use natural processes to remediate areas of environmental media with lesser chemical impact

QAPP Worksheet 10
Problem Definition

Observations from any site reconnaissance reports:

MNA Program
Field reports are submitted to Louis Berger by Tetra Tech twice a month. The data include are from the monitoring wells and include water level measurements, measurement of free product, the observance of sheen, and sorbent sock installation/replacement including relative product saturation of the sock. Louis Berger includes this information in the quarterly and annual reports to the USEPA.

CMI Program
Additional information will be included with future Field Modifications (refer to Attachment 4 for template).

A synopsis of Existing data or information from site reports:

The following conclusions were presented in the MNA Annual Progress Report for 2014 by Louis Berger, February 27, 2015:

- The BTEX results from January, April, July, and October 2014 support the conclusion that, in general, the areal extent of groundwater impacts at the facility is limited, displaying relatively rapid attenuation with distance from the presumed source areas. With a few noted exceptions, statistical analysis of historical and current analytical results generally shows that BTEX and MTBE concentrations at the site are decreasing or stable.
- Currently, groundwater as sampled from perimeter monitoring wells, is in compliance with the GCOs for BTEX, MTBE, and PAHs established in the approved CMS report. Groundwater monitoring across the Site also demonstrates that most contaminant plumes continue to shrink and decrease in concentration consistent with the requirements of the Order for non-perimeter groundwater.
- Hot spot and perimeter monitoring performed in conjunction with the MNA program has been very effective in monitoring existing and previous ICMs, the downgradient property boundaries, and other Remediation Area “hot spots” identified in the ICMI and SV/RFI reports; in addition to monitoring the facility for unknown and/or migrating releases.

QAPP Worksheet 10
Problem Definition

The possible classes of contaminants and the affected matrices: MNA Program Groundwater: Benzene, Toluene, Ethylbenzene, Xylenes (BTEX), Methyl tertiary butyl ether (MTBE), indicator parameters (Nitrate+Nitrite, Sulfate, Dissolved Oxygen, Ferrous Iron, Methane, and Carbon Dioxide). CMI Program Potential matrices and analytes may include, but are not limited to: Soil and Groundwater: Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs), Total Petroleum Hydrocarbons (TPH)-Gasoline Range Organics (GRO), TPH-Diesel Range Organics (DRO), and Metals. Additional information will be provided in future Field Modifications (refer to Attachment 4 for template).
The rationale for inclusion of chemical and nonchemical analyses: MNA Program The compounds included under the MNA program are specified in the Order and are for groundwater only. CMI Program Additional information will be provided in future Field Modifications (refer to Attachment 4 for template).
Project decision conditions: MNA Program If groundwater concentrations in perimeter monitoring wells are increasing beyond GCOs, evaluate whether natural attenuation should be enhanced or if more aggressive remedial approach is warranted. If the CMI Program is active, the MNA Program will continue to be implemented. CMI Program Additional information will be included in future Field Modifications (refer to Attachment 4 for template).

Worksheet 10 - Table of Contaminant Class and Matrices

Contaminant Class	MNA Program-Groundwater	CMI Groundwater[1]	CMI Groundwater[1]	CMI - Soil[1]
	Aqueous (Whole Water)	Aqueous (Whole Water)	Aqueous (Dissolved)	Soil-Solids
Benzene	X			
Toluene	X			
Ethylbenzene	X			
Xylenes (total)	X			
Methyl tertiary butyl ether (MTBE)	X			
MNA Indicator Parameters	X			
TCL VOCs		X		X
TPH-GRO		X		X
TPH-DRO		X		X
TCL SVOCs		X		X
TAL Metals		X	X	X

Note:

1. The contaminant classes and matrices for the MNA program and the CMI program are represented under this QAPP.
2. Contaminant class and matrices for CMI programs above, are generic and will vary based on the revised CMI Workplan and future Field Directives. The contaminant classes and matrices will be specified in future Field Directives.
3. MNA – Monitored Natural Attenuation
4. TLC – Target Compound List
5. VOCs – Volatile Organic Compounds
6. TPH-GRO – Total Petroleum Hydrocarbons – Gasoline Range Organics
7. TPH-DRO - Total Petroleum Hydrocarbons – Diesel Range Organics
8. SVOCs – Semi-Volatile Organic Compounds
9. TAL – Target Analyte List

QAPP Worksheet 11
Project Quality Objectives/Systematic Planning Process Statements

Who will use the data?
USEPA, NYSDEC, and stakeholders

What will the data be used for?
The data are being provided in response to the Order. The data will be used for the following purposes:

- Monitor groundwater contaminant trends through quarterly sampling
- Perform statistical analysis to verify contaminant trends
- Support risk assessment and evaluate potential remedial alternatives
- Identify the nature and extent of subsurface liquid-phase hydrocarbons
- Design and implement ICMs

What type of data is needed?
Field crew will document observations and field activities in field notebooks. Sample shipment will be documented with COC and laboratory login (refer to Worksheets 26 and 27). Parameter list with achievable laboratory reporting limits and appropriate environmental standards is provided in Worksheet 15.

Additional information will be provided in future Field Modifications (refer to Attachment 4 for template).

How "good" do the data need to be in order to support the environmental decision?
Data must be technically defensible and of sufficient quality to support the projects objectives. Laboratory generated-data will be validated. Validation and verification guidelines are provided in Worksheets 35 and 36. Refer to Worksheet 15 for summary of analytical parameters, laboratory achievable reporting limits, and project quantitation limits.

Additional information for the CMI Program will be provided in future Field Modifications (refer to Attachment 4 for template).

How much data are needed? (number of samples for each analytical group, matrix, and concentration)
Refer to Worksheet 20 for anticipated number of field samples and quality control samples to be shipped to the assigned laboratory.

Additional information for the CMI Program will be provided in future Field Modifications (refer to Attachment 4 for template).

Where, when, and how should the data be collected/generated?
Where: Kinder Morgan Staten Island Terminal, 1401 Arthur Kill Road, Staten Island, New York
When: MNA sampling is conducted on a quarterly basis. The collection of CMI data will performed in accordance with the future project schedules which will be presented in future Field Modifications (refer to Attachment 4 for template).
How: Per field SOPs (refer to Worksheet 21, Attachment 3, and future Field Modifications (refer to Attachment 4 for template).

QAPP Worksheet 11
Project Quality Objectives/Systematic Planning Process Statements

Who will collect and generate the data? MNA Program Tetra Tech Project Team field personnel will collect the groundwater samples and transfer samples under COC to the assigned laboratory. The laboratory will analyze samples. The data will be validated by an externa data validator under contract with Louis Berger. Validation and verification guidelines are provided in Worksheets 35 and 36. CMI Program Louis Berger Project Team field personnel will collect the samples. Additional information will be presented in future Field Modifications (refer to Attachment 4 for template).
How will the data be reported? Field work will be documented in field notebooks; no photographs are allowed at the site unless under direct written instruction by Kinder Morgan. The field information collected by Tetra Tech will be provided to Louis Berger electronically so that the Quarterly and Annual Reports can be prepared by Louis Berger. Test America will put their Laboratory analytical data packages on their portal, which will be accessed by Louis Berger. Louis Berger will put the laboratory packages on an FTP site for the external data validator. The quarterly and annual reports provide a data summary table, and the annual reports also include a PDF copy of the Analytical Report. Additional information for the CMI Program will be provided in future Field Modifications (refer to Attachment 4 for template).
How will the data be archived? Electronic data and hard copies of laboratory data reports will be kept in Louis Berger project files. Electronic data will be provided in USEPA in MS Excel spreadsheets. The length of time that records will be archived will be at the discretion of USEPA.

QAPP Worksheet 12-1
Measurement Performance Criteria Table

Matrix	Groundwater
Analytical Group	VOC
Concentration Level	Low

Sampling Procedure	**Analytical Method/SOP[1]**	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria[1]**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)**
QAPP (dated January 2016); samples will be collected by Tetra Tech sampling team, chain of custody will be transferred to the laboratory. Tetra Tech will utilize the equipment and field SOPs in **Attachment 3**	SW846 8260C (TestAmerica SOP: ED-MSV-014) (analysis for benzene, toluene, ethylbenzene, xylenes, and methyl tertiary butyl ether only) Subcontractor laboratory will follow their analytical SOP for analysis, which must meet at a minimum all requirements stated in the USEPA SW846 Methods	Precision	RPD ≤ 30% for duplicate values greater than or equal to 5 times the QL	Field Duplicate	S & A
		Accuracy/Bias/ Precision	Laboratory Statistical Limits per the laboratory SOP, recoveries must be within laboratory derived limits and allowable exceedance; RPD ≤ 30%	Matrix Spike / Matrix Spike Duplicate (MS/MSD)	S & A
		Accuracy/Bias	Laboratory Statistical Limits per the laboratory SOP, recoveries must be within laboratory derived limits and allowable exceedance.	Laboratory Control Sample (LCS)	A
		Sensitivity	Less than QLs	Method Blank (MB)	A
		Accuracy/Bias	Laboratory Statistical Limits per the laboratory SOP, recoveries must be within laboratory derived limits and allowable exceedance.	Surrogate Recovery	A
		Sensitivity	Less than QLs	Trip Blank	S & A
		Sensitivity	Less than QLs	Field Blank	S & A
		Completeness	>90% sample collection and >90% laboratory analysis	Data Completeness Check	S & A

1. The subcontractor laboratory must perform and meet all of the measurement performance criteria that assess the analytical DQIs specified in USEPA SW846 8260C.

QAPP Worksheet 12-2
Measurement Performance Criteria Table

Matrix	Groundwater
Analytical Group	Anions (Sulfate, Nitrate, and Nitrite)
Concentration Level	Low

Sampling Procedure	**Analytical Method/SOP[1]**	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria[1]**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)**
QAPP (dated January 2016); samples will be collected by Tetra Tech sampling team, chain of custody will be transferred to the laboratory. Tetra Tech will utilize the equipment and field SOPs in **Attachment 3**	EPA 300.0 (TestAmerica SOP: ED-GCS-022) Subcontractor laboratory will follow their analytical SOP for analysis, which must meet at a minimum all requirements stated in the EPA 300.0.	Precision	RPD ≤ 30% for duplicate values greater than or equal to 5 times the QL	Field Duplicate	S & A
		Accuracy/Bias/ Precision	90-110% Recovery; RPD ≤ 15%	Matrix Spike / Matrix Spike Duplicate (MS/MSD)	S & A
		Accuracy/Bias	90-110% Recovery	Laboratory Control Sample (LCS)	A
		Sensitivity	Less than QLs	Method Blank (MB)	A
		Sensitivity	Less than QLs	Field Blank	S & A
		Completeness	>90% sample collection and >90% laboratory analysis	Data Completeness Check	S & A

1. The subcontractor laboratory must perform and meet all of the measurement performance criteria that assess the analytical DQIs specified in EPA 300.0 or equivalent methods.

QAPP Worksheet 12-3
Measurement Performance Criteria Table

Matrix	Groundwater
Analytical Group	Dissolved Oxygen
Concentration Level	Low

Sampling Procedure	**Analytical Method/SOP[1]**	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria[1]**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)**
QAPP (dated January 2016); samples will be collected by Tetra Tech sampling team, chain of custody will be transferred to the laboratory. Tetra Tech will utilize the equipment and field SOPs in **Attachment 3**	SM4500-O C (TestAmerica SOP: ED-WET-053) Subcontractor laboratory will follow their analytical SOP for analysis, which must meet at a minimum all requirements stated in the SM4500-O.	Precision	RPD ≤ 30% for duplicate values greater than or equal to 5 times the QL	Field Duplicate	S & A
		Accuracy	Less than QLs	Procedural Blank (Winkler Titration Sample)	A
		Precision	Per the laboratory SOP, RPD must meet within the laboratory derived limit	Laboratory Replicate	A
		Sensitivity	Less than QLs	Field Blank	S & A
		Completeness	>90% sample collection and >90% laboratory analysis	Data Completeness Check	S & A

1. The subcontractor laboratory must perform and meet all of the measurement performance criteria that assess the analytical DQIs specified in the SM4500-O.

QAPP Worksheet 12-4
Measurement Performance Criteria Table

Matrix	Groundwater
Analytical Group	Ferrous Iron
Concentration Level	Low

Sampling Procedure	**Analytical Method/SOP[1]**	**Data Quality Indicators (DQIs)**	**Measurement Performance Criteria[1]**	**QC Sample and/or Activity Used to Assess Measurement Performance**	**QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)**
QAPP (dated January 2016); samples will be collected by Tetra Tech sampling team, chain of custody will be transferred to the laboratory. Tetra Tech will utilize the equipment and field SOPs in **Attachment 3**	SM3500-Fe D (TestAmerica SOP: ED-WET-057) Subcontractor laboratory will follow their analytical SOP for analysis, which must meet at a minimum all requirements stated in the SM3500-Fe D.	Precision	RPD ≤ 30% for duplicate values greater than or equal to 5 times the QL	Field Duplicate	S & A
		Accuracy/Bias/ Precision	75-120% Recovery; RPD ≤ 20%	Matrix Spike / Matrix Spike Duplicate (MS/MSD)	S & A
		Accuracy/Bias	83-115% Recovery	Laboratory Control Sample (LCS)	A
		Sensitivity	Less than QLs	Method Blank (MB)	A
		Sensitivity	Less than QLs	Field Blank	S & A
		Completeness	>90% sample collection and >90% laboratory analysis	Data Completeness Check	S & A

1. The subcontractor laboratory must perform and meet all of the measurement performance criteria that assess the analytical DQIs specified in the SM3500-Fe D.

QAPP Worksheet 12-5
Measurement Performance Criteria Table

Matrix	Groundwater
Analytical Group	Dissolved Gases
Concentration Level	Low

Sampling Procedure	Analytical Method/SOP[1]	Data Quality Indicators (DQIs)	Measurement Performance Criteria[1]	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
QAPP (dated January 2016); samples will be collected by Tetra Tech sampling team, chain of custody will be transferred to the laboratory. Tetra Tech will utilize the equipment and field SOPs in **Attachment 3**	RSK-175 (TestAmerica SOPs: NV04-89 [methane] and BR-AT-006 [carbon dioxide]) Subcontractor laboratory will follow their analytical SOP for analysis, which must meet at a minimum all requirements stated in the RSK-175.	Precision	RPD ≤ 30% for duplicate values greater than or equal to 5 times the QL	Field Duplicate	S & A
		Accuracy/Bias Precision	Methane: Laboratory Statistical Limits per the laboratory SOP, recoveries must be within laboratory derived limits and allowable exceedance; RPD ≤ 30% Carbon dioxide: 70-130% Recovery; RPD ≤ 30%	Matrix Spike / Matrix Spike Duplicate (MS/MSD)	S & A
		Accuracy/Bias	80-120% (methane) 70-130% (carbon dioxide)	Laboratory Control Sample (LCS)	A
		Accuracy/Bias	Per the laboratory SOP, the surrogate recovery must be within laboratory control limit	Surrogate	A
		Sensitivity	Less than QLs	Method Blank (MB)	A
		Sensitivity	Less than QLs	Field Blank	S & A
		Completeness	>90% sample collection and >90% laboratory analysis	Data Completeness Check	S & A

1. The subcontractor laboratory must perform and meet all of the measurement performance criteria that assess the analytical DQIs specified in the RSK-175.

QAPP Worksheet 13
Secondary Data Criteria and Limitations Table

Existing Data[1]	Data Source (Originating Organization, Report Title, and Date)	Data Generator(s) (Originating Org., Data Types, Data Generation/ Collection Dates)	How Data Will Be Used	Limitations on Data Use
Facility Assessment	RCRA Facility Assessment (RFA) by A/T. Kearney (July 1993)	1990s facility risk assessment	Source for historical background information and data	None
Interim Corrective Measures Investigation	Interim Corrective Measures Investigation (ICMI) by Fluor Daniel GTI (Revision 1; April 17, 1997)	Data and findings from 1990s investigation	Source for historical background information and data	Some conclusions and findings may be based on cleanup criteria no longer in effect.
Risk Assessment	Risk Assessment by Fluor Daniel GTI (December 1998)	1990s risk assessment	Source for historical background information and data	Some conclusions and findings may be based on cleanup criteria no longer in effect.
Ecological Risk Assessment	Revised Ecological Risk Assessment by Woodard & Curran (September 29, 2004)	Ecological risk assessment	Source for historical background information and data	Some conclusions and findings may be based on cleanup criteria no longer in effect.
Facility sampling and investigation	Combined RCRA Facility Assessment Sampling Visit/RCRA Facility investigation (SV/RFI) by Woodard & Curran (June 18, 1998; Revised December 3, 2004, Final January 4, 2007	Data and findings from late 1990 to early 2000s investigations	Source for historical background information and data	Some conclusions and findings may be based on cleanup criteria no longer in effect.
Corrective Measures Study Work Plan	RCRA Corrective Measures Study (CMS) Work Plan (draft December 8, 2009, June 11, 2010)	Workplan includes proposed pilot study	Source for historical background information and data	Some conclusions and findings may be based on cleanup criteria no longer in effect.
Corrective Measures Study Report	Corrective Measures Study (CMS) Report (April 30, 2012, Revised June 14, 2013).	Findings include pilot study test results	Source for historical background information and data. Outlines cleanup standards.	None
MNA Program: Quarterly Progress Reports for 2010 through 2015 (Q1, Q2 and Q3)	Woodard and Curran (2010 through Q2 2014); Louis Berger Q3 2014 through current)	2010 through 2013 field data collected by Roux Associates; 2013 through current field data collected	Data and other information from Quarterly Report will be compiled into Annual Report.	None

		by Tetra Tech Inc.		
CMI Program: AOC 7 Oil/Water Separator (endpoint sampling)	Louis Berger, Former Oil/Water Separator Soil Characterization and Product Observations, October 28, 2014	Louis Berger collected cursory end point soil samples	Evaluate impact and if additional investigation/remediation needed	None
CMI Program: AOC 7 Oil/Water Separator (Product Removal)	Louis Berger, AOC7 Product Delineation Interim & Remedial Measures, January 14, 2015	Louis Berger collected groundwater and product samples	Evaluate impact and if additional investigation/remediation needed	None

1. The only formerly generated data for the Facility that will be used to make project decisions are data generated through previous investigations and ICMs conducted as part of the RCRA Corrective Action Program. These activities were conducted under two former USEPA approved QAPPs dated November 16, 1995, and January 14, 2011 (as listed in Worksheet 2); therefore, these data are useable for future decision making. External data or data generated prior to the RCRA Corrective Action Program is not anticipated to be used to make future project decisions.

QAPP Worksheet 14
Summary of Project Tasks

Sampling Tasks: Refer to Worksheet 10 for Problem Definition and Worksheet 11 for Project Quality Objectives.
Analysis Tasks: TestAmerica (under contract to Kinder Morgan) will conduct analyses on the field samples according to requirements provided on Worksheet 12. Analytical methods are provided in Worksheet 23 and corresponding corrective actions are provided in Worksheet 28. Calibration requirements for each analytical method are listed in Worksheet 24.
Quality Control Tasks: TestAmerica will conduct analyses on the quality control samples (both external quality control samples shipped from the field and internal method-required quality control samples) according to requirements provided in Worksheets 12 and 28. Number of estimated quality control samples is listed in Worksheet 20. Groundwater samples will be analyzed for chemical parameters by USEPA or Standard Method, and validated by Data Check, Inc. (under subcontract to Louis Berger).
Existing Data: Secondary data sources are provided in Worksheet 13.
Data Management Tasks: Tetra Tech (under contract to Kinder Morgan) will collect field samples and field measurements. Laboratory (TestAmerica) will distribute copies of signed COC and sample login to Tetra Tech, Louis Berger, and Kinder Morgan. Tetra Tech will be responsible for tracking field samples to confirm completeness of field program. Louis Berger will coordinate completion of data validation. The field information collected by Tetra Tech will be provided to Louis Berger electronically so that the Quarterly and Annual Reports can be prepared by Louis Berger. Test America will put their Laboratory analytical data packages on their portal, which will be accessed by Louis Berger. Louis Berger will put the laboratory packages on an FTP site for the external data validator. The quarterly and annual reports provide a data summary table, and the annual reports also include a PDF copy of the Analytical Report. Worksheet 29 provides the minimum requirements for data management.
Documentation and Records: All hardcopy data (field notes and COCs) will be maintained in the Tetra Tech project files. No photographs are allowed at the site unless under direct written instruction by Kinder Morgan. Laboratory (TestAmerica) will distribute copies of signed COC and sample login to Tetra Tech, Louis Berger, and Kinder Morgan.
Assessment/Audit Tasks: Refer to Worksheet 31 for assessments and audits.
Data Review Tasks: Laboratory data produced by subcontracted laboratories will be validated by data validators based on the criteria in the applicable analytical SOPs, QAPP, and applicable USEPA data validation guidance. Field measurements will be verified for completeness. Data verification and validation are described in Worksheets 34 through 36.

QAPP Worksheet 15

QAPP Worksheet 15 - 1
Reference Limits and Evaluation Tables
Matrix: Groundwater
Analytical Group: VOC (SW846 8260C)
Concentration Level: Low

Analyte	CAS Number	Units	Surface Water Criteria[1]	Perimeter Area Groundwater Criteria[2]	Project QL[3]	Analytical Method		Achievable Laboratory Limits	
						MDL	QL	MDL	QL
Benzene	71-43-2	ug/L	670	6,700	6,700	Per SW846 8260C	Per SW846 8260C	0.09	1
Ethylbenzene	100-41-4	ug/L	41	410	410	Per SW846 8260C	Per SW846 8260C	0.3	1
m,p-Xylene	179601-23-1	ug/L	170 (total xylenes)	1,700 (total xylenes)	1,700 (total xylenes)	Per SW846 8260C	Per SW846 8260C	0.28	1
Methyl tert-butyl ether	1634-04-4	ug/L	210,000	2,100,000	2,100,000	Per SW846 8260C	Per SW846 8260C	0.13	1
o-Xylene	95-47-6	ug/L	170 (total xylenes)	1,700 (total xylenes)	1,700 (total xylenes)	Per SW846 8260C	Per SW846 8260C	0.32	1
Toluene	108-88-3	ug/L	430	4,300	4,300	Per SW846 8260C	Per SW846 8260C	0.25	1

1: The surface water criteria is based on the NYSDEC Division of Water Technical and Operation Guidance Series (1.1.1) *Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations* (October 1993) Table 1. The surface water classification of SD (saline water, classification for Arthur Kill water body) and type AA (fish survival) are used above.
2: To account for the significant mixing and dilution of groundwater that would occur as it discharges to the Arthur Kill River, the perimeter area groundwater criteria is defined as multiplication of factor of 10 on the surface water criteria for each chemical of concern. (*Reference: Corrective Measures Study (CMS) Report by ExxonMobil Refining & Supply Company, a division of ExxonMobil Corporation, document No. 206923, Revised June 14, 2013, Section 4.2 Perimeter Groundwater Cleanup Objectives)*
3: Project QLs are equal to the perimeter area groundwater criteria. No project QLs or action levels are established for non-perimeter area locations.
4: Units represent mass of contaminant per liter.
5: Achievable laboratory limits are equal to subcontractor laboratory (TestAmerica) method detection limits and quantitation limits using Method 8260C with a 5 mL purge and trap.

QAPP Worksheet 15 - 2
Reference Limits and Evaluation Tables
Matrix: Groundwater
Analytical Group: MNA Indicator Parameters (Sulfate, Nitrate, Nitrite, Dissolved Oxygen, Ferrous Iron, Methane, and Carbon Dioxide)
Concentration Level: Low

Analyte	CAS Number	Units	Project QL	Analytical Method		Achievable Laboratory Limits	
				MDL	QL	MDL	QL
Sulfate	14808-79-8	mg/L	0.60	Per EPA 300.0	Per EPA 300.0	0.105	0.60
Nitrate	14797-55-8	mg/L	0.10	Per EPA 300.0	Per EPA 300.0	0.021	0.10
Nitrite	14797-65-0	mg/L	0.12	Per EPA 300.0	Per EPA 300.0	0.029	0.12
Dissolved Oxygen	7782-44-7	mg/L	1	Per SM4500-O C	Per SM4500-O C	1	1
Ferrous Iron	15438-31-0	mg/L	0.1	Per SM3500-Fe D	Per SM3500-Fe D	0.048	0.1
Methane	74-82-8	ug/L	5	Per RSK-175	Per RSK-175	2.5	5
Carbon Dioxide	124-38-9	ug/L	1000	Per RSK-175	Per RSK-175	200	1000

1: No project action levels are required for Monitored Natural Attenuation (MNA) indicator parameters. The project QLs are equal to the laboratory achievable quantitation limits.
2: Units represent mass of contaminant per liter.
3: Achievable laboratory limits are equal to subcontractor laboratory (TestAmerica) method detection limits and quantitation limits.

QAPP Worksheet 16
Project Schedule Timeline Table

MNA Program

Sampling and reporting for Groundwater is conducted quarterly. The specific tasks, group responsible for their execution and dates are listed in the following table.

Activity	Responsible Party	Planned Start Date	Planned completion Date	Deliverable	Deliverable Due Date
1st Quarter Groundwater Sampling	Tetra Tech	January (date flexible)	To be completed within Q1	Field notes and excel summary sheet	Within 1 week of completion of sampling
Laboratory analysis	Test America	Upon sample receipt	10 day turnaround time	Report of Analyses/Data Package	10 day turnaround time
Validation	Data Check	Upon receipt of data	4-6 weeks after receipt of data	Validation Summary Report	4-6 weeks after receipt of data
Reporting	Louis Berger	Upon receipt of data	Within 45 Days of end of quarter	1st Quarter Progress Report (January - March)	May 15th
2nd Quarter Groundwater Sampling	Tetra Tech	April (date flexible)	To be completed within Q2	Field notes and excel summary sheet	Within 1 week of completion of sampling
Laboratory analysis	Test America	Upon sample receipt	10 day turnaround time	Report of Analyses/Data Package	10 day turnaround time
Validation	Data Check	Upon receipt of data	4-6 weeks after receipt of data	Validation Summary Report	4-6 weeks after receipt of data
Reporting	Louis Berger	Upon receipt of data	Within 45 Days of end of quarter	2nd Quarter Progress Report (April to June)	August 15th
3rd Quarter Groundwater Sampling	Tetra Tech	July (date flexible)	To be completed within Q3	Field notes and excel summary sheet	Within 1 week of completion of sampling
Laboratory analysis	Test America	Upon sample receipt	10 day turnaround time	Report of Analyses/Data Package	10 day turnaround time
Validation	Data Check	Upon receipt of data	4-6 weeks after receipt of data	Validation Summary Report	4-6 weeks after receipt of data
Reporting	Louis Berger	Upon receipt of data	Within 45 Days of end of quarter	3rd Quarter Progress report (July to September)	November 15th
4th Quarter Groundwater Sampling	Tetra Tech	October (date flexible)	To be completed within Q4	Field notes and excel summary sheet	Within 1 week of completion of sampling

Activity	Responsible Party	Planned Start Date	Planned completion Date	Deliverable	Deliverable Due Date
Laboratory analysis	Test America	Upon sample receipt	10 day turnaround time	Report of Analyses/Data Package	10 day turnaround time
Validation	Data Check	Upon receipt of data	4-6 weeks after receipt of data	Validation Summary Report	4-6 weeks after receipt of data
Reporting	Louis Berger	Upon receipt of data	Within 60 Days of end of quarter	Annual Progress Report (October to December, year Summary)	March 1st

CMI Program

The schedule for future activities to be performed pursuant to the Order will be developed and presented in task-specific work plans (Field Modifications to the QAPP and CMI Workplan) based on the milestones and timeframes outlined in the Order.

QAPP Worksheet 17
Sampling Design and Rationale

Kinder Morgan is conducting MNA sampling of groundwater in accordance with the Order. The MNA program is being implemented to monitor specific areas of known contamination (remediation areas), identify groundwater contaminant concentration trends in and downgradient of these areas, monitor perimeter wells to evaluate potential contaminant migration to the Arthur Kill, and monitor upgradient wells to evaluate background conditions. As described on QAPP Worksheet 10, the seven remediation areas are:

- Area 1: Tank 41 Berm
- Area 2: Tank 50
- Area 3: North Beach/Monitoring Well MW-100 Area
- Area 4: Bulkhead Recovery Area
- Area 5: Boiler House
- Area 6: Former Lube Tanks
- Area 7: Siphon Building

Groundwater wells and analytical parameters to be sampled for each quarter are presented in Figure 3A, 3B, and 3C. As outlined in QAPP Worksheet 10, groundwater samples are analyzed quarterly for BTEX and MTBE. In addition, annual Q4 (October) groundwater analysis also includes MNA parameters to evaluate the effectiveness of the MNA program. The sampling parameters and schedule are presented in **Attachment 1**, and are summarized as follows:

- The sampling frequency for perimeter wells and wells in the Bulkhead areas must be on a quarterly basis (January, April, July, and October).
- Wells in the Tank Farm and/or those containing stable or downward trending dissolved concentrations must be sampled on a semi-annual basis (January and July)
- Wells with non-detected and dissolved concentrations must be sampled on an annual basis to confirm groundwater contaminant trends in these areas.

Modifications to the MNA program, such as including additional wells, may be recommended based on the evaluation of sample results. In addition, the results of the MNA program may be used to design investigations and ICMs under the CMI program.

Groundwater Collection

- One groundwater (whole water) sample will be collected from each monitoring well (exclusive of field duplicates).
- Groundwater will be purged and containerized. Groundwater stabilization will be monitored using a water quality meter. Once stabilized, groundwater (whole water only) will be sampled using a bladder pump and USEPA low-flow sampling techniques.
- Field measurements will include: water level, product thickness (if present), observation of sheen, and sorbent sock installation/replacement.
- If groundwater volume is limited, sample jars will be filled in an analytical hierarchy: VOCs and then water quality indicator parameters (preference to nitrite and dissolved oxygen).
- During pumping, air monitoring will be conducted at the ground surface of the borehole.
- Dedicated (disposable) tubing and bladder will be used for groundwater sampling.
- Sample jars will be filled and preserved following QAPP Worksheet 19. Number of samples and sample IDs are provided in QAPP Worksheets 20 and 26.
- Refer to Attachment 3 for equipment and field SOPs; refer to Worksheet 22 for calibration of field equipment.

QAPP Worksheet 17
Sampling Design and Rationale

Investigative Derived Waste

- Equipment will arrive on-site decontaminated. If equipment needs to be decontaminated in the field, field crew will containerize spent fluid on-site in containers provided by Tetra Tech.
- Purge water from groundwater monitoring wells will be containerized on-site in containers provided by Tetra Tech. Kinder Morgan will be responsible for drum disposal.

QAPP Worksheet 18
Sampling Locations and Methods/SOP Requirements Table

Sampling Location/ID Number	Matrix	Depth	Analytical Group	Concentration Level	Estimated Number of Samples (identify field duplicates)	Sampling SOP Reference	Rationale for Sampling Location
MNA Program[1] (refer to Worksheet 27 on sample ID definition)	Groundwater	Applicable depth of groundwater screen and intake pump	BTEX, MTBE, Sulfate, Nitrate, Nitrite, Dissolved Oxygen, Ferrous Iron, Methane, and Carbon Dioxide	Low	Refer to Worksheet 20	Refer to Worksheet 21	Refer to Figure 3A, 3B, and 3C for sampling map of proposed locations. Rationale: Perform the collection and analysis of quarterly groundwater sampling programs for BTEX and MTBE and include MNA parameters during annual sampling to: identify groundwater contaminant concentration trends in and downgradient of known impacted areas; monitor perimeter wells to evaluate potential contaminant migration to the Arthur Kill; and monitor upgradient wells to evaluate background conditions.

1. The 42 wells sampled in the current MNA program are listed below, and the sampling schedule and parameters for each sampling quarter are presented in **Attachment 1**. The sample ID shall consist of the well name, followed by the sampling year, and sampling quarter as outlined on QAPP Worksheet 27 (e.g., MW-103-2016Q1).

I-1	ICM-10	MW-110	RFI-1
I-2	KM-GP05	MW-111	RFI-2
I-3	KM-GP13	MW-112	RFI-4
I-5	L-2	MW-113	RFI-6
I-6	L-8	MW-114	RFI-7
ICM-1	L-27	MW-116	RFI-8R
ICM-3	L-34	MW-117	RFI-9R
ICM-5	MH-1	MW-118	RFI-11
ICM-6	MW-103	N-42	RW-1A
ICM-7	MW-107	N-43	
ICM-9	MW-109	OW-MW-3	

QAPP Worksheet 19
Analytical SOP Requirement Table

Matrix	Analytical Group	Conc Level	Analytical and Preparation Method/SOP Reference	Sample Volume/Mass per Analysis	Containers (number, size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/ analysis)
Groundwater	VOC	Low	SW846 8260C	120 mL	Three 40 mL VOA vials w/Teflon lined septum caps Nine 40 mL VOA vials (when collecting QC sample)	Preserve with 1:1 HCl to pH<2; cool to <6°C (not frozen); No headspace	14 days to analysis
Groundwater	Anions (Sulfate, Nitrate, Nitrite)	Low	EPA 300.0	250 mL	One 250 mL plastic bottle (no extra volume required for QC samples)	Cool to <6°C (not frozen)	28 days for Sulfate 48 hours for Nitrate and Nitrite
Groundwater	Dissolved Oxygen	Low	SM4500-O C	300 mL	One 300 mL BOD (Biological Oxygen Demand) bottle with stopper, no headspace Two 300 mL BOD bottles (when collecting QC sample)	Field preserve: add 2ml of manganous sulfate followed by 2ml of iodide-azide solution below surface of liquid. Stored in dark.	8 hours for analysis
Groundwater	Ferrous Iron	Low	SM3500-Fe D	250 mL	One 250 mL plastic bottle (no extra volume required for QC samples)	Cool to <6°C (not frozen)	Analyze as soon as possible
Groundwater	Methane	Low	RSK-175	120 mL	Three 40 mL VOA vials w/Teflon lined septum caps, no headspace. Nine 40 mL VOA vials (when collecting QC sample)	Preserve with 1:1 HCl to pH<2; cool to <6°C (not frozen); No headspace	14 days to analysis
Groundwater	Carbon Dioxide	Low	RSK-175	120 mL	Three 40 mL VOA vials w/Teflon lined septum caps, no headspace. Nine 40 mL VOA vials (when collecting QC sample)	Cool to <6°C (not frozen); No headspace	14 days to analysis

1. Laboratory will provide pre-cleaned bottles for sampling.
2. “Maximum holding time” refers to technical holding time from time of collection, which differs from the USEPA Verified Time of Sample Receipt (VTSR) holding time.

QAPP Worksheet 20
Field Quality Control Sample Summary Table

MNA Program
The groundwater samples per quarter will be collected as follow:
Quarter 1 and Quarter 3: Groundwater samples will be collected for 10 well locations with an estimated 2-day field activities each quarter, yielding total of (10 wells x 1 sample per well = 10 samples) each quarter for VOC analyses.
Quarter 2: Groundwater samples will be collected for 23 well locations with the estimated 3-day field activities, yielding total of (23 wells x 1 sample per well = 23 samples) for VOC samples.
Quarter 4: Groundwater samples will collected for 42 well locations with the estimated 5-day field activities, yielding total of (42 wells x 1 sample per well = 42 samples), the 42 samples will also be analyzed for indicator parameters (including sulfate, nitrate, nitrite, dissolved oxygen, ferrous iron, methane, and carbon dioxide).

Matrix	Analytical Group	Conc. Level	Analytical and Preparation SOP Reference	Estimated No. of Field Samples	Estimated No. of Field Duplicates	Estimated No. of Field Blanks	Estimated No. of QC Samples	Estimated No. of Trip Blanks	Estimated Total No. of Samples to Lab
Groundwater	VOC	Low	SW846 8260C	85	7	7	7	12	118
Groundwater	Anions (Sulfate, Nitrate, Nitrite)	Low	EPA 300.0	42	3	3	3	0	51
Groundwater	Dissolved Oxygen	Low	SM4500-O C	42	3	3	3	0	51
Groundwater	Ferrous Iron	Low	SM3500-Fe D	42	3	3	3	0	51
Groundwater	Methane	Low	RSK-175	42	3	3	3	0	51
Groundwater	Carbon Dioxide	Low	RSK-175	42	3	3	3	0	51

Notes:
1: Field duplicates and laboratory QC samples (see Worksheet 12 for each analytical group required QC samples) will be collected at a rate of 1 per 20 field samples per quarter. Anticipate 1 set of QC (field duplicate + QC) in Quarter 1; 2 sets of QC in Quarter 2; 1 set of QC in Quarter 3; 3 sets of QC in Quarter 4 (total of 7 sets of QC for VOC and 3 sets for MNA indicator parameters).
2: Field blanks will be prepared at a minimum frequency of 1 for each set of associated samples to a maximum of 20 samples (minimum 5% frequency).
3: Trip blanks will be collected at a rate of 1 per shipment.

QAPP Worksheet 21
Project Sampling SOP Reference Table

Reference Number	Title, Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work?	Comments
SOP No. 1	Tetra Tech, Standard Operating Procedure, Revision 2, November 2014 "Dissolved Oxygen (Membrane Electrode)"	Tetra Tech	Refer to SOP	No	Refer to Attachment 3 for Field and Equipment SOP
SOP No. 2	Tetra Tech, Standard Operating Procedure, Revision 1, November 2014 "pH (Electrometric)"	Tetra Tech	Refer to SOP	No	Refer to Attachment 3 for Field and Equipment SOP
SOP No. 3	Tetra Tech, Standard Operating Procedure, Revision 0, December 2011 "Specific Conductance (Wheatstone Bridge)"	Tetra Tech	Refer to SOP	No	Refer to Attachment 3 for Field and Equipment SOP
SOP No. 4 and SOP No. 5	Tetra Tech, Standard Operating Procedure, "Taylor Waterproof Digital Thermometer" Tetra Tech, Standard Operating Procedure, Revision 1, November 2014 "Temperature (Thermometric)"	Tetra Tech	Refer to SOP	No	Refer to Attachment 3 for Field and Equipment SOP
SOP No. 6	Tetra Tech, Standard Operating Procedure, Revision 0, December 2011 "Turbidity (Nephelometric)"	Tetra Tech	Refer to SOP	No	Refer to Attachment 3 for Field and Equipment SOP
SOP No. 7	Louis Berger, Standard Operating Procedure, Revision 1, October 2015 "Procedure for Collection of Low-Flow, Minimal-Drawdown Groundwater Samples"	Louis Berger	Refer to SOP	No	Refer to Attachment 3 for Field and Equipment SOP
SOP No. 8	Louis Berger, Standard Operating Procedure, Revision 0, October 2015 "Procedure to Conduct Sample Management"	Louis Berger	Refer to SOP	No	Refer to Attachment 3 for Field and Equipment SOP
SOP No. 9	Kinder Morgan, Standard Operating Procedure, contractor Notification, October 2014 "Secondary Containment Requirements"	Kinder Morgan	Refer to SOP	No	To be used by the field team as a guide while conducting field work
EPA540-R -07-06	USEPA Contract Laboratory Program Guidance for Field Samplers, EPA540-R-07-06, July 2007 (or latest version)	USEPA	Refer to referenced document	No	To be used by the field team as a guide for collecting and preparing samples

QAPP Worksheet 22
Field Equipment Calibration, Maintenance, Testing, and Inspection Table

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Photoionization Detector (PID) MiniRae 3000 or equivalent	Daily prior to use.	Battery and operation check performed before each use	Pre-calibrated by the supplier. Calibration check at beginning and end of day.	Check for signs of damage to casing or sensors	Check before each use	Within manufacturer allowed tolerance	Replace battery, clean sensors, check user manual	Tetra Tech	Refer to Attachment 3 for Field and Equipment SOP
Bladder Pump (Micro-purge QED Control and Sample Pro ¾ inch Portable Micro-purge pump or equivalent)	None	Battery and operation check performed before each use. Dedicated tubing and bladder.	Perform battery and operation check per operator manual	Check for signs of damage. Check tubing and bladder.	Check before each use	None	Replace battery, check user manual, check tubing and bladder	Tetra Tech	Refer to Attachment 3 for Field and Equipment SOP
Multi Water Quality Check Model U-50 Series	Daily prior to use.	Battery and operation check performed before each use	Pre-calibrated by the supplier. Calibration check at beginning and end of day.	Check for signs of damage to casing or sensors	Check before each use	Within manufacturer allowed tolerance	Replace battery, clean sensors, check user manual	Tetra Tech	Refer to Attachment 3 for Field and Equipment SOP
Water Level / Interface Probe Solinst Model 122 or equivalent	None	Battery and operation check performed before each use	Perform battery and operation check per operator manual	Check for signs of wear or damage to probe	Check before each use	None	Replace battery, clean probe, check operator manual	Tetra Tech	Refer to Attachment 3 for Field and Equipment SOP

QAPP Worksheet 23
Analytical SOP Reference Table

Reference Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group	Instrument	Proposed Laboratory for Performing Analysis	Modified for Project Work?
SW846 8260C	Laboratory SOP No. ED-MSV-014 (Revision 4, 12-08-2014) "SW846 Method 8260C, Volatile Organic Compounds by Gas Chromatography / Mass Spectrometry (GC/MS)"	Definitive	TCL VOC (BTEX and MTBE)	GC/MS	TestAmerica - Edison	No
EPA 300.0	Laboratory SOP No. ED-GCS-022 (Revision 3, 08-19-2014) "Anions by Ion Chromatography using EPA Method 300.0, SW846 9056A and SM4110B"	Definitive	Anions (Sulfate, Nitrate, Nitrite)	Ion Chromatography	TestAmerica - Edison	No
SM4500-O C	Laboratory SOP No. ED-WET-053 (Revision 8, 12-18-2014) "Dissolved Oxygen, Titrimetric Analysis of Dissolved Oxygen by Standard Method 4500-O C"	Definitive	Dissolved Oxygen	Titration	TestAmerica - Edison	No
SM3500-Fe D	Laboratory SOP No. ED-WET-057 (Revision 6, 08-08-2014) "Analysis of Ferrous Iron in Aqueous Samples by Standard Method 3500-Fe D – Discrete Analyzer"	Definitive	Ferrous Iron	Discrete Analyzer	TestAmerica - Edison	No
RSK-175	Laboratory SOP No. NV04-89-12b (Revision 12b, 05-31-2015) "Method RSK 175 Modified: Sample Preparation and Calculation for Dissolved Gas Analysis in Water Samples using a GC Headspace Equilibration Technique"	Definitive	Methane	GC/FID	TestAmerica - Nashville	No
RSK-175	Laboratory SOP No. BR-AT-006 (Revision 14, 10-17-2014) "Dissolved Gases in Groundwater (RSK-175)"	Definitive	Carbon Dioxide	GC/TCD	TestAmerica - Burlington	No

QAPP Worksheet 24
Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
GC/MS (VOC)	Tune with BFB (4-Bromofluorobenzene), Five-point initial calibration curve, immediately followed by ICV, CCV as required	ICAL: prior to sample analysis and when CCV fails ICV: immediately after ICAL CCV: every 12 hours	Tune with BFB must meet criteria specified in the laboratory SOP ICAL: refer to laboratory SOP, response factor RSD < 30% ICV: % R ± 30% CCV: % D ± 20% for most compounds (refer to laboratory SOP)	Inspect system, re-calibrate as needed. Reanalyze affected samples.	TestAmerica Lab personnel	SW846 8260C
Ion Chromatography (Anions)	Five-point initial calibration curve, immediately followed by ICV, ICB, CCV, CCB as required	ICAL: prior to sample analysis and when CCV fails ICV and ICB: immediately after ICAL CCV and CCB: every 10 samples and at end of sequence	ICAL: linear with r^2 ≥0.995 ICV: % R ± 10% ICB: less than half QL CCV: % D ± 10% CCB: less than half QL	Inspect system, re-calibrate as needed. Reanalyze affected samples.	TestAmerica Lab personnel	EPA 300.0
Titration (Dissolved Oxygen)	No calibration for titration	Not applicable	Not applicable	Not applicable	Not applicable	SM4500-O C
Discrete Analyzer (Ferrous Iron)	initial calibration curve, immediately followed by ICV, CCV as required	Calibration: daily ICV: daily after initial calibration CCV: after every 10 samples	Calibration: linear with r^2 ≥0.995 ICV: ± 5% of true value CCV: ± 5% of true value	Inspect system, re-calibrate as needed. Reanalyze affected samples.	TestAmerica Lab personnel	SM3500-Fe D

QAPP Worksheet 24
Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
GC/FID (Methane)	Minimum five-point calibration, immediately following by ICV, ICB, CCV, CCB as required, methane RL verification	ICAL: prior to sample analysis, perform instrument re-calibration monthly ICV and ICB: immediately after ICAL, ICB after ICV CCV and CCB: every 12 hours (not to exceed 20 samples), CCB after each CCV Methane RL verification: daily when in use	ICAL: linear with r^2 ≥0.990. Re-calculation of lowest point must be within 30% of true value or re-calibrate. RSD of CF ≤20% ICV: within 20% of expected value CCV: within 20% of expected value and RT window ICB and CCB: < QL Methane RL verification: 70-130%	Inspect system, re-calibrate as needed. Reanalyze affected samples.	TestAmerica Lab personnel	RSK-175
GC/TCD (Carbon Dioxide)	initial calibration curve, immediately followed by ICV, CCV as required	ICAL: ICAL: prior to sample analysis and when CCV fails ICV: immediately after ICAL CCV: every 24 hours and at the end of the sequence	ICAL: RSD < 30% ICV: % R ± 30% CCV: % D ± 30%	Inspect system, re-calibrate as needed. Reanalyze affected samples.	TestAmerica Lab personnel	RSK-175

QAPP Worksheet 25
Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment [1,2,3]	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Refer to list of instruments provided in Worksheet 24	Refer to laboratory quality manual[1,2,]	Refer to laboratory quality manual[1,2,]	Refer to laboratory quality manual[1,2,]	Refer to laboratory quality manual[1,2,]	Refer to laboratory quality manual[1,2,]	Correct problems prior to analyzing project samples	Assigned laboratory personnel	Refer to methods listed in Worksheet 24

Notes:

1. The maintenance of the analytical instruments including the testing activity, inspection activity, frequency, acceptance criteria, responsible person, and SOP reference must be documented in the Laboratory's Quality Manual of the assigned government laboratory.
2. Spare parts and maintenance of laboratory analytical instrumentation is the responsibility of the laboratory.

QAPP Worksheet 26
Sample Handling System

SAMPLE COLLECTION, PACKAGING, AND SHIPMENT
Sample Collection (Personnel/Organization): MNA program groundwater samples will be collected by Tetra Tech field team
Sample Packaging (Personnel/Organization): Tetra Tech
Coordination of Shipment (Personnel/Organization): Tetra Tech
Type of Shipment/Carrier: Courier to the laboratory at the end of each sampling day. Tetra Tech will courier samples to TestAmerica Edison branch. Test America will be responsible to transfer sample to designated branch laboratories (per Worksheet 30).
SAMPLE RECEIPT AND ANALYSIS
Sample Receipt (Personnel/Organization): TestAmerica laboratory personnel
Sample Custody and Storage (Personnel/Organization): TestAmerica laboratory personnel
Sample Preparation (Personnel/Organization): TestAmerica laboratory personnel
Sample Determinative Analysis (Personnel/Organization): TestAmerica laboratory personnel
SAMPLE ARCHIVING
Field Sample Storage (Number of days from sample collection): Samples will be delivered within 24 hours of collection.
Sample Extract/Digestate Storage (Number of days from extraction/digestion): Refer to Worksheet 19 for holding time and preservation requirements.
SAMPLE DISPOSAL
Personnel/Organization: TestAmerica laboratory personnel
Number of Days from Analysis: Per TestAmerica subcontract with Kinder Morgan

Sample Handling and Custody

Sample custody procedures ensure the timely, correct, and complete analysis of each sample for all parameters requested. A sample is considered to be in someone's custody if it:

- Is in his/her possession.
- Is in his/her view, after being in his/her possession
- Is in his/her possession and has been placed in a secured location.
- Is in a designated secure area.

Sample custody documentation provides a written record of sample collection and analysis. Sample custody procedures provide for specific identification of samples associated with an exact location, the recording of pertinent information associated with the sample (including time of sample collection and any preservation techniques), and a record, called a chain of custody (COC) form that serves as physical evidence of sample custody. Custody procedures will be similar to the procedure outlined in USEPA CLP Guidance for Field Samplers (USEPA, 2007). The COC documentation system provides the means to individually identify, track, and monitor each sample from the time of collection through final data reporting.

Field Sample Handling and Custody

Field records provide a means of recording information for each field activity performed at the Site. COC procedures document pertinent sampling data and all transfers of custody until the samples reach the analytical laboratory. Laboratory (TestAmerica) will distribute copies of signed COC and sample login to Tetra Tech, Louis Berger, and Kinder Morgan.

Field Procedures

The general responsibilities of the field team are listed below:

- MNA program groundwater samples will be collected by Tetra Tech field team.
- The field crew is personally responsible for the care and custody of the samples until they are transferred to the sample management team or until they are properly dispatched. As few people as possible should handle the samples.
- The field crew is responsible for entering the proper information on the field forms, including all pertinent information such as sample identification number, date and time of sample collection, type of analysis, and description of sample location. The information entered on the field form will be used to generate a COC.
- All sample containers will be labeled with the project identification, sample number, matrix, type of analysis required, and preservation requirements techniques employed, if applicable.
- The samples will be properly preserved, bagged, and packed into coolers. The original COC form will be placed into the lead cooler and will be shipped to the laboratory.
- The sample management team will review all field activities to determine whether proper custody procedures were followed during the field work and if additional samples are required.

Sample Identification System

All samples collected from the Site must be identified with a sample label in addition to an entry on the COC. Indelible ink will be used to complete sample labels and handwritten COCs. Refer to Worksheet 27 for Sample Identification nomenclature and information on COC.

Sample Labels

Sample labels will require (at a minimum) the field team to record the following information for each sample container:

- Sample Identification
- Sample Matrix
- Parameters to be analyzed
- Date Collected
- Time Collected
- Sample program name

Sample Receipt

A designated sample custodian accepts custody of the samples and verifies that the information on the sample labels matches the information on the COC. The sample custodian will document any discrepancies and will sign and date all appropriate receiving documents. The sample custodian will also document the condition of the samples upon receipt at the laboratory. Once the samples have been accepted by the laboratory, checked and logged in, they must be maintained in accordance with laboratory custody and security requirements. To ensure traceability of samples while in the possession of the laboratory, a method for sample identification that has been documented in a laboratory SOP will be used to assign sample numbers. The following stages of analysis must be documented by the laboratory:

- Sample Extraction/Preparation,
- Sample Analysis,
- Data Reduction, and
- Data Reporting.

Laboratory personnel are responsible for the custody of samples until they are returned to the sample custodian. When sample analyses and quality assurance checks have been completed in the laboratory, the used portion of the sample must be stored or disposed of in accordance with the protocols specified by the subcontractor agreement. Identifying labels, data sheets, COCs, and laboratory records will be retained until analyses and quality assurance checks are completed in accordance with the protocols specified by the subcontractor agreement.

QAPP Worksheet 27
Sample Custody Requirements

Field Sample Custody Procedures **Sample Collection:** MNA program groundwater samples will be collected by Tetra Tech field team. Laboratory (TestAmerica) will distribute copies of signed COC and sample login to Tetra Tech, Louis Berger, and Kinder Morgan. **Packaging and Shipping:** The field sample custody procedures (including sample packing, shipment, and delivery requirements) are discussed in Worksheet 26. **Delivery:** Courier to the contractor laboratory at the end of sampling day. Tetra Tech will courier samples to TestAmerica Edison branch. Test America will be responsible to transfer sample to designated branch laboratories (per Worksheet 30).
Laboratory Sample Custody Procedures Laboratory will have a sample custodian, who accepts custody of the samples and verifies that the information on the sample labels matches the information on the COC. The sample custodian will document any discrepancies and will sign and date all appropriate receiving documents, as well as document the condition of the samples upon receipt at the laboratory. If any sampling archiving is included in the program, the sample custodian will document which samples have been identified for archiving and record the holding times, the required analysis date to stay within holding times, and the date the sample was put into archive status.
COC Procedures A COC record will accompany the samples from the time of sampling through all transfers of custody. Tetra Tech will manage samples and create COC. (Depending on field conditions, staff can generate a hand-written COC for sample shipment, if needed.) Laboratory (TestAmerica) will distribute copies of signed COC and sample login to Tetra Tech, Louis Berger, and Kinder Morgan.

Sample Identification Procedure

- Sample labeling procedures are discussed in the text in Worksheet 26.
- Each sample will receive a client sample identification number.
- Sample identification scheme for this project will be as the following:

MWXXX-YYYY**Q**Z (such as MW-101-2016Q1), which stands for:
MW = “Monitoring Well”
XXX = Location ID of monitoring well
YYYY = Calendar Year
Q = “Quarter”
Z = Quarter number (such as Q1 for Quarter 1)

Chain of Custody Procedure
A COC record will accompany the samples from the time of sampling through all transfers of custody. The following information (at a minimum) will be included on the COC forms. All COC forms must be signed in ink:

- Sample identification
- Signature of sampler.

- Date of collection.
- Sample matrix.
- Analyses required.
- Preservation (if applicable).
- Sampling program name
- Air way bill (if applicable)

The COC form serves as an official communication to the laboratory detailing the particular analyses required for each sample. The COC record will accompany the samples from the time of sampling through all transfers of custody. It will be kept on file at the assigned government laboratory where samples are analyzed. An electronic or hard-copy of each COC should also be made and kept in the Louis Berger project electronic-file directory. The sample management team completes a COC record to accompany each shipment from the field to the contractor laboratory. The completed COC is placed in a zip-lock bag and taped to the inside cover of the sample shipping container. If there is more than one container in a shipment, copies of the COC form will be placed in each container. Each container is then sealed with signed custody seals and custody is transferred to the laboratory.

Transfer of Custody and Shipment

The custody of samples must be maintained from the time of sampling through shipment and relinquishment to the contractor laboratory. Instructions for transferring custody are given below:

- All samples are accompanied by a COC. When transferring custody of samples, the individuals relinquishing and receiving will sign, date, and note the time on the COC. This form documents sample custody transfer from the sample management team, through the shipper, to the analytical laboratory. Since a common carrier will usually not accept responsibility for handling COC forms, the name of the carrier is entered under “Received by” and the COC form is placed in a zip-lock plastic bag and taped to the inside lid of the lead shipping cooler. Copies of the COC form will be placed in each additional cooler in a shipment.
- Samples will be packaged for shipment and either picked up at the Site by the laboratory or dispatched to the appropriate laboratory via overnight delivery service. A separate COC record must accompany each shipment. Shipping containers will be sealed for shipment to the laboratory. Two custody seals will be applied to each cooler to document that the container was properly sealed and to determine if the container was tampered with during shipment. The signed custody seals will be placed on the coolers in such a manner that the custody seal would be broken if the cooler were opened.
- The original COC will accompany the shipment. A copy (electronic or hardcopy) will be retained by the investigative organization.

Laboratory Custody Procedures

The laboratory custody procedures will be equivalent to those described in the latest edition of the laboratory custody SOPs, including:

- A designated sample custodian accepts custody of the samples and verifies that the information on the sample labels matches the information on the COC. The sample custodian will document any discrepancies and will sign and date all appropriate receiving documents. The sample custodian will also document the condition of the samples upon receipt at the laboratory.
- Once the samples have been accepted by the laboratory, checked and logged in, they must be maintained in accordance with laboratory custody and security requirements.
- To ensure traceability of samples while in the possession of the laboratory, a method for sample identification that has been documented in a laboratory SOP will be used to assign sample numbers.
- The following stages of analysis must be documented by the laboratory:
    - Sample Extraction/Preparation,
    - Sample Analysis,

  - Data Reduction, and
  - Data Reporting.
- Laboratory personnel are responsible for the custody of samples until they are returned to the sample custodian.
- When sample analyses and quality assurance checks have been completed in the laboratory, the used portion of the sample must be stored or disposed of in accordance with the protocols specified by CLP. Identifying labels, data sheets, COCs, and laboratory records will be retained until analyses and quality assurance checks are completed in accordance with the protocols specified by subcontractor agreement

Final Evidence Files

In the final phase of sample custody, the COC records and sample analysis request form copies are archived in their respective project files. Laboratory custody forms, sample preparation and analysis logbooks, and data packages will become part of the laboratory final evidence file. Field notes, pictures, and logs will be archived by Tetra Tech. Other relevant documentation including records, reports, correspondence, and data review reports will be archived by Louis Berger.

Sample Holding Times

Information on sample holding times and required preservation for each test method will be provided in Worksheet 19.

Sample Packaging and Shipping Requirements

Custody of samples must be maintained through the shipment of samples to the selected laboratory. All samples will be packaged and shipped within 24 hours of sample collection unless other arrangements are made with the laboratory. .

QAPP Worksheet 28-1
QC Sample Table
Matrix: Groundwater
Analytical Group / SOP Reference: VOC / SW846 8260C

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1 per 20 field samples. If fewer than 20 samples collected in a quarter, then 1 per quarter.	QAPP	If the RPDs exceed limits for the field duplicates, investigate field sampling method and flag data as necessary	Site Quality Control Officer and Data Validator	Precision	RPD ≤ 30% for duplicate values greater than or equal to 5 times the QL
Matrix Spike / Matrix Spike Duplicate (MS/MSD)	1 per 20 field samples. If fewer than 20 samples collected in a quarter, then 1 per quarter.	SW846 8260C (TestAmerica SOP: ED-MSV-014)	Investigate matrix effects, reanalyze affected samples as necessary, and flag data as necessary	TestAmerica and Data Validator	Accuracy/Bias/ Precision	Laboratory Statistical Limits per the laboratory SOP, recoveries must be within laboratory derived limits and allowable exceedance; RPD ≤ 30%
Laboratory Control Sample (LCS)	1 per analytical batch	SW846 8260C (TestAmerica SOP: ED-MSV-014)	Investigate problem, reanalyze affected samples as necessary, and flag data as necessary	TestAmerica and Data Validator	Accuracy/Bias	Laboratory Statistical Limits per the laboratory SOP, recoveries must be within laboratory derived limits and allowable exceedance.
Method Blank (MB)	1 per analytical batch	SW846 8260C (TestAmerica SOP: ED-MSV-014)	Investigate problem, reanalyze affected samples as necessary, and flag data as necessary	TestAmerica and Data Validator	Sensitivity	Less than QLs
Surrogate Recovery	Per sample	SW846 8260C (TestAmerica SOP: ED-MSV-014)	Investigate problem, reanalyze affected samples as necessary, and flag data as necessary	TestAmerica and Data Validator	Accuracy/Bias	Laboratory Statistical Limits per the laboratory SOP, recoveries must be within laboratory derived limits and allowable exceedance.
Trip Blank	1 per shipment	QAPP	Investigate the source of contamination	Site Quality Control Officer and Data Validator	Sensitivity	Less than QLs

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Blank	1 per 20 field samples	QAPP	Investigate the field sampling equipment and flag data as necessary	Site Quality Control Officer and Data Validator	Sensitivity	Less than QLs
Note: The subcontractor laboratory must perform and meet all of the measurement performance criteria that assess the analytical DQIs specified in USEPA SW846 8260C.						

QAPP Worksheet 28-2
QC Sample Table
Matrix: Groundwater
Analytical Group / SOP Reference: Anions / EPA 300.0

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1 per 20 field samples	QAPP	If the RPDs exceed limits for the field duplicates, investigate field sampling method and flag data as necessary	Site Quality Control Officer and Data Validator	Precision	RPD ≤ 30% for duplicate values greater than or equal to 5 times the QL
Matrix Spike / Matrix Spike Duplicate (MS/MSD)	1 per analytical batch	EPA 300.0 TestAmerica SOP: ED-GCS-022	Investigate matrix effects, reanalyze affected samples as necessary, and flag data as necessary	TestAmerica and Data Validator	Accuracy/Bias/ Precision	90-110% Recovery; RPD ≤ 15%
Laboratory Control Sample (LCS)	1 per analytical batch	EPA 300.0 TestAmerica SOP: ED-GCS-022	Investigate problem, reanalyze affected samples as necessary, and flag data as necessary	TestAmerica and Data Validator	Accuracy/Bias	90-110% Recovery
Method Blank (MB)	1 per analytical batch	EPA 300.0 TestAmerica SOP: ED-GCS-022	Investigate problem, reanalyze affected samples as necessary, and flag data as necessary	TestAmerica and Data Validator	Sensitivity	Less than QLs
Field Blank	1 per 20 field samples	QAPP	Investigate the field sampling equipment and flag data as necessary	Site Quality Control Officer and Data Validator	Sensitivity	Less than QLs
Note: The subcontractor laboratory must perform and meet all of the measurement performance criteria that assess the analytical DQIs specified in EPA 300.0.						

QAPP Worksheet 28-3
QC Sample Table
Matrix: Groundwater
Analytical Group / SOP Reference: Dissolved Oxygen / SM4500-O C

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1 per 20 field samples	QAPP	If the RPDs exceed limits for the field duplicates, investigate field sampling method and flag data as necessary	Site Quality Control Officer and Data Validator	Precision	RPD ≤ 30% for duplicate values greater than or equal to 5 times the QL
Procedural Blank (Winkler Titration Sample)	1 analytical batch	SM4500-O C TestAmerica SOP: ED-WET-053	Investigate problem, reanalyze affected samples as necessary, and flag data as necessary	TestAmerica and Data Validator	Accuracy	Less than QLs
Laboratory Replicate	1 analytical batch	SM4500-O C TestAmerica SOP: ED-WET-053	Investigate problem, reanalyze affected samples as necessary, and flag data as necessary	TestAmerica and Data Validator	Precision	Per the laboratory SOP, RPD must meet within the laboratory derived limit
Field Blank	1 per 20 field samples	QAPP	Investigate the field sampling equipment and flag data as necessary	Site Quality Control Officer and Data Validator	Sensitivity	Less than QLs
Note: The subcontractor laboratory must perform and meet all of the measurement performance criteria that assess the analytical DQIs specified in SM4500-O C.						

QAPP Worksheet 28-4
QC Sample Table
Matrix: Groundwater
Analytical Group / SOP Reference: Ferrous Iron / SM3500-Fe D

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1 per 20 field samples	QAPP	If the RPDs exceed limits for the field duplicates, investigate field sampling method and flag data as necessary	Site Quality Control Officer and Data Validator	Precision	RPD ≤ 30% for duplicate values greater than or equal to 5 times the QL
Matrix Spike / Matrix Spike Duplicate (MS/MSD)	1 per analytical batch	SM3500-Fe D TestAmerica SOP: ED-WET-057	Investigate matrix effects, reanalyze affected samples as necessary, and flag data as necessary	TestAmerica and Data Validator	Accuracy/Bias/ Precision	75-120% Recovery; RPD ≤ 20%
Laboratory Control Sample (LCS)	1 per analytical batch	SM3500-Fe D TestAmerica SOP: ED-WET-057	Investigate problem, reanalyze affected samples as necessary, and flag data as necessary	TestAmerica and Data Validator	Accuracy/Bias	83-115% Recovery
Method Blank (MB)	1 per analytical batch	SM3500-Fe D TestAmerica SOP: ED-WET-057	Investigate problem, reanalyze affected samples as necessary, and flag data as necessary	TestAmerica and Data Validator	Sensitivity	Less than QLs
Field Blank	1 per 20 field samples	QAPP	Investigate the field sampling equipment and flag data as necessary	Site Quality Control Officer and Data Validator	Sensitivity	Less than QLs
Note: The subcontractor laboratory must perform and meet all of the measurement performance criteria that assess the analytical DQIs specified in SM3500-Fe D.						

QAPP Worksheet 28-5
QC Sample Table
Matrix: Groundwater
Analytical Group / SOP Reference: Methane and Carbon Dioxide / EPA Method RSK-175

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1 per 20 field samples	QAPP	If the RPDs exceed limits for the field duplicates, investigate field sampling method and flag data as necessary	Site Quality Control Officer and Data Validator	Precision	RPD ≤ 30% for duplicate values greater than or equal to 5 times the QL
Matrix Spike / Matrix Spike Duplicate (MS/MSD)	1 per analytical batch	EPA RSK-175 TestAmerica SOPs: NV04-89.12b and BR-AT-006	Investigate matrix effects, reanalyze affected samples as necessary, and flag data as necessary	TestAmerica and Data Validator	Accuracy/Bias Precision	Methane: Laboratory Statistical Limits per the laboratory SOP, recoveries must be within laboratory derived limits and allowable exceedance; RPD ≤ 30% Carbon dioxide: 70-130% Recovery; RPD ≤ 30%
Laboratory Control Sample (LCS)	1 per analytical batch	EPA RSK-175 TestAmerica SOPs: NV04-89.12b and BR-AT-006	Investigate problem, reanalyze affected samples as necessary, and flag data as necessary	TestAmerica and Data Validator	Accuracy/Bias	80-120% (methane) 70-130% (carbon dioxide)
Surrogate Recovery	Per Sample	EPA RSK-175 TestAmerica SOPs: NV04-89.12b and BR-AT-006	Investigate problem, reanalyze affected samples as necessary, and flag data as necessary	TestAmerica and Data Validator	Accuracy/Bias	Per the laboratory SOP, the surrogate recovery must be within laboratory control limit
Method Blank (MB)	1 per analytical batch	EPA RSK-175 TestAmerica SOPs: NV04-89.12b and BR-AT-006	Investigate problem, reanalyze affected samples as necessary, and flag data as necessary	TestAmerica and Data Validator	Sensitivity	Less than QLs

QC Sample	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Blank	1 per 20 field samples	QAPP	Investigate the field sampling equipment and flag data as necessary	Site Quality Control Officer and Data Validator	Sensitivity	Less than QLs
Note: The subcontractor laboratory must perform and meet all of the measurement performance criteria that assess the analytical DQIs specified in EPA Method RSK-175.						

QAPP Worksheet 29
Project Documents and Records Table

Sample Collection Documents and Records	On-site Analysis Documents and Records	Off-site Analysis Documents and Records	Data Assessment Documents and Records	Other
Field measurements	Field notes and field measurements	Copies of field notes will be made and stored electronically in the project files and distributed as needed to Project Team.	No assessment required	None
COCs (airway bill if needed)	COC (airway bill if needed)	TestAmerica will distribute copies of signed COC and sample login to Tetra Tech, Louis Berger, and Kinder Morgan. Electronic copies of the COC and Sample Login will be stored in the project files.	Sample Login	None
EDD and laboratory data packages	COC	Electronic data deliverables will be prepared by laboratory and submitted to investigative organization.	EDD	None
Data validation reports	Not applicable	Data validation reports will be provided to investigative organization and saved in project directory.	Validated database	None

Project Document Control System
Project documents will be controlled by Louis Berger Project Manager, who will maintain and distribute hardcopies and electronic copies of the project documents and any amendments. Electronic copies of project information will be maintained in the project electronic-file directory and the project database.

Data Recording
Data for this project will be collected by handwritten entries into field forms. Tetra Tech will manage samples and create COC. (Depending on field conditions, staff can generate a hand-written COC and sample labels for sample shipment, if needed.) Computer-generated data associated with laboratory analyses will be generated by assigned government laboratory.

Data Quality Assurance Checks
Louis Berger Project Manager will monitor the progress of sample collection to verify that samples are collected as planned. The progress of sample collection and processing will be monitored through documentation of the samples collected each day.

The assigned laboratory will have a formal in-house Quality Assurance Plan to which it adheres and implements as part of daily operations. Data generation processes will be reviewed and modified to meet objectives, if necessary. A formalized data generation procedure will be utilized. Each analyst must have previously demonstrated, through the laboratory quality assurance program, their requisite skills.

Laboratory Data Transmittal
Laboratory data are managed by the laboratory's internal management system, beginning with sample check-in on the sample-receiving data terminal. Laboratory will be responsible for maintaining and archiving laboratory data reports for each sample delivery group (SDG).

Data Storage and Retrieval

The field information collected by Tetra Tech will be provided to Louis Berger electronically so that the Quarterly and Annual Reports can be prepared by Louis Berger. Test America will put their Laboratory analytical data packages on their portal, which will be accessed by Louis Berger. Louis Berger will put the laboratory packages on an FTP site for the external data validator. The quarterly and annual reports provide a data summary table, and the annual reports also include a PDF copy of the Analytical Report.

QAPP Worksheet 30
Analytical Services Table

Matrix	Analytical Group	Conc Level	Sample Location/ ID Numbers	Analytical SOP	Data Package Turnaround Time	Proposed Laboratory	Backup Laboratory/ (Name and Address, Contact Person and Telephone Number)
Groundwater	VOC	Low	Refer to Worksheet 18	Method 8260C	10-day TAT	TestAmerica Contact: Patricia Grieco 777 New Durham Road Edison, NJ 08817 Phone: 732-593-2507	Not Currently Assigned
Groundwater	Sulfate, Nitrate, and Nitrite	Low	Refer to Worksheet 18	EPA 300.0	10-day TAT	TestAmerica Contact: Patricia Grieco 777 New Durham Road Edison, NJ 08817 Phone: 732-593-2507	Not Currently Assigned
Groundwater	Dissolved Oxygen	Low	Refer to Worksheet 18	SM4500-C	10-day TAT	TestAmerica Contact: Patricia Grieco 777 New Durham Road Edison, NJ 08817 Phone: 732-593-2507	Not Currently Assigned
Groundwater	Ferrous Iron	Low	Refer to Worksheet 18	SM3500-FeD	10-day TAT	TestAmerica Contact: Patricia Grieco 777 New Durham Road Edison, NJ 08817 Phone: 732-593-2507	Not Currently Assigned
Groundwater	Methane	Low	Refer to Worksheet 18	RSK-175	10-day TAT	TestAmerica Contact: Patricia Grieco 2960 Foster Creighton Drive Nashville, TN 37204 Phone: 615-726-0177	Not Currently Assigned
Groundwater	Carbon Dioxide	Low	Refer to Worksheet 18	RSK-175	10-day TAT	TestAmerica Contact: Patricia Grieco 30 Community Drive Suite 11 South Burlington, VT 05403 Phone: 802-660-1990	Not Currently Assigned

Note:
The laboratory will submit the EDD within 10-day of sample receipt follow by the laboratory data package (level 4).

QAPP Worksheet 31
Planned Project Assessments Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing Corrective Actions	Person(s) Responsible for Monitoring Effectiveness of Corrective Action
Quality control reports of any field non-conformance	Refer to Worksheet 6 for communication and notifications	Internal	Refer to Worksheet 6 for communication and notifications	Refer to Worksheet 6 for communication and notifications	Refer to Worksheet 6 for communication and notifications	Project Manager or Site Quality Control Officer (depending on nature of the non-conformance)	Project Manager or Site Quality Control Officer (depending on nature of the non-conformance)
Field Technical Systems Audit and/or Field Health Safety Audit	Audit will be conducted I f a field non-conformance is reported	Internal	Louis Berger	Refer to Worksheet 6 for communication and notifications	Refer to Worksheet 6 for communication and notifications	Project Manager or Site Quality Control Officer (depending on nature of the non-conformance)	Project Manager or Site Quality Control Officer (depending on nature of the non-conformance)
Laboratory Audit	Annually	External	TestAmerica	Lab QA Manager	Project Manager or Site Quality Control Officer (depending on nature of the non-conformance)	Lab Director or QA Manager	Lab QA Manager

QAPP Worksheet 32
Assessment Findings and Corrective Action Responses

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response	Timeframe for Response
Quality control reports of any non-conformance (field or laboratory)	See description below	Site Quality Control Officer and Project Manager (Louis Berger)	Refer to Worksheet 6 for communication and notifications	Complete non-conformance form (refer to Attachment 5)	Refer to Worksheet 6 for communication and notifications	Refer to Worksheet 6 for communication and notifications
Field Technical Systems Audit and/or Field Health Safety Audit	See description below	Site Quality Control Officer and Project Manager (Louis Berger)	Refer to Worksheet 6 for communication and notifications	Field Audit Report	Refer to Worksheet 6 for communication and notifications	Refer to Worksheet 6 for communication and notifications
Laboratory Audits	See description below	TestAmerica	Annually	Per Laboratory Quality Manual	Site Quality Control Officer (Louis Berger) depending on the nature of the non-conformance	Per Laboratory Quality Manual

Non-Conformance
A non-conformance is defined as an identified or suspected deficiency or discrepancy with regard to:

- An approved document, for example, improper sampling procedures, improper instrument calibration, or incorrect calculations;
- An item where the quality of the end product or subsequent activities using the document or item would be affected by the deficiency; or
- An activity which is not conducted in accordance with the established plans or procedures.

Any field member or laboratory engaged in project work that discovers or suspects a non-conformance is responsible for submitting a non-conformance report to the Site Quality Control Officer. The Site Quality Control Officer will evaluate each non-conformance report and provide a corrective action. An example of a Non-Conformance Quality Control Report is included as Attachment 5. The Project Manager, depending on the nature of the non-conformance, will verify that no further project work dependent on the non-conforming item or activity will be performed until the non-conformance is properly addressed and approval to continue is issued. A copy of each non-conformance report will be included in the project file. Copies of all non-conformance reports will also be maintained by the Site Quality Control Officer or designee.

Assessment and Oversight
Louis Berger will conduct a field Technical System Audit and/or Field Health and Safety Audit if a field non-conformance is reported. Laboratory audits will be conducted to measure the accuracy of the measurement systems, per the Laboratory Quality Manual.

Internal Laboratory Audits
As part of its quality assurance program, the Laboratory Quality Assurance Manager will conduct periodic checks and audits of the analytical systems to ensure that the systems are working properly and personnel are adhering to established procedures and documenting the required information. These checks and

audits will also assist in determining or detecting where problems are occurring. In addition to conducting internal reviews and audits, as part of its established quality assurance program, the laboratory is required to take part in regularly scheduled performance evaluation and laboratory audits from state and federal agencies for applicable tests. The laboratory selected to support this program must maintain current state or federal certifications, as appropriate.

Laboratory Corrective Actions

If a particular laboratory analysis is deemed "out of control," corrective action will be taken by the laboratory to maintain continued data quality. The laboratory must adhere to their in-house corrective action policy. The coordinator of the laboratory's analytical section will be responsible for initiating laboratory corrective actions, when necessary.

QAPP Worksheet 33
QA Management Reports Table

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (Title and Organizational Affiliation)	Report Recipient(s) (Title and Organizational Affiliation)
Laboratory Data Reports and EDD	After shipment of samples under COC	10-day TAT for EDD and laboratory report	TestAmerica	Site Quality Control Officer and Project Manager (Louis Berger)
Data Validation Report	After laboratory data are received	42-day TAT for data validation report	Gloria Switalski Data Check, Inc.	Site Quality Control Officer and Project Manager (Louis Berger)
Corrective Action Reports	When corrective action is required	When corrective action is implemented	Site Quality Control Officer and Project Manager (Louis Berger)	Project Team
Quarterly and Annual Reports	Refer to Worksheet 16	Refer to Worksheet 16	Site Quality Control Officer and Project Manager (Louis Berger)	Kinder Morgan, USEPA, and NYSDEC

QAPP Worksheet 34
Verification (Step I) Process Table

Verification Input	Description	Internal/ External	Responsible for Verification (Name, Organization)
COC	Tetra Tech will initially review COC in the field for complete and correct information.	External	Tetra Tech
	Upon receipt at the laboratory, the COC will be compared to sample containers and any discrepancies will be resolved.	External	TestAmerica (Laboratory)
Field Notes	Record field activities, field measurements, and collection of field samples and external QC samples. This information will be transmitted to the Site Quality Control Officer or designee for reporting and verification.	External/Internal	Tetra Tech and Louis Berger
Field Measurement Verification	Field measurements will be verified for completeness. Electronic transcriptions will be back-checked against hard-copy field notes.	External/Internal	Tetra Tech and Louis Berger
Corrective Action	Corrective action will be implemented and verified for completeness. Corrective actions must also be communicated to appropriate staff (refer to Worksheet 6 for communication pathways).	External/Internal	Refer to Worksheet 6 for responsibilities
QAPP Field Modification	Verify completeness of Field Modification form (refer to Attachment 4 for template) documenting the modification to the QAPP.	External/Internal	Refer to Worksheet 6 for responsibilities
EDD	Laboratory data reports and EDDs will be verified by the laboratory performing the work for completeness and technical accuracy prior to release.	External	TestAmerica (Laboratory)
Data Verification	Verify completeness of field program and collection of required field samples.	External	Tetra Tech

QAPP Worksheet 35
Validation (Steps IIa and IIb) Process Table

Step IIa/IIb	Validation Input	Description	Responsible for Validation (Name, Organization)
IIa	COC	- TestAmerica will distribute copies of signed COC and sample login to Tetra Tech, Louis Berger, and Kinder Morgan. Tetra Tech will be responsible for tracking field samples to confirm completeness of field program. Louis Berger will coordinate completion of data validation. - During validation, the COC will be verified against laboratory receipt and report to examine traceability of data.	Tetra Tech and Data Validator
IIa	EDD	Laboratory data reports and EDDs will be verified by the laboratory performing the work for completeness and technical accuracy prior to release.	TestAmerica (Laboratory)
IIb	Validation of laboratory data reports	Validation will follow requirements stated in Worksheet 36.	Data Validator
IIb	Data Validation Reports	Verification that entry of qualifiers into the database and data validation reports has been performed correctly and completely will be conducted.	Louis Berger
IIb	Quarterly and Annual Reports	Louis Berger will submit Quarterly and Annual Reports. Quarterly Reports will include data summary tables and data validation reports. Annual Reports will include data evaluations and findings based on the data.	Louis Berger
IIb	Deviations from SOP and project documents	Determine impacts of any deviation from method and the project plan.	Project Team

QAPP Worksheet 36
Validation (Steps IIa and IIb) Summary Table

Step IIa/IIb	Matrix	Analytical Group	Concentration Level	Validation Criteria	Data Validator (title and organizational affiliation)
IIa/IIb	Groundwater	VOC, Sulfate, Nitrate, Nitrite, Dissolved Oxygen, Ferrous Iron, Methane, and Carbon Dioxide	Low	USEPA National Functional Guidelines, QAPP, and laboratory SOPs	Gloria Switalski Data Check, Inc.

Chemical Parameters
The assigned laboratory will perform verification of chemical data according to their laboratory quality control manual prior to submittal of EDD and laboratory data packages to Louis Berger. Laboratory data will then be validated against the QAPP, laboratory SOPs, and USEPA National Functional Guidelines. Validation procedures will follow a "Stage 2B" validation as described in the USEPA Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use (dated January 2009, EPA 540-R-08-005).

Data Validation Level Stage 2B will be based on information provided by the laboratory on their quality control forms. No actual instrument outputs review will occur during the limited validation process. The Stage 2B validation will provide a review of the following elements (as applicable to the parameter group):

- Holding Times
- Surrogate Recovery
- Matrix Spike/Matrix Spike Duplicate (MS/MSD) Results
- Laboratory Control Samples
- Trip, Equipment, Field, Laboratory-Fortified, and Method Blanks
- Initial and Continuing Calibration Verification
- Field Duplicate Results
- Compound Identification
- Compound Quantitation and Reported Detection Limits
- Sample result verification

Once data validation is completed, a data validation report will be generated. The report will contain information regarding the parameters that were qualified, the reason for the qualification, and the direction of the bias for parameters qualified as estimated, when possible. Based upon the quality assurance review of the analytical data, specific codes (data qualifiers or "flags") will be placed next to results to provide an indication of the quantitative and qualitative reliability of the analytical results. The data qualifier codes in the National Function Guidelines are being used for this project. Qualifiers assigned by the laboratory will be defined by the laboratory in their data package and will be superseded by the data validator's qualifiers.

QAPP Worksheet 37
Usability Assessment

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

Data validation will assess completeness, accuracy, precision, and sensitivity of the analytical data. A summary of assessment steps is provided below:

- Precision: Precision is defined as a measure of the reproducibility of individual measurements of the same property under a set of conditions. It is a qualitative measure of the variability of a group of data compared to their average value. Results of field duplicates, laboratory replicates, and MS/MSD will be evaluated based on the measurement performance criteria presented on Worksheet 12. Any conclusions about the precision of the analyses or sample collection techniques will be drawn and any limitations on the use of the data will be described.
- Sensitivity: Sensitivity is the ability of the method or instrument to detect a constituent at the level of interest. Results of trip blanks, laboratory blanks, and field blanks will be evaluated based on the measurement performance criteria presented on Worksheet 12. All analytical results reported will be evaluated to determine if adequate sensitivity was achieved. The results for each analyte will be cross-checked against the project action levels presented in Worksheet 15. Any conclusions about the accuracy/bias of the analyses based on contamination will be drawn and any limitations on the use of the data will be described.
- Accuracy/Bias: Accuracy is a measure of the bias in a measurement system, which may result from sampling or analytical error. Results of LCS and calibration will be evaluated based on the measurement performance criteria presented on Worksheets 12 and 24. Any conclusions about the accuracy of the analyses or sample collection techniques will be drawn and any limitations on the use of the data will be described.
- Representativeness: Representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variation, or environmental concern. Representativeness is achieved through adherence to sampling and analytical procedures described in the QAPP and compliance with stipulated sample holding times. After evaluation of relative compliance with specified procedures and holding times, conclusions about data representativeness will be drawn and any limitations on the use of data will be described.
- Comparability: Comparability is a measure of the degree of confidence with which one set of data can be compared to a related set of data. Comparability will be assessed through evaluation of achieved sample specific reporting limits, units of measure, and adherence to specified analytical methodologies and field/sample collection standard operating procedures specified in the QAPP.
- Completeness: The field completeness will be calculated by the ratio of the number of samples received in acceptable condition by the laboratories to the number of samples planned to be collected as specified in this document.

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

Assigned laboratory will perform a data verification of chemical data according to their laboratory quality control manual prior to submittal of EDD and laboratory data packages. Laboratory data will then be validated against the QAPP, laboratory SOPs, and USEPA National Functional Guidelines. The validator will apply qualifiers and comments on the usability of the data. Once the validation packages are received, they will be reviewed by the Site Quality Control Officer and sample management personnel. Any quality issues or non-conformances will be discussed with the validator and laboratory.

Identify the personnel responsible for performing the usability assessment:

The usability of the data is the responsibility of Site Quality Control Officer or designee to determine if data generated for the project meet project goals. Refer to Worksheet 35 for data reporting.

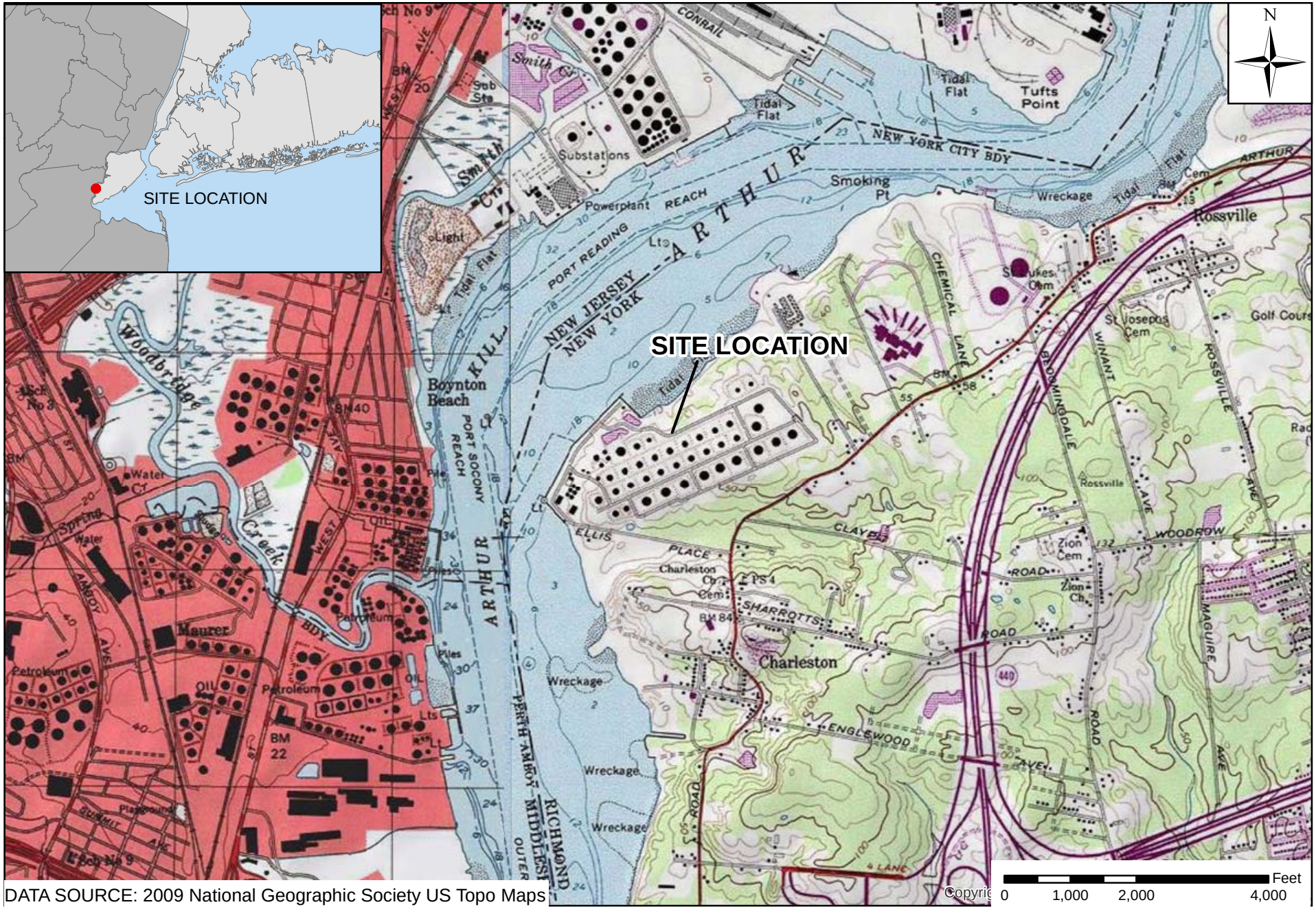
Describe the process to evaluate whether or not MNA is a viable alternative for this site

The on-going MNA program has been used to evaluate the effectiveness of natural attenuation to achieve the site-specific remediation goals for the existing contaminants on concern at the Facility. Statistical analysis, along with assessing the aquifer's assimilative capacity, are conducted as follows:

- Statistical evaluation using the Mann-Kendall non-parametric test is used to assess whether groundwater concentrations exhibit increasing or decreasing trends over time to a specified level of significance. The evaluation is conducted using BTEX and MTBE concentrations in groundwater and is presented and described in annual reports.

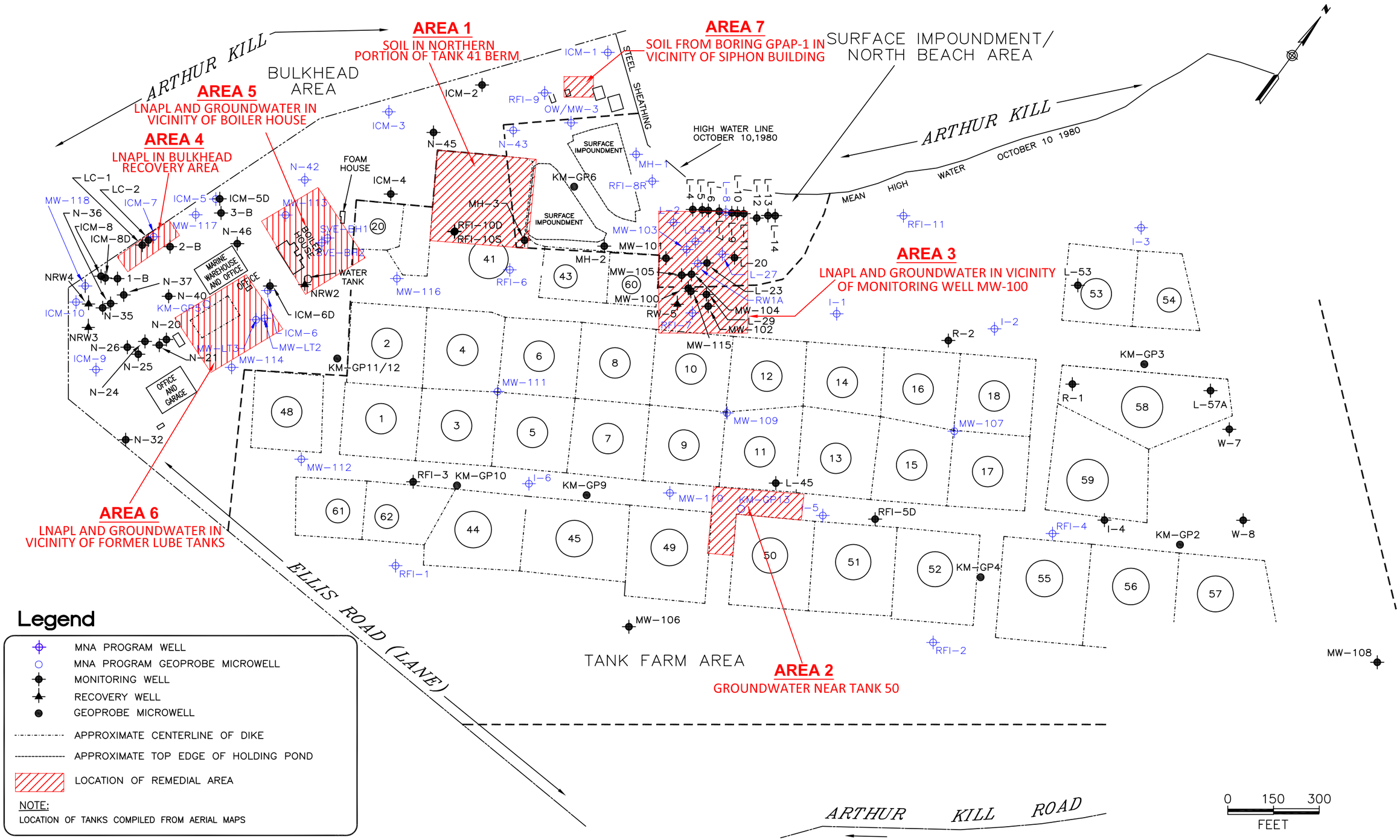
- To assess the aquifer's potential to biodegrade hydrocarbons, the assimilative capacity is measured based on terminal electron acceptor (TEAs) and terminal electron acceptor product (TEAP) concentrations. The TEA and TEAP parameters include sulfate, ferrous iron, dissolved oxygen and methane, and the evaluation is presented and described in the annual reports.

Figures



DATA SOURCE: 2009 National Geographic Society US Topo Maps

KINDER MORGAN	SITE LOCATION MAP Former Port Mobil Terminal, Staten Island, New York	Louis Berger	FIGURE 1



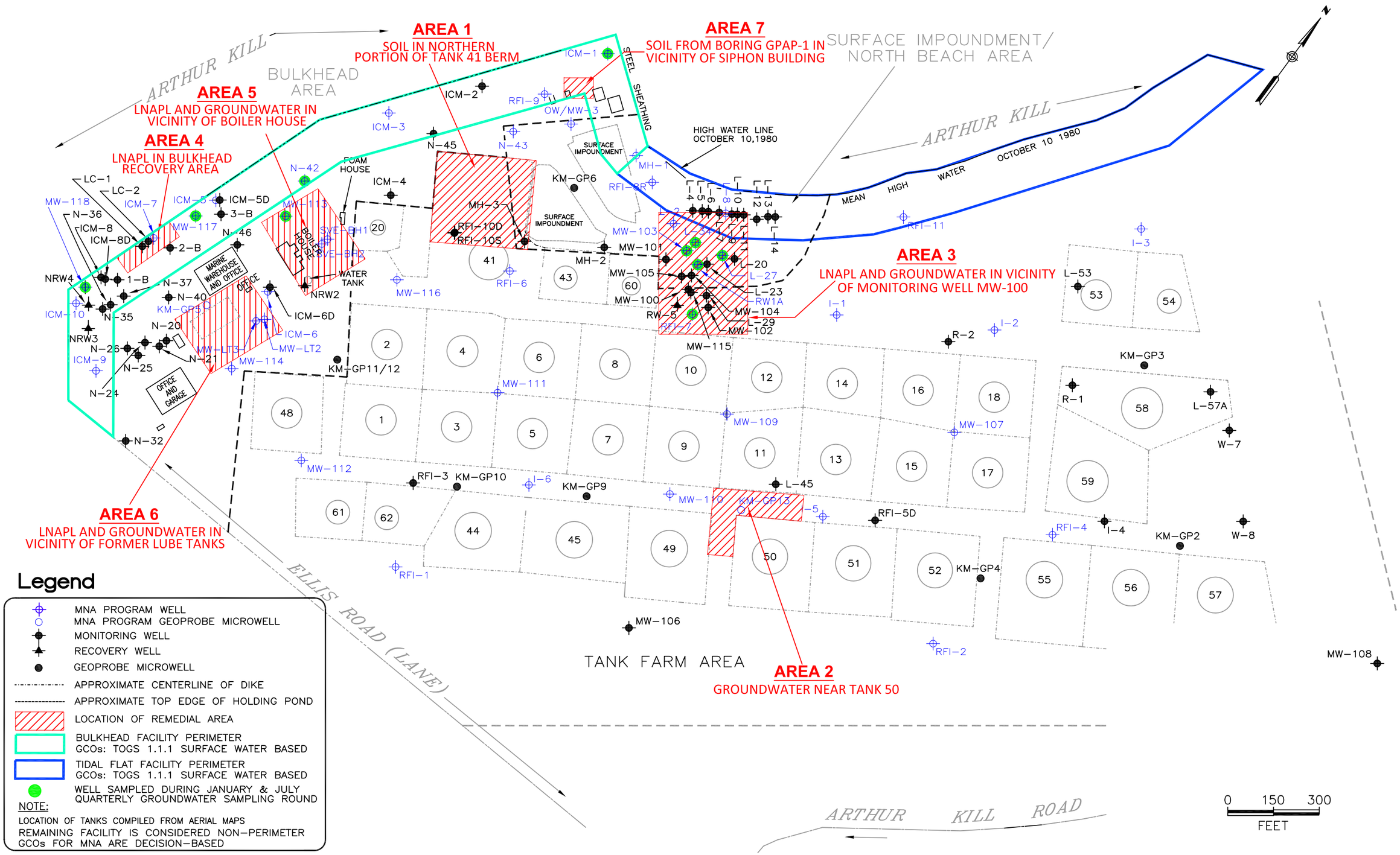
KINDER MORGAN

LOCATION OF GROUNDWATER WELLS AND REMEDIAL AREAS

FORMER PORT MOBIL TERMINAL, STATEN ISLAND, NEW YORK

Louis Berger

FIGURE 2



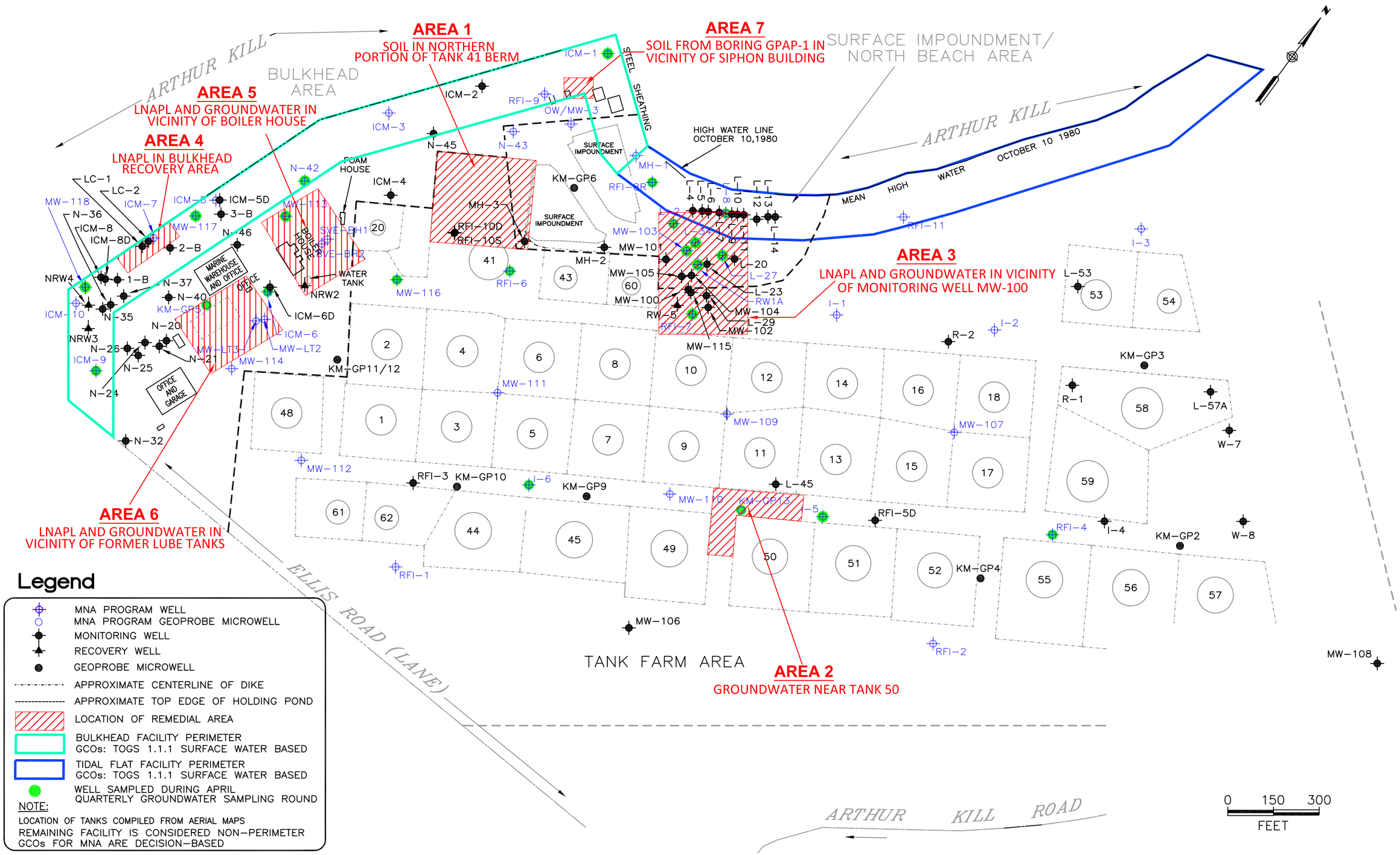
KINDER MORGAN

GROUNDWATER WELLS SAMPLED IN JANUANRY AND JULY QUARTERLY SAMPLING ROUND

FORMER PORT MOBIL TERMINAL, STATEN ISLAND, NEW YORK

Louis Berger

FIGURE 3A



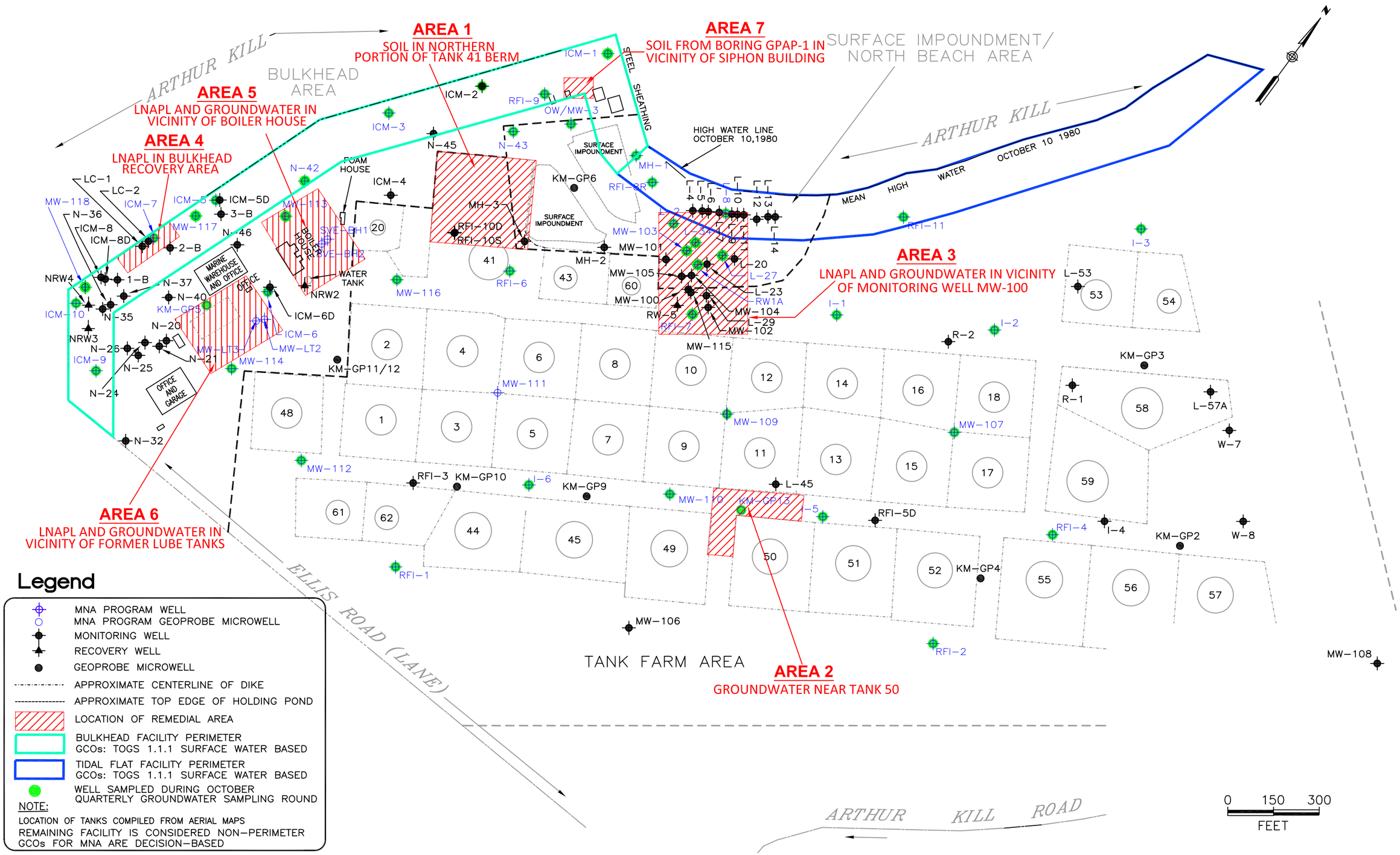
KINDER MORGAN

GROUNDWATER WELLS SAMPLED IN APRIL QUARTERLY SAMPLING ROUND

FORMER PORT MOBIL TERMINAL, STATEN ISLAND, NEW YORK

Louis Berger

FIGURE 3B



KINDER MORGAN

GROUNDWATER WELLS SAMPLED IN OCTOBER QUARTERLY SAMPLING ROUND

FORMER PORT MOBIL TERMINAL, STATEN ISLAND, NEW YORK

Louis Berger

FIGURE 3C

Attachment 1
Revised MNA Monitoring Program Schedule

Table 5
Revised MNA Monitoring Program Schedule
Quarterly Progress Report
Former Port Mobil Terminal, Staten Island, NY

Well ID	Purpose	Liquid Levels [1]	Analytical Sampling Frequency [2]		
			Quarterly (January and July)	Semi-Annually (April)	Annually (October)
I-1	Hydrogeologic and water quality characterization - downgradient of tank farm	X			X
I-2	Hydrogeologic and water quality characterization - downgradient of tank farm	X			X
I-3	Hydrogeologic and water quality characterization - downgradient of lower tank farm	X			X
I-5	Hydrogeologic and water quality characterization - between upper and lower tank farms; elevated dissolved concentrations detected during SV/RFI	X		X	X
I-6	Investigate water quality in area with historic LNAPL and elevated dissolved concentrations detected during SV/RFI	X		X	X
ICM-1	Hydrogeologic and water quality characterization - downgradient of Siphon Building area. Thin layer of LNAPL occasionally present with increased dissolved concentrations detected.	X	X	X	X
ICM-2	Liquid level monitoring - downgradient of Siphon Building area	X			
ICM-3	Hydrogeologic and water quality characterization - downgradient of Tank 41 area	X			X
ICM-5	Hydrogeologic and water quality characterization - downgradient of Boiler House area	X			X
ICM-6	Hydrogeologic and water quality characterization - in Boiler House area; elevated dissolved concentrations detected during SV/RFI	X		X	X

Table 5
Revised MNA Monitoring Program Schedule
Quarterly Progress Report
Former Port Mobil Terminal, Staten Island, NY

Well ID	Purpose	Liquid Levels [1]	Analytical Sampling Frequency [2]		
			Quarterly (January and July)	Semi-Annually (April)	Annually (October)
ICM-7	Hydrogeologic and water quality characterization - in LNAPL ICM area	X			X
ICM-9	Hydrogeologic and water quality characterization - in southern parking lot area; elevated dissolved concentrations detected during SV/RFI	X		X	X
ICM-10	Hydrogeologic and water quality characterization - downgradient of former Southern Recovery Area	X			X
KM-GP05	Hydrogeologic and water quality characterization - Downgradient of Lube Tank area, elevated concentrations detected.	X		X	X
KM-GP13	Hydrogeologic and water quality characterization - Tank Farm area, elevated concentrations detected.	X		X	X
L-2	Hydrogeologic and water quality characterization - North Beach Area and downgradient of MW-100 / RFI-7 release area and LNAPL recovery.	X		X	X
L-8	Hydrogeologic and water quality characterization - North Beach Area; downgradient of former LNAPL recovery	X		X	X
L-14	Liquid level monitoring - North Beach Area; downgradient of former LNAPL recovery	X			
L-27	Hydrogeologic and water quality characterization - Downgradient of MW-100 / RFI-7 release area and LNAPL recovery.	X	X	X	X
L-34	Hydrogeologic and water quality characterization - Downgradient of MW-100 / RFI-7 release area and LNAPL recovery.	X	X	X	X

Table 5
Revised MNA Monitoring Program Schedule
Quarterly Progress Report
Former Port Mobil Terminal, Staten Island, NY

Well ID	Purpose	Liquid Levels [1]	Analytical Sampling Frequency [2]		
			Quarterly (January and July)	Semi-Annually (April)	Annually (October)
MH-1	Hydrogeologic and water quality characterization - downgradient of Surface Impoundment Area	X			X
MW-103	Hydrogeologic and water quality characterization - Downgradient of MW-100 / RFI-7 release area and LNAPL recovery.	X	X	X	X
MW-107	Hydrogeologic and water quality characterization - Tank Farm area.	X			X
MW-109	Hydrogeologic and water quality characterization - Tank Farm area.	X			X
MW-110	Hydrogeologic and water quality characterization - Tank Farm area.	X			X
MW-111	Hydrogeologic and water quality characterization - Tank Farm area.	X		X	X
MW-112	Hydrogeologic and water quality characterization - Tank Farm area.	X			X
MW-113	Hydrogeologic and water quality characterization - downgradient of Boiler House. Monitor downgradient of Tank 24 and Tank 48 piping releases.	X	X	X	X
MW-114	Hydrogeologic and water quality characterization - Tank Farm area.	X			X
MW-116	Hydrogeologic and water quality characterization - Tank Farm area.	X		X	X

Table 5
Revised MNA Monitoring Program Schedule
Quarterly Progress Report
Former Port Mobil Terminal, Staten Island, NY

Well ID	Purpose	Liquid Levels [1]	Analytical Sampling Frequency [2]		
			Quarterly (January and July)	Semi-Annually (April)	Annually (October)
MW-117	Hydrogeologic and water quality characterization - Barge Berth #2 area. Monitor downgradient of product release from damaged above-ground piping.	X	X	X	X
MW-118	Hydrogeologic and water quality characterization - Ship Berth #1A area. Monitor in area of product release from damaged above-ground piping .	X	X	X	X
N-42	Hydrogeologic and water quality characterization - downgradient of Boiler House. Monitor downgradient of Tank 24 and Tank 48 piping releases.	X	X	X	X
N-43	Hydrogeologic and water quality characterization - downgradient of Surface Impoundment Area and Tank 41 area	X			X
OW/MW3	Hydrogeologic and water quality characterization - downgradient of Surface Impoundment Area; upgradient of former LNAPL ICM in siphon building area	X			X
RFI-1	Hydrogeologic and water quality characterization - upgradient of upper tank farm	X			X
RFI-2	Hydrogeologic and characterization - upgradient of upper tank farm	X			X
RFI-4	Hydrogeologic and water quality characterization - between upper and lower tank farms	X		X	X
RFI-6	Hydrogeologic and water quality characterization - downgradient of lower tank farm in Tank 41 area; elevated dissolved concentrations detected during SV/RFI	X		X	X
RFI-7	Hydrogeologic and water quality characterization - downgradient of lower tank farm. LNAPL frequently present in this well, product recovery currently active.	X	X	X	X

Table 5
Revised MNA Monitoring Program Schedule
Quarterly Progress Report
Former Port Mobil Terminal, Staten Island, NY

Well ID	Purpose	Liquid Levels [1]	Analytical Sampling Frequency [2]		
			Quarterly (January and July)	Semi-Annually (April)	Annually (October)
RFI-8R	Hydrogeologic and water quality characterization - North Beach Area, downgradient of former LNAPL recovery. Within area of remedial hotspot soil removal conducted in July 2003.	X		X	X
RFI-9	Hydrogeologic and water quality characterization - downgradient of former LNAPL ICM in siphon building area	X			X
RFI-11	Hydrogeologic and water quality characterization - downgradient of Tank Farm Area.	X			X
RW-1A	Hydrogeologic and water quality characterization - Downgradient of current RFI-7 / MW-100 LNAPL recovery system area.	X	X	X	X

Notes
(1) Liquid levels are guaged on a quarterly basis.
(2) All samples will be analyzed for BTEX with MTBE (benzene, toluene, ethylbenzene, xylenes, and methyl tert-butyl ether) during each sampling event.
MNA parameters (dissolved oxygen, carbon dioxide, nitrate, ferrous iron (+2), sulfate and methane) will also be analyzed during the Annual sampling event.

Attachment 2
Summary of EPA Deadlines

Summary of Deadlines
Administrative Order of Consent # RCRA-02-2009-7306
Kinder Morgan Terminal / Former Port Mobil Terminal

Activity	Deadline Schedule	Frequency	Deadline Date
Surface Impoundments			
Subsurface Investigation beneath Surface Impoundments	Upon liner replacement or decommission	One time	12/31/2011
Remediation (if necessary) beneth SI's	Upon EPA evaluation of results - no hard deadline given	As needed	TBD
Corrective Measures Study (CMS)			
Draft CMS Workplan	Within 90 days of Order	One time	12/9/2009 (Draft), 6/11/2010 (Final)
Commence CMS Field Work	Within 60 days of receipt of final approved CMS Workplan	One time	Ongoing (System O&M, MNA) July 2010 (Pilot Test Actvities Initiated)
Draft CMS Report	Within 60 days of CMS field work completion	One time	4/30/2012 (Draft), 6/14/2013 (Final)
Draft CMI Workplan	Within 60 days of approved final CMS Report	One time	6/13/2014
Commence CMI Field Work	Within 60 days of receipt of final approved CMI Workplan	One time	TBD
Draft CMI Final Report	After completion of CMI - no hard deadline given	One time	TBD
Financial assurance and cost estimate for corrective action	Within 90 days of selection of of corrective measure	As needed	TBD
USEPA Approval Process			
Submission of revised document	Within 30 days of receipt of EPA comments	As needed	TBD
EPA - approval of final document	Within 60 of receipt of revised document	As needed	TBD
Commence field or other work	Within 60 days of receipt of final approved document	As needed	TBD
EPA - document incorporation into Order	Ten (10) days following written final approval	As needed	TBD
ICM, CMS, CMI, and MNA (annual only) Progress Reports			
1st Quarter Progress Report (January-March)	Within 45 Days of end of quarter	Yearly	May 15th
2nd Quarter Progress Report (April to June)	Within 45 Days of end of quarter	Yearly	August 15th
3rd Quarter Progress Report (July to September)	Within 45 Days of end of quarter	Yearly	November 15th
Annual Progress Report (October to December, year summary)	Within 60 Days of end of quarter	Yearly	March 1st
Time Extension Request			
Request for extension period for work/documents	Written with 30 days of work deadline	As needed	TBD
Potential Additional Work Required by EPA			
Opportunity/meeting to discuss EPA's notice of additional work	Within 15 days of receipt of notice	As needed	TBD
Response/disagreement to EPA's notice of additional work	Written within 20 days of meeting	As needed	TBD
Invoking of dispute resolution	Written within 20 days of disagreement response	As needed	TBD
Workplan for additional work	After agreement or dispute resolution - no hard deadline given	As needed	TBD
Existing or Imminent Threat to Human or Environmental Health			
Notify EPA of threat	In writing within 10 days of identifying threat	As needed	TBD
Workplan and/or mitigation of threat	ASAP - case by case basis	As needed	TBD
Proposed Additional and Non-Routine Work			
Notify EPA of proposed additional work	Oral within 20 days	As needed	TBD
Notify EPA of proposed additional work - short time frame	Oral, followed by written documentation within 10 days	As needed	TBD
Record Preservation			
Preseravation of Records	During Order and minimum of 6 years after termination	As needed	TBD
EPA - Response to notification of disagreement	Written within 30 days of receipt of notification	As needed	TBD

Note: Consent order effective date: 9/10/09

Attachment 3
Field and Equipment SOPs

Equipment Standard Operating Procedures (SOP)

Equipment SOP – 1

Solinst Interface Meter Model 122

Model 122

Operating Principle

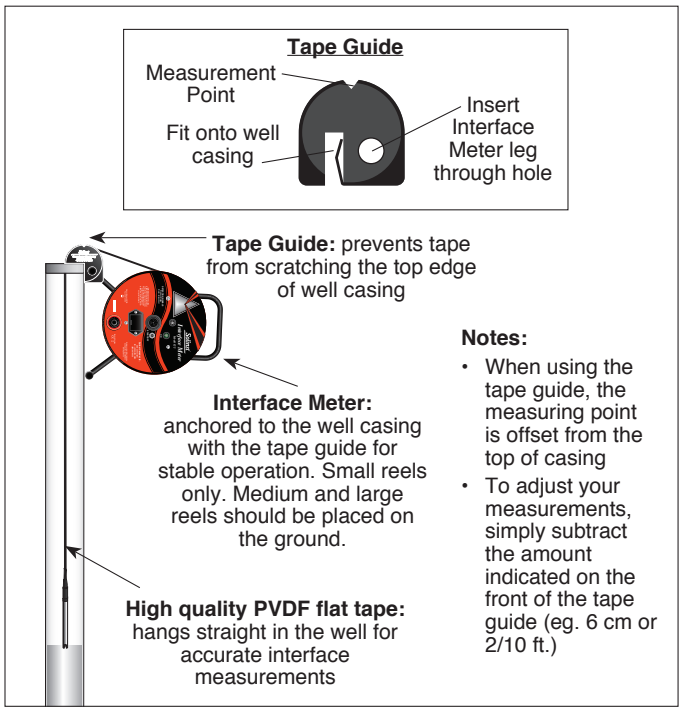
The Solinst Model 122 Interface Meter has a narrow 5/8" (16 mm) diameter probe and uses laser-marked PVDF flat tape. It is certified to CSA Standards, for use in hazardous locations Class 1, Div. 1, Groups C & D T3C, and is ATEX certified under directive 94/9/EC, as II 3 G Ex ic IIB T4 Gc. It has an infra-red circuit which detects the presence of a liquid. A conductivity circuit differentiates between conductive liquid (water) and non-conductive liquid (LNAPL or DNAPL product).

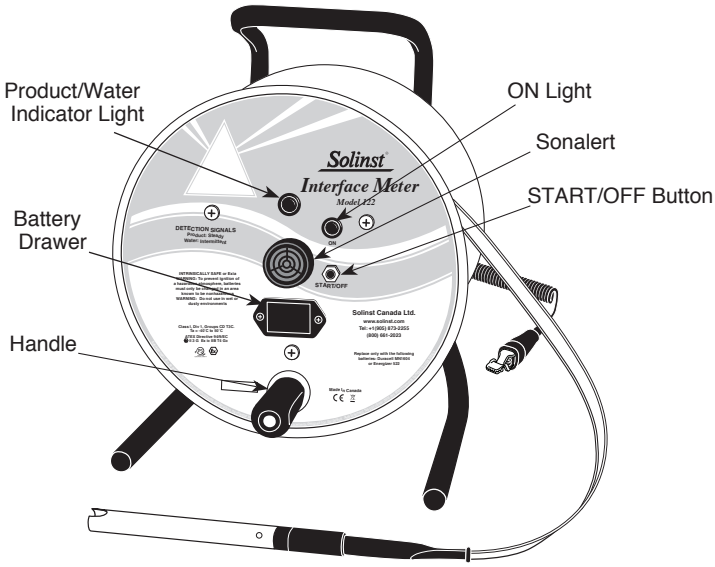
Equipment Check

Before beginning any measurements, check the electronics and battery condition by pushing the 'START/OFF' button. Five quick beeps with the green light flashing, indicates that the meter is functional. A flashing green light every second indicates the meter is on. It will automatically turn off after 10 minutes to preserve battery life.

Using the Tape Guide

1. The tape guide has been designed to: improve accuracy when reading interface measurements; to prevent the laser-marked PVDF flat tape being cut by well casing; and to allow the tape and probe to hang straight from the side of the well.
2. If interface measurements are being taken in a 2" dia well, then simply fit the small end of the tape guide onto the edge of the well casing.
3. Insert the leg of the Interface Meter into the hole on the Tape Guide (small reels only).
4. Once inserted, rest the Interface Meter on the side of the well casing.





Field Measurements

IMPORTANT

1. To meet safety requirements and to protect the electronics from damage, always ground the meter by attaching the grounding clip to the metal well casing or to a suitable ground rod.

2. Push the 'START/OFF' button. Five brief tones and green light indicate that the meter is functional and the flashing green light indicates that the meter is on. The meter automatically turns off after 10 minutes. Press the 'START/OFF' button as necessary during operation to turn the meter back on.
3. Place the slotted part of the tape guide onto the edge of the well casing. Lay the Interface Meter laser-marked PVDF flat tape into the groove on the top of the tape guide. Measurements are read at the V-notch on the tape guide.

Note: When using the tape guide, remember to subtract the compensation factor stamped onto the side of the guide from each measurement.

4. A steady tone and re light indicates a non-conductive liquid (e.g. product). An intermittent tone and red light indicates a conductive liquid (e.g. water).
5. For floating product (LNAPL), take the air/product interface measurement on the way into the liquid, and the water/product interface on the way up. When passing through product into water, some product may adhere to the probe sensors due to surface tension. Therefore, when water is detected below product, the probe should be raised and lowered rapidly in a short vertical motion to remove any product that may have been carried down with the probe.

Continued overleaf...

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6. The water/product interface should then be measured as the probe is raised very slowly back up. Once the interface is detected the probe can be raised and lowered in small increments to precisely determine the interface.
7. Repeat measurements to confirm water/product interface.
8. To determine the thickness of product, subtract the water/product interface from the product/air interface.
9. To determine if there is any sinking product (DNAPL) in the well, continue lowering the probe slowly. If steady signals activate, determine the top of the sinking layer by reading directly from the PVDF flat tape. Continue lowering the probe slowly until the tape slackens when the well bottom is reached. Read the level directly from the PVDF flat tape and subtract one from the other to determine thickness.
10. Upon completion of readings clean the tape and probe; as described in the Cleaning and Maintenance section.

Cleaning and Maintenance

After each use, the laster-marked PVDF tape should be wiped clean and carefully rewound onto the reel.

The probe should be cleaned as follows:

- Wash probe thoroughly with a non-abrasive mild detergent. **DO NOT USE ANY SOLVENTS**. Use a soft cloth around the pins on the end of the probe to remove all product. Use the brush provided to remove all product from inner part of the probe.

  USE LUKE-WARM, NOT HOT WATER. DAMAGE TO THE PROBE MAY RESULT.
- Rinse probe thoroughly with distilled water, wipe dry.
- Return the probe to the holder.

Other suitable cleaning method:

- Steam clean the PVDF flat tape only.

Battery Replacement

Push the battery drawer in and up and then release. The battery drawer should eject slightly, allowing it to be pulled out. Replace the 9V alkaline battery.

Other General Tips:

1. The probe should be cleaned after each use.
2. Always use the grounding cable.
3. Do not drop probe: damage to probe tip may result.
4. If battery is weak, the start tone will not sound, and flashing "green" light will be off. Replace the 9V alkaline battery.
5. Where possible, use a Solinst tape guide to protect the tape from scraping on well casing.
6. Before storage, make sure the meter is turned off. If the Interface Meter is going to be stored for longer than two months, the 9V alkaline battery should be removed to avoid potential leakage.
7. The meter can be checked by placing the probe in distilled (non-conductive) water or pure phase product, for example lamp oil (**avoid bright sunlight during testing and resting the probe on the bottom of the container**). A steady tone and light should be observed.
8. To maintain Intrinsic Safety Certifications, do not splice the tape.

Note: In rare circumstances it is possible that the 122 might sound when directed toward sunlight, and not in a liquid. This is normal and does not affect proper operation in a monitoring well.

Troubleshooting

Instrument will not turn 'ON' (no starting tone)

1. Replace the battery
2. Check the polarity of the battery in the drawer: make sure the + and - on the battery and the drawer match. The probe may be harmed by a reversed battery.
3. ON/OFF button could be faulty. Contact Solinst.

When instrument is turned 'ON', it immediately sounds product tone or intermittent water tone

1. Probe sensor may be dirty. Clean according to Cleaning and Maintenance instructions.
2. Water may have leaked into the probe. Carefully, remove the probe, keeping the wires connected. Dry out the probe, wipe and inspect the o-ring, replace if necessary and/or lubricate with silicone. To avoid any nicks, make sure the wires are tucked back into the probe body when replacing the probe. See Probe Replacement Instructions.
3. Tape may be damaged. Clean the tape and look for any cuts or nicks. If necessary, replace the damaged tape. To maintain the 122 Intrinsic Safety rating, do not splice or repair a damaged tape. Contact Solinst for assistance.
4. The reel or probe circuitry could be damaged. Please contact Solinst.

Instrument does not detect liquid

1. Check battery. Replace if necessary.
2. Clean probe tip following the Cleaning and Maintenance instructions.
3. Probe may be damaged. Please contact Solinst.

Instrument detects "Product" as "Water"

1. Note that this can happen if the probe is pulled into product too quickly and therefore pulls water in with it. Thoroughly dry the probe tip or shake the probe and try again at a slower speed.
2. Product may have degraded or is now disturbed enough to become an emulsion. If it has a detectable level of conductivity, it will read water. Wait for it to settle and try again.

Instrument does not detect water

1. Clean the probe tip. Follow the Cleaning and Maintenance instructions.
2. The water could be pure and non-conductive or product may be coating the probe, in which case, shake the probe for a while in the water column to clean product from the probe.
3. The probe circuitry could be damaged due to high voltage (static) in the well. Always use a ground cable. Please contact Solinst.

For further information contact: Solinst Canada Ltd.
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Solinst®

Equipment SOP – 2

MiniRAE3000

MiniRAE 3000
User's Guide

RAE SYSTEMS

Rev. A
April 2007
P/N 059-4020-000

FCC Information

Contains FCC ID: S22BTMODULE-CL2

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.

The instrument 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

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 and 059-3052-000. 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. 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 4.2V/3300mAH 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, Group A, B, C, D Europe: ATEX (II 1G EEx ia IIC T4) IECEx (Ex ia IIC T4)
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.

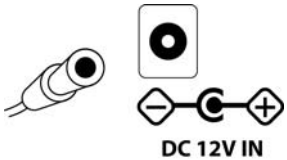
Charging The Battery

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 or Energizer E91), 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

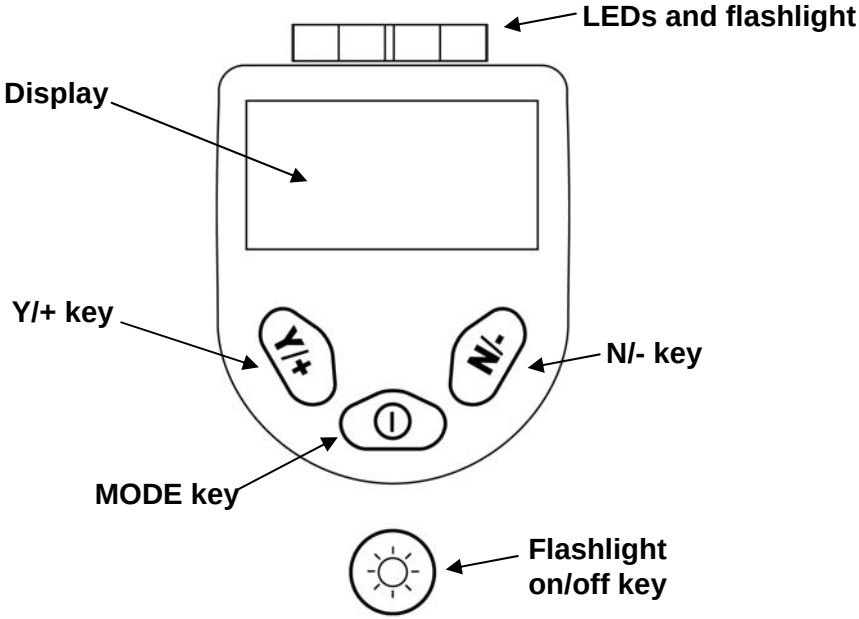
When the instrument is turned off, all the current real-time data including last measured values are erased. However, the datalog data is preserved in non-volatile memory. Even if the battery is disconnected, the datalog data will not be lost.

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.

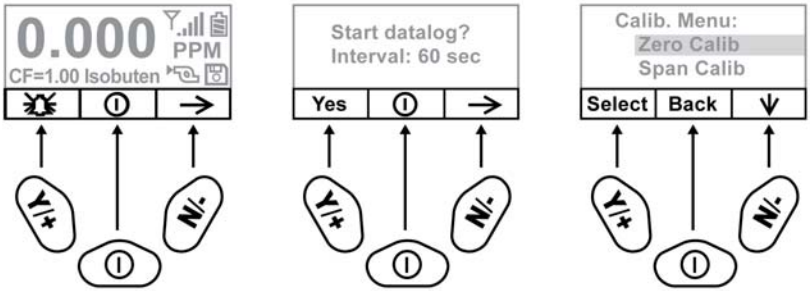


In addition to their labeled functions, the keys labeled Y/+, MODE, and N/- act as "soft keys" that control different parameters and make different selections within the instrument's menus. From menu to

menu, each key controls a different parameter or makes a different selection.

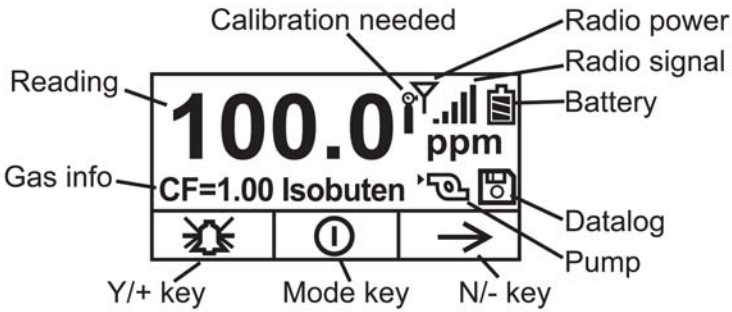
Three panes along the bottom of the display are "mapped" to the keys. These change as menus change, but at all times the left pane corresponds to the [Y/+] key, the center pane corresponds to the [MODE] key, and the right pane corresponds to the [N/-] key. Here are three examples of different menus with the relationships of the keys clearly shown:

RELATIONSHIP OF BUTTONS TO CONTROL FUNCTIONS



Display

The display shows the following information:



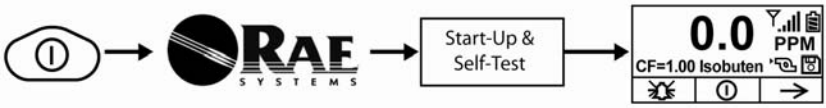
Graph	Graphic representation of concentration plotted over time
Gas info	Tells the Correction Factor and type of calibration gas
Reading	Concentration of gas as measured by the instrument
Calibration needed	Indicates that calibration should be performed
Radio power	Indicates whether radio connection 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

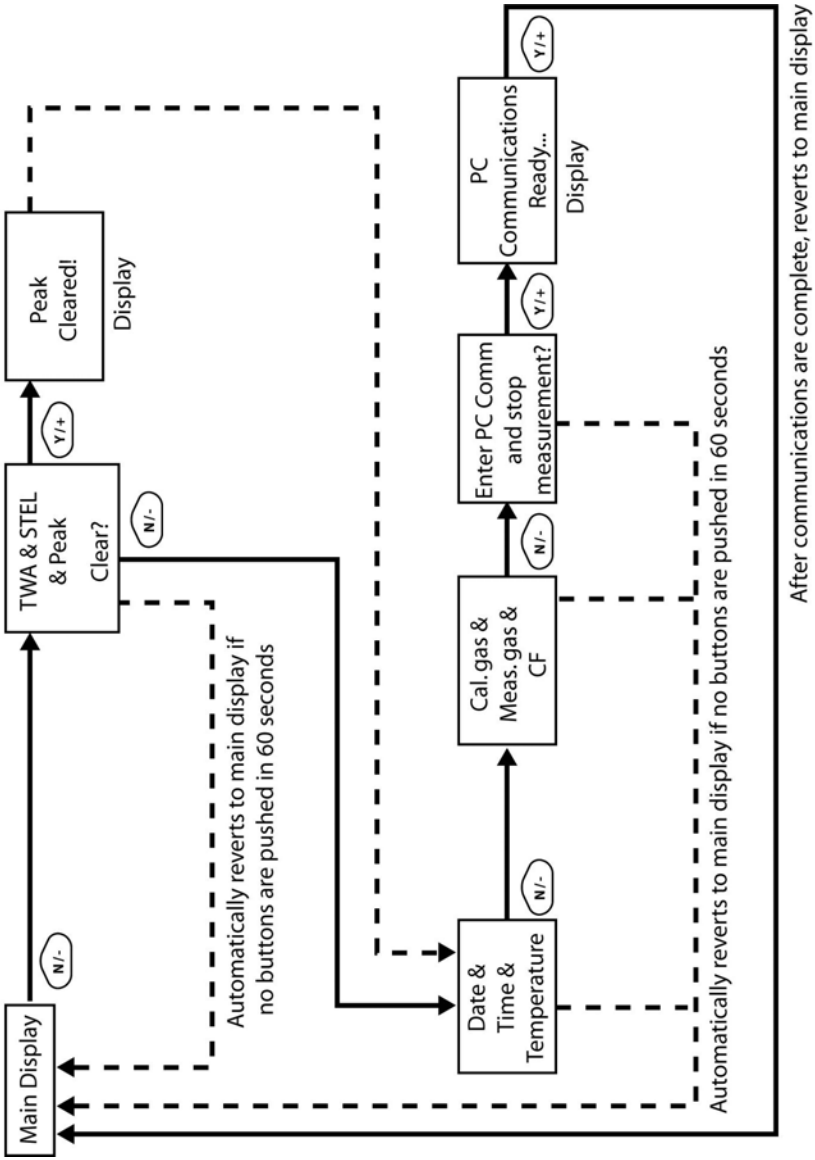
Using ProRAE Studio allows access to other options. In addition, Diagnostic Mode (page 83) is available for service technicians.

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 200' (61 m) away horizontally, or 90' (27.5 m) vertically, at about 3' (0.9 m) per second flow speed.

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.

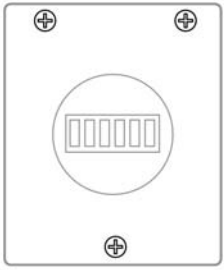
A completely discharged instrument can be charged to full capacity within 8 hours. Batteries drain slowly even if an instrument is off. Therefore, if the instrument has been in storage or has not been charged for several days or longer, check the charge before using it.

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 or Energizer E91) 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

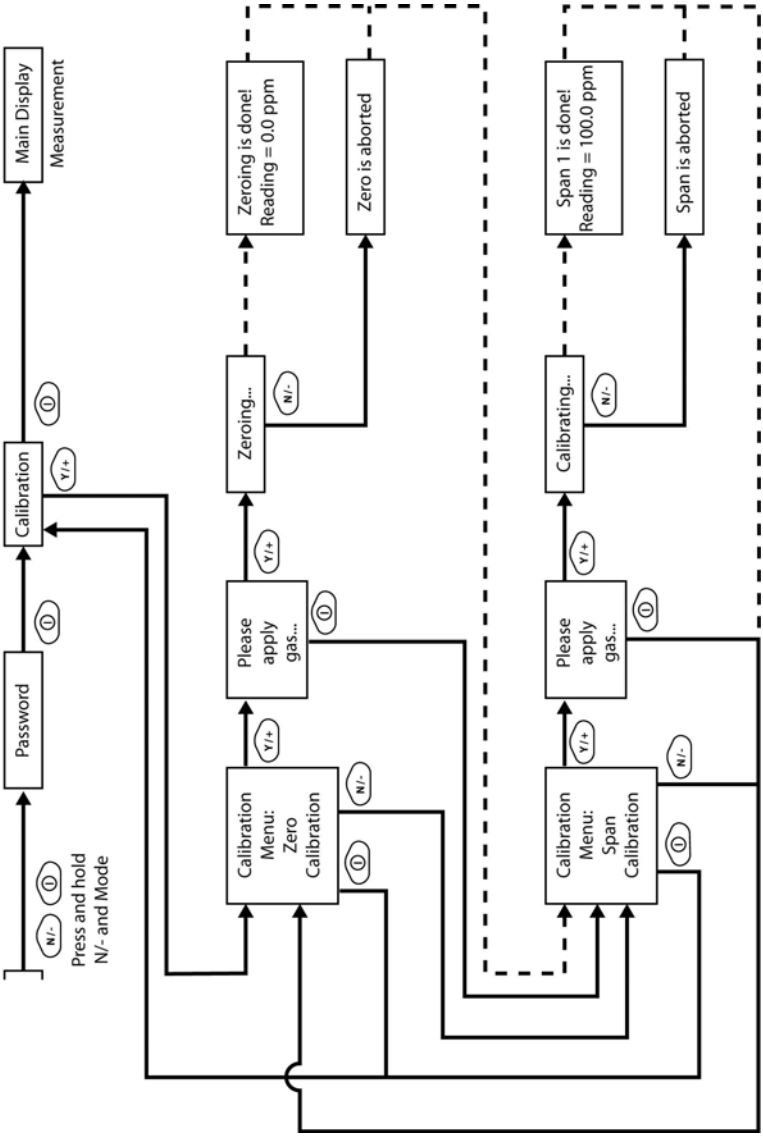
The Calibration Regulator is used in the calibration process. It regulates the gas flow rate from the Span gas cylinder into the gas inlet of the instrument during calibration process. The maximum flow rate allowed by the flow controller is about 0.5L/min (500 cc per min.). Alternatively, a demand-flow 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)

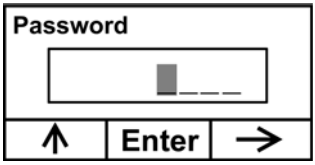
The following diagram shows the instrument's calibrations in Basic/Hygiene mode.



Note: Dashed line indicates automatic progression.

Entering Calibration

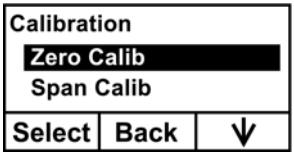
1. Press and hold [MODE] and [N/-] until you see the Password screen.



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.

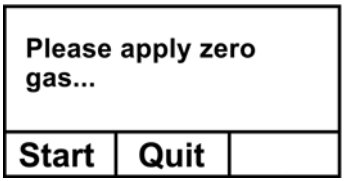
Zero (Fresh Air) Calibration

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

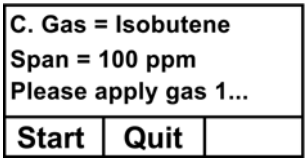
This procedure determines the second point of the sensor calibration curve for the sensor. A cylinder of standard reference gas (span gas) fitted with a 500 cc/min. flow-limiting regulator or a flow-matching regulator is the simplest way to perform this procedure. Choose the 500 cc/min. regulator only 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…

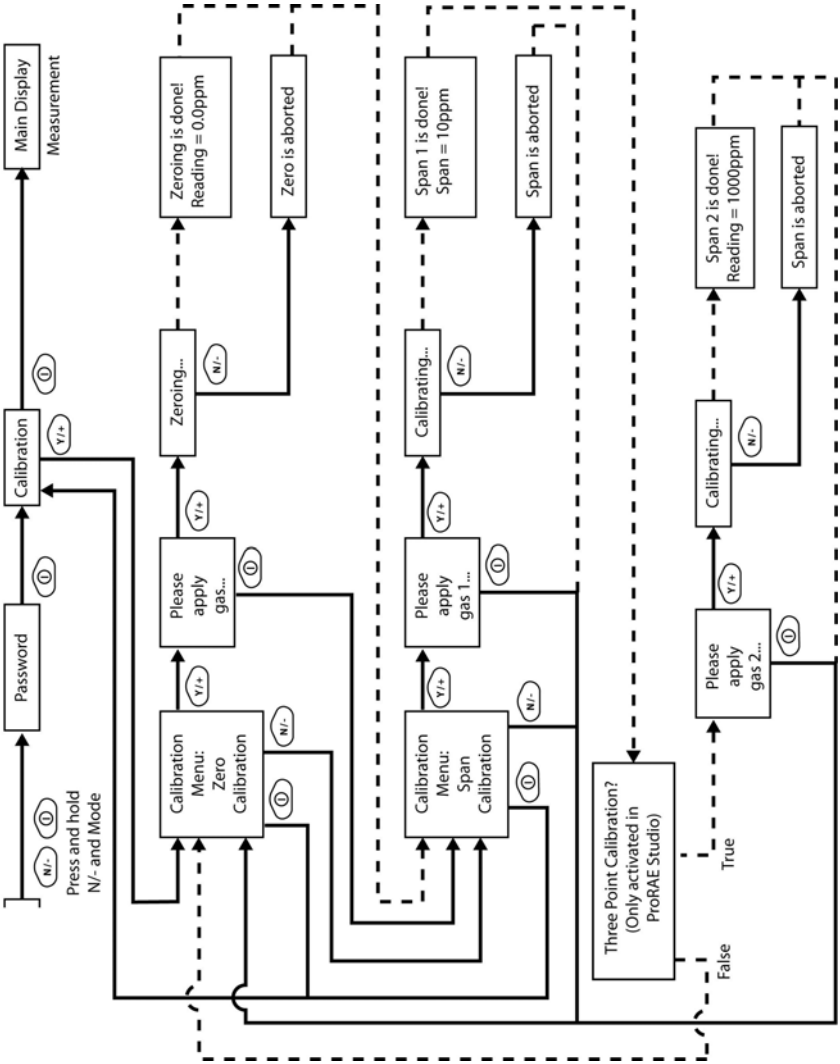
The instrument updates its settings and then returns to the main display. It begins or resumes monitoring.

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…

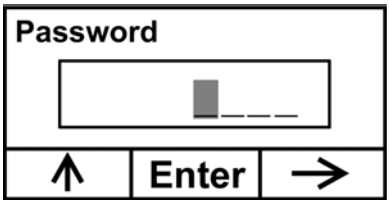
The instrument updates its settings and then returns to the main display. It begins or resumes monitoring.

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.



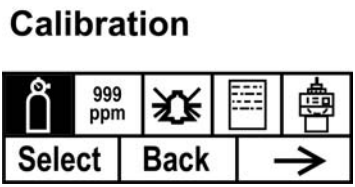
2. Input the 4-digit password:

- 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.

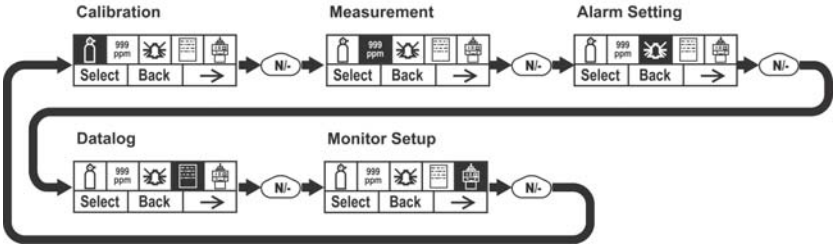
Note: The default password is 0000.

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

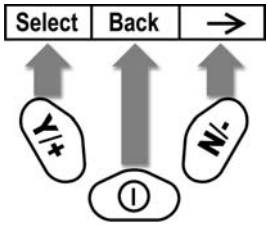
Once you enter Programming Mode, the LCD displays the first menu, Calibration. Each subsequent menu is accessed by pressing [N/-] repeatedly until the desired menu is displayed. To enter a sub-menu of a menu, press [Y/+].

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:



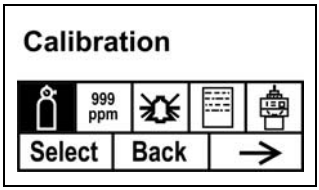
Note: Pressing [MODE] in the Programming Mode's top level causes the instrument to exit Programming Mode and return to monitoring.

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

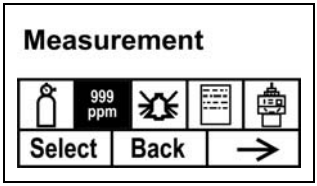
The procedure for performing a zero calibration is covered on page 35.

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/-].

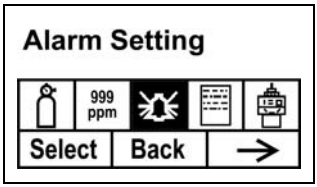
Leave the sub-menu and return to the Programming Mode menus by pressing [MODE].

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 µg/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

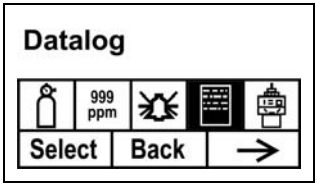
1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates your selection).
3. When you have completed your selections, press [MODE].

   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.

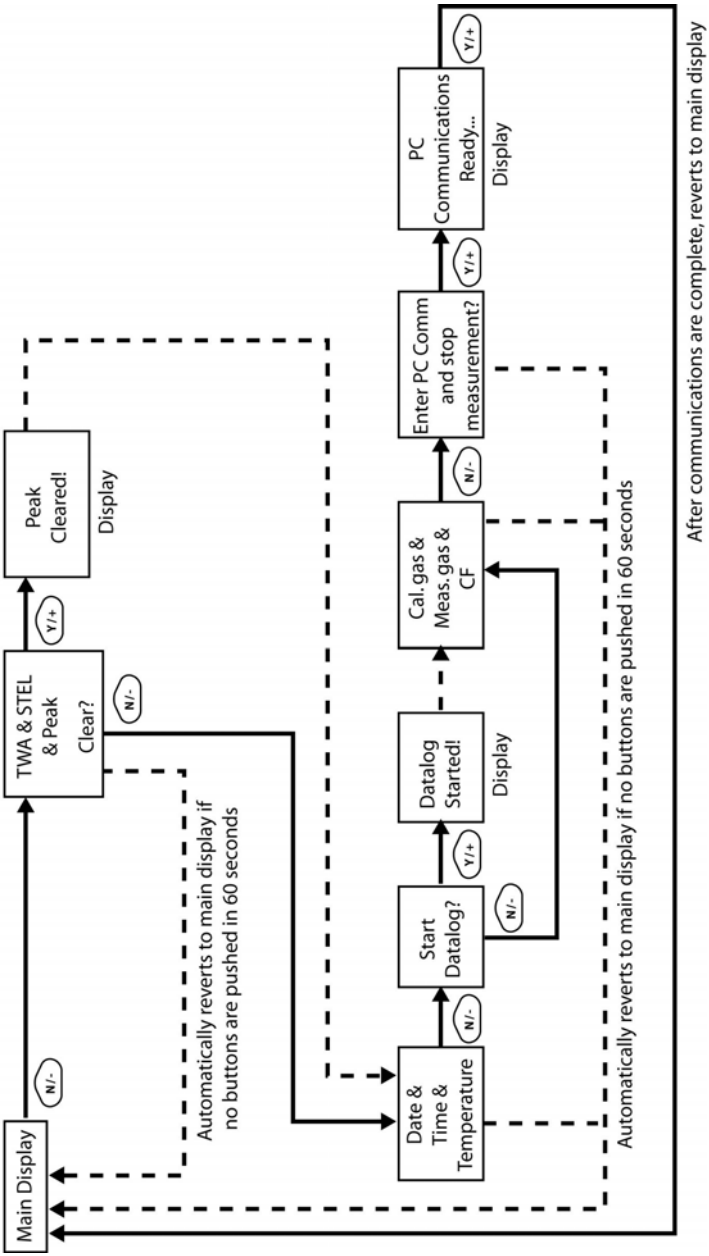
Press [N/-] to undo the changes and revert to the previous settings.

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.

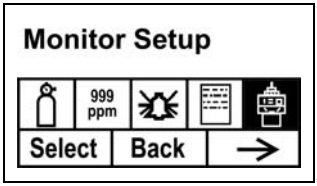
Snapshot Datalog

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

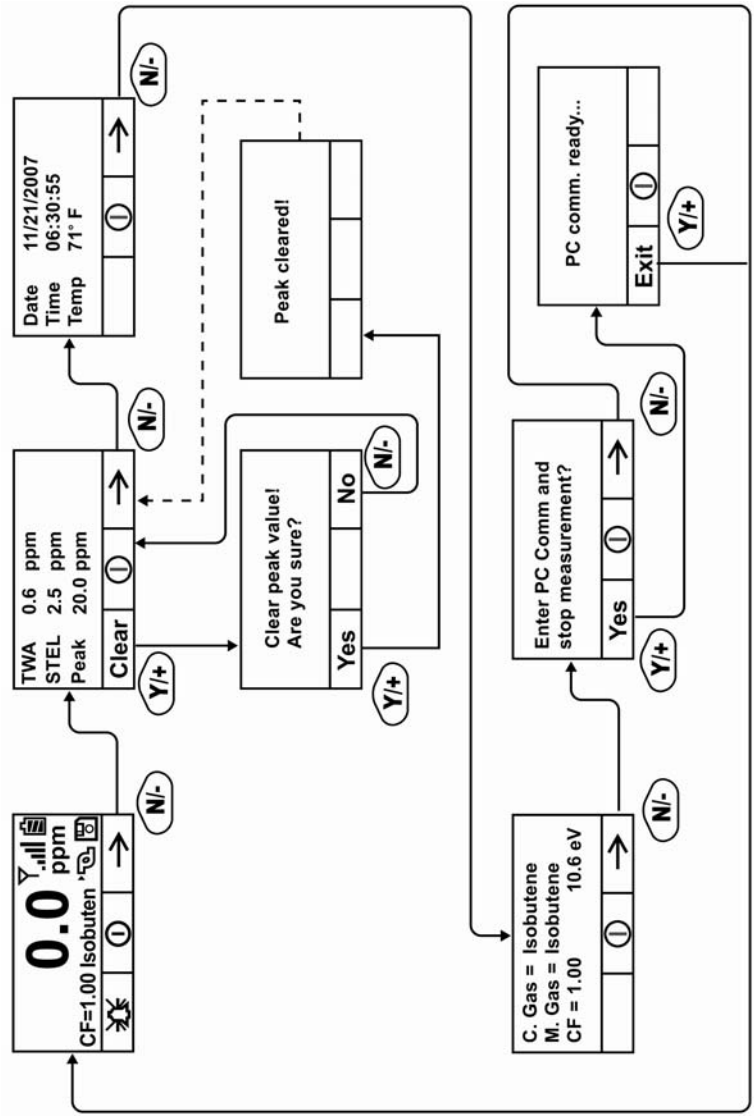
The instrument usually operates in Hygiene Mode, which provides basic functionality. However, it is possible to operate it in a second mode called Search Mode. Here are the primary differences:

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

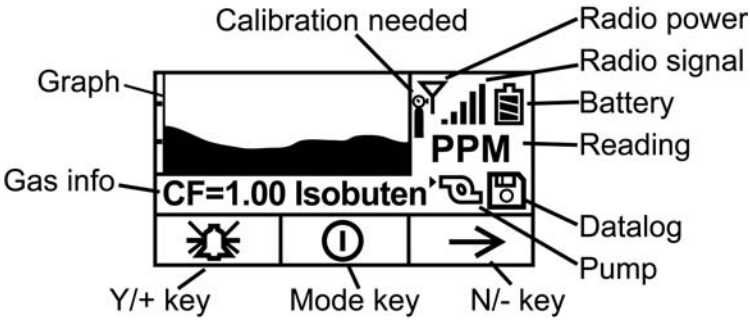
The current mode is indicated by a dark circle within the circle in front of either Hygiene or Search.

1. Select Hygiene or Search by pressing [N/-].
2. Press [Y/+] to place the instrument into the selected mode.

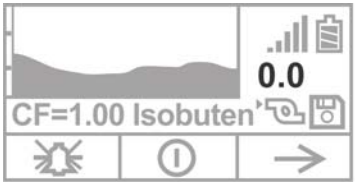
3. Press [MODE] when you want to register your selection to place the instrument in the selected mode.
4. Press [Y/+] to commit the change and exit to the Monitor Setup screen, or press [N/-] to Undo (exit to the Monitor Setup screen without changing the Mode).

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)

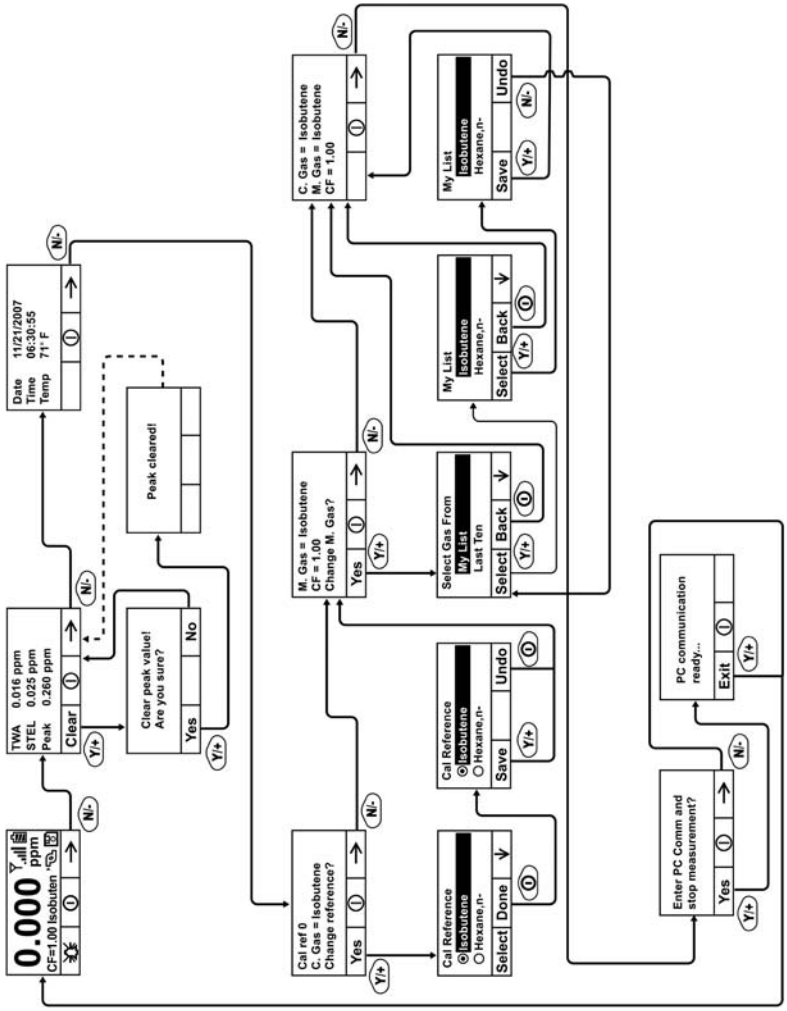
The User Mode called Advanced User Level allows a greater number of parameters to be changed than Basic User Level. It can be used with either of the Operation Modes, Hygiene Mode or Search Mode.

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.

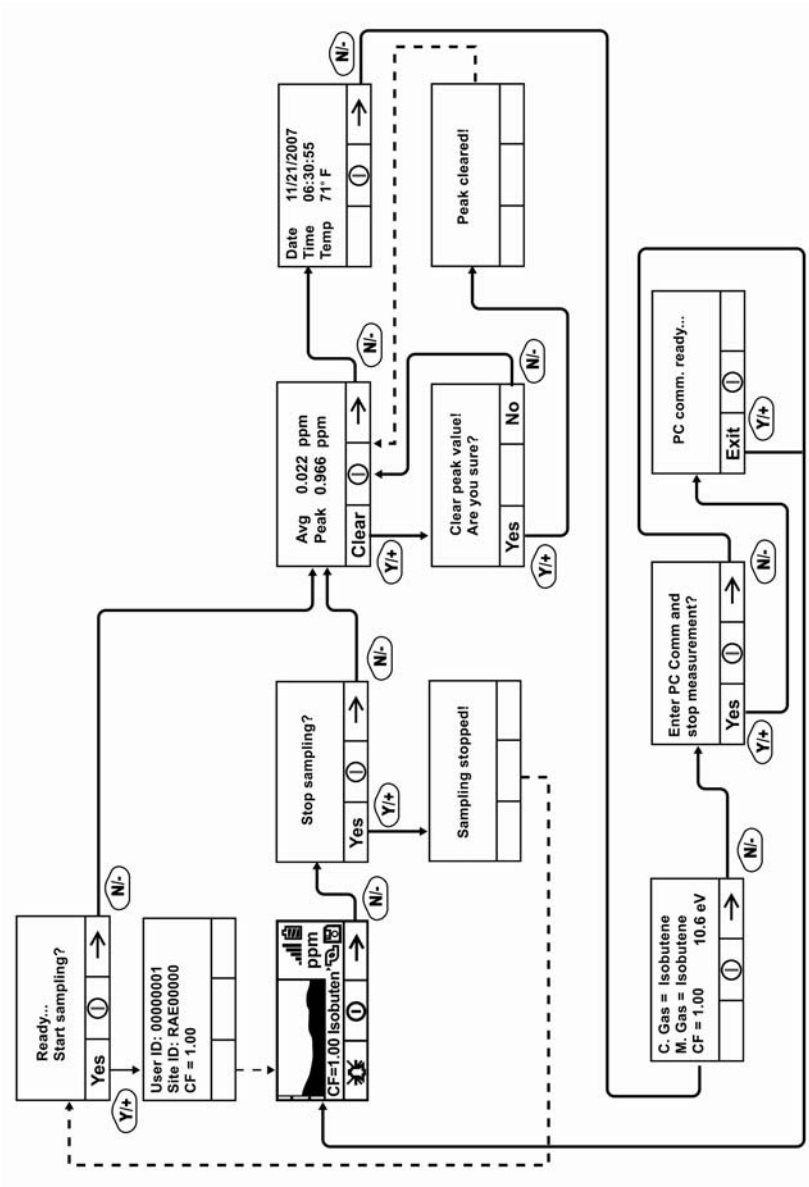


Note: Dashed line indicates automatic progression.

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).

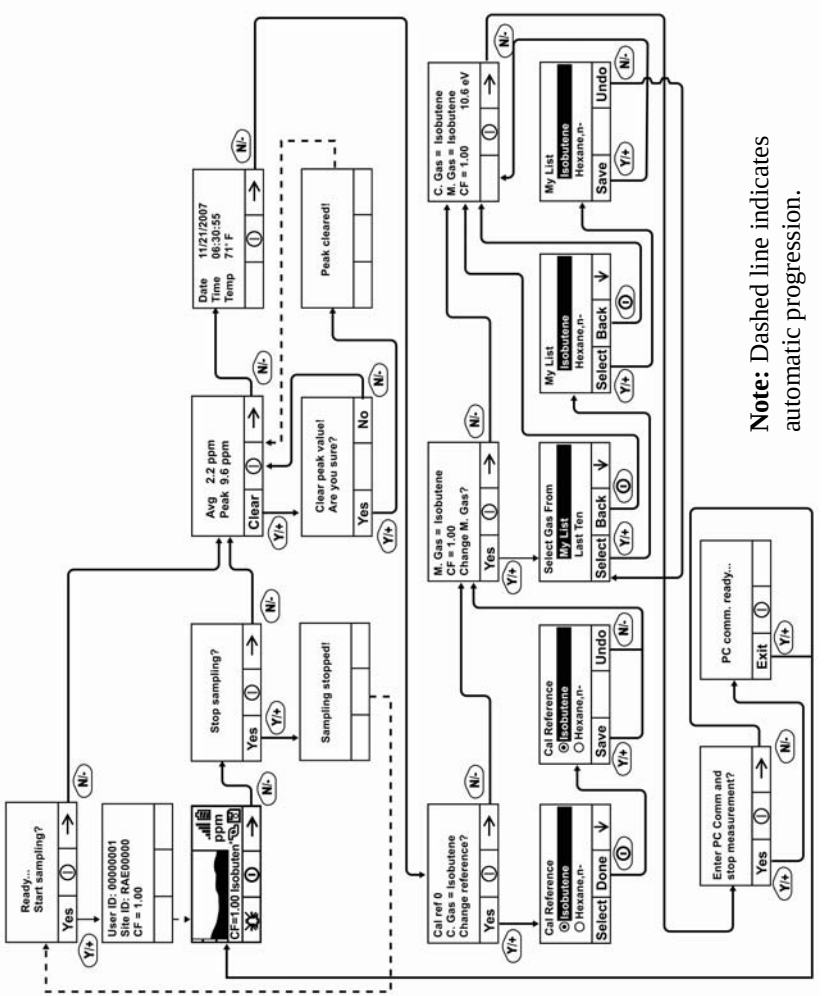
When the instrument is in Search Mode, it only samples when you activate sampling. When you see the display that says, "Ready…Start sampling?" press [Y/+] to start. The pump turns on and the instrument begins collecting data. To stop sampling, press [N/-] while the main display is showing. You will see 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 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. Select Operation → Download Firmware.

Once communication is established, follow the instructions that accompany ProRAE Studio and the firmware to upload the new firmware to your instrument.

Note: Check for the latest updates to ProRAE Studio 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

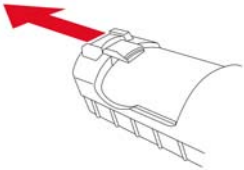
When the display shows a flashing empty battery icon, the battery requires recharging. It is recommended to recharge the instrument upon returning from fieldwork. A fully charged battery runs a instrument for 16 hours continuously. The charging time is less than 8 hours for a fully discharged battery. The battery may be replaced in the field (in areas known to be non-hazardous), if required.

WARNING!

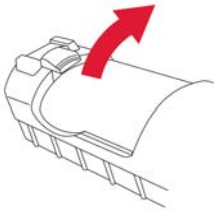
To reduce the risk of ignition of hazardous atmospheres, recharge battery only in area known to be non-hazardous. **Remove and replace battery only in areas known to be non-hazardous.**

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.

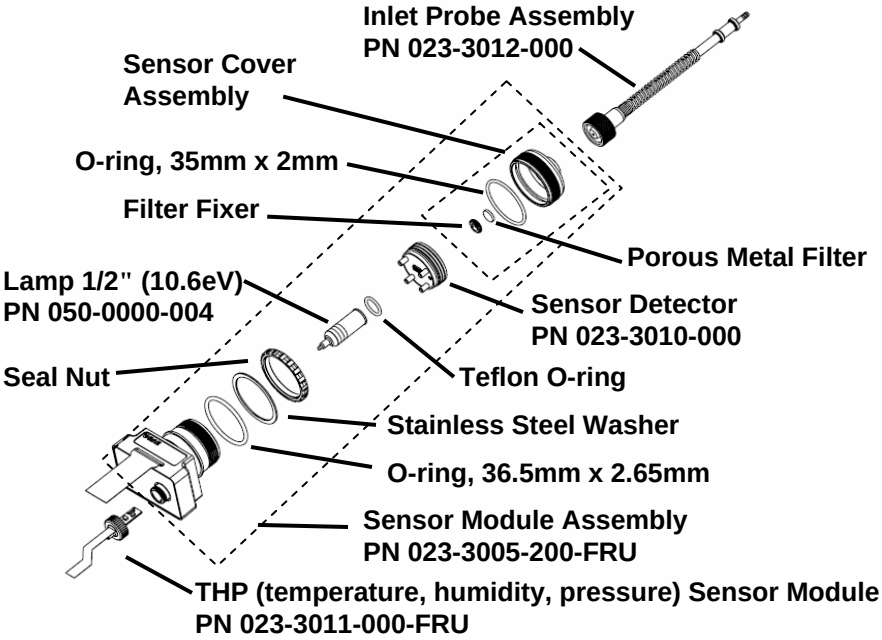
WARNING!

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.

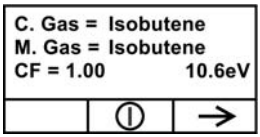
Determining Lamp Type

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

RAE Systems Contacts

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Email: krsales@raesystems.com

Appendix A: Regulatory Information

059-4020-000-APNDX Rev A.

Intrinsic Safety:	US and Canada: Class I, Division 1, Group A, B, C, D Europe: ATEX (II 1G EEx ia IIC T4) IECEx (Ex ia IIC T4)
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

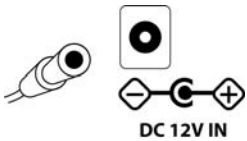
Charging The Battery

Always fully charge the battery before using the instrument. The instrument's Li-ion 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 (part number 059-3051-000) 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 or Energizer E91), 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 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.

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 The Rechargeable Li-Ion 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 or Energizer E91).

Do not mix old and new batteries or batteries from different manufacturers.

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. A
April 2007
P/N 059-4020-000

Equipment SOP – 3

Micro Purge QED Control and Power Pack Model MP15

MICRO PURGE basics QED

MODEL MP15

CONTROL & POWER PACK

PATENT PENDING

User's Guide

Part No. 95178 REV. # 11-9-01

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SAFETY WARNINGS

Safety Warnings

CAUTION: Use caution when working with compressed air or gas. **HIGH CONCENTRATIONS OF CARBON DIOXIDE CAN CAUSE DROWSINESS, INJURY OR DEATH BY ASPHYXIATION. STORE AND USE CYLINDERS IN A WELL-VENTILATED AREA**. Compressed gas cylinders are under extreme pressure and can discharge violently and be propelled by this discharge if not properly restrained. **DO NOT OPEN THE VALVE ON ANY COMPRESSED GAS CYLINDER UNLESS IT HAS FIRST BEEN PROPERLY ATTACHED TO THE CORRECT SYSTEM FITTINGS IN GOOD CONDITION, WITH THE SEALING WASHER IN PLACE (SEE FIGURE x). COMPRESSED CARBON DIOXIDE CAN CREATE EXTREME AND DAMAGING CHILLING OF HUMAN SKIN SURFACE AND OTHER OBJECTS IF THEY ARE SUBJECT TO DIRECT DISCHARGE OF THE CYLINDER CONTENTS. DO NOT TRANSPORT OR STORE A COMPRESSED CO2 CYLINDER,OR OPERATE THE MP15 CONTROLLER IN THE PASSENGER SPACE OF A VEHICLE, IN A CONFINED ROOM, OR IN ANY CONFINED SPACE OR PIT. ALWAYS KEEP THE CO2 CYLINDER VALVE CLOSED WHEN THE MP15 IS NOT BEING OPERATED**.

Do not over pressurize your controller. Failure to operate the controller within the pressure limits could result in failure. Read all operating instructions before operating the MP15 controller.

Warning. Do not disassemble the pneumatic pump while it is connected to a compressed gas source. Dangerous pressures could cause injury.

CO2 Cylinder Safety and Handling

.

The MP15 MicroPurge basics Control & Power Pack includes an on-board power source, a CO2 (carbon dioxide) cylinder, to operate bladder -type sampling pumps. The 5 lb. capacity cylinder makes the MP15 very versatile and portable. **HOWEVER, AS WITH ANY COMPRESSED**

GAS CYLINDER, IT MUST BE TREATED WITH CARE TO AVOID INJURY OR DEATH.

- The CO2 (carbon dioxide) cylinder is highly pressurized, and damage to the outlet valve could result in sudden discharge of the highly pressurized contents, potentially propelling the cylinder with sufficient force to cause injury or damage.
- Carbon dioxide gas can cause drowsiness or asphyxiation in high concentrations and confined spaces.
- Sudden discharge of large amounts of carbon dioxide can create extremely low temperatures on any surfaces it is discharged onto, **INCLUDING HUMAN SKIN, WHICH COULD BE FROZEN OR DAMAGED AS A RESULT!**

Make sure the CO2 cylinder is always handled with care, protected from impact during transport and handling, and has the valve closed at all times except when properly connected to the MP15 and in use. Keep the cylinder valve closed at all other times. Make sure that the MP15 is never operated in a confined space (such as the passenger compartment of a vehicle), building, or a pit or well in which the heavier-than-air carbon dioxide can collect. Under some conditions of usage, condensation or frost may develop on the exterior of the cylinder due to the cooling effect of gas expansion.

The MP15 should always be used in an upright, vertical position, so that gaseous CO2 exits from the top of the cylinder for use in the MP15, rather than the liquid CO2 present in the bottom of the cylinder. Discharge of liquid CO2 from a non-vertical cylinder will cause excess usage of CO2 and may cause malfunction of the MP15

CYLINDER FILLING

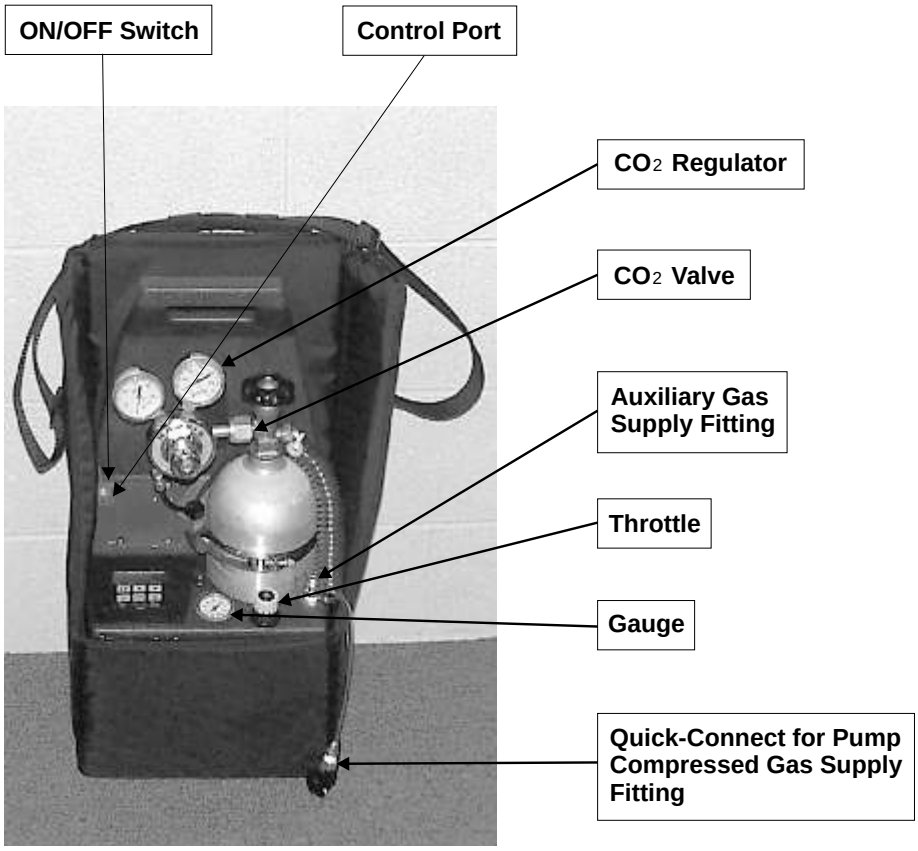
CO2 CYLINDER FILLING

The aluminum CO2 cylinder supplied with the MP15 can be refilled at many different facilities,
and can be supplemented with steel, pre-filled standard 5 lb. CO2 cylinders which are also widely available. The original cylinder provided with the MP15 is aluminum for lighter weight, but the heavier, more common steel cylinders have the same dimensions and will function identically in the MP15.

Facilities which can typically refill the CO2 cylinder for the MP15 include the following: fire extinguisher service businesses, beverage system supply firms, welding supply shops, and industrial gas supply outlets. It is recommended that a phone call be made first to verify availability and whether that facility can refill your own cylinder while you wait. Some firms can only exchange pre-filled cylinders for empty ones, which will commonly mean that you will receive a heavier, steel cylinder in place of the original aluminum. Fire extinguisher service and beverage system supply shops are often better prepared to fill cylinders on demand. When the aluminum cylinder cannot be refilled, it is recommended that a standard steel cylinder or cylinders be rented from the facility then returned for credit after use. **Use care during transport of all cylinders to avoid damage to the valve or fittings. Follow all safety instructions noted on the cylinder**.

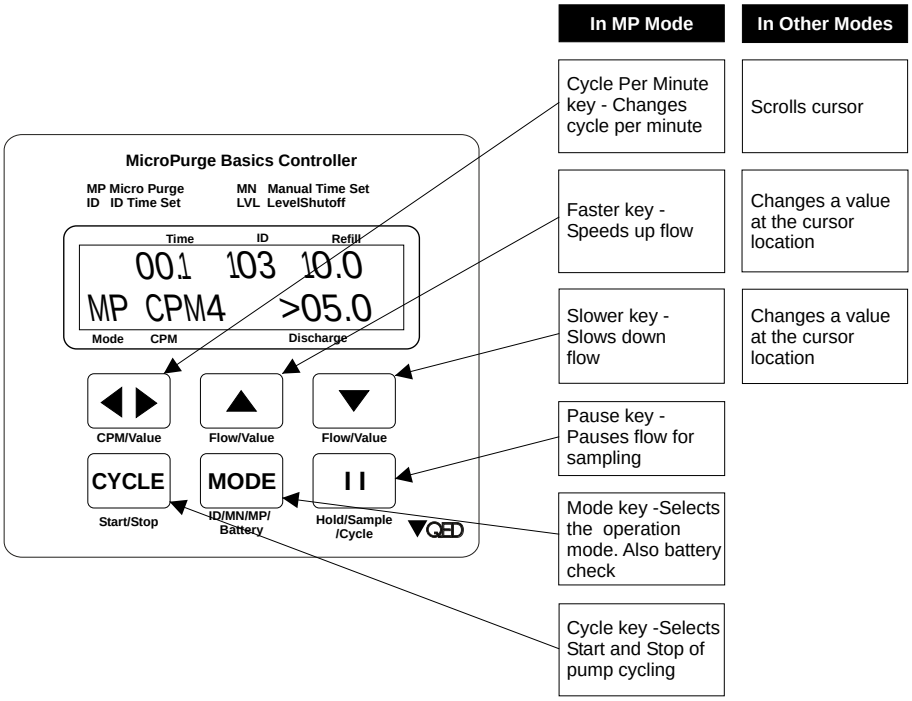
Diagrams and Conventions used in the Text

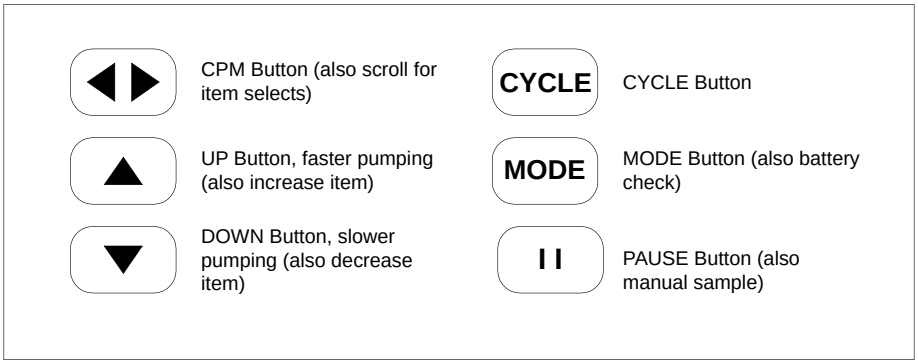
MP15 Overview Diagram



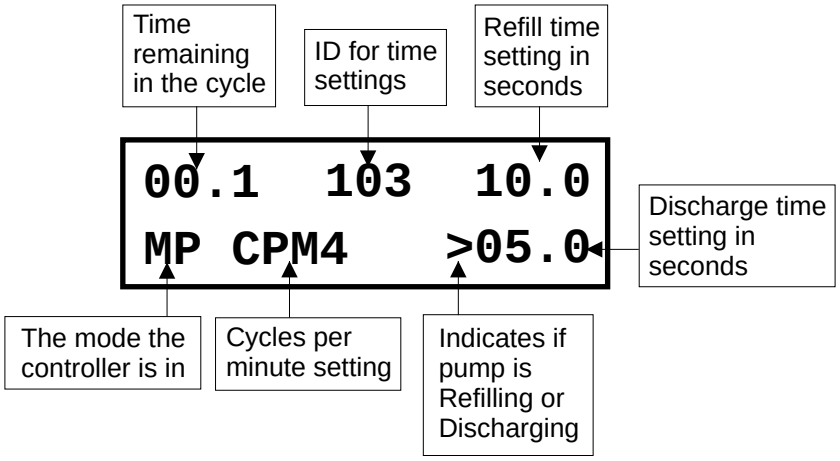
DIAGRAMS / CONVENTIONS

MP15 Control Keys:





MP15 Display:



Abbreviations:

CPM	Cycles per minute
MP	MicroPurge mode
ID	ID time set mode
HELD	Held in a cycle
MN	Manual time set mode
BAT	Battery
LVL	Level pause
>	Indicates Refill or Discharge cycle

Introduction / Quick start

Introduction: The MP15 Micro Purge Basics Controller is used to operate QED Well Wizard bladder sampling pumps to purge and sample ground water. The MP15, with its self-contained CO2 cylinder (or another compressed gas source connected to the bypass supply fitting) is taken portably from well to well. The MP15 has specific design features to make MicroPurge™ sampling easier. These features include:

- **MicroPurge Mode Operation** Simple Increase / Decrease keys allow you to easily set the flow rate you need for each well.
- **ID Time Set Mode Operation** Quickly recalls pre-determined settings for each well by specifying a 3-digit ID.
- **Level Delay Interface** The controller plugs into the optional MP30 MicroPurge Drawdown / Water Level Meter to provide direct feedback of well drawdown and to pause pump operation until the level recovers.

The optional MP30 MicroPurge Drawdown / Water Level Meter plugs into the MP15 to provide water level feedback. The MP30 uses a standard conductivity probe to detect the ground water surface and a marked tape allowing the user to measure the depth. When the meter is set in MicroPurge mode, the probe is lowered a specific distance below the static water level and fixed in this position. During well sampling if the water level drops below the user-set probe position, the MP15 is paused which prevents further drawdown by the pump. Once the level recovers the MP15 begins pump operation again, starting in the pump refill cycle. Use of the MP15 with the MP30 is detailed later in this manual.

Insert Batteries: Remove the battery cover on the top of the MP15. Insert 3, AA alkaline batteries into the battery holder and carefully replace the holder in the carrier. Replace the battery cover and tighten the 4 screws. Batteries should last for about 6-8 weeks of typical full-time field use. If the MP15 will be stored longer than 3 months, the alkaline batteries should be removed to prevent leakage.

Quick Start: Open the CO_2 valve and supply up to 125 psi compressed air or gas to the controller. Turn the controller throttle until the gauge reads the approximate depth of the sample pump. Follow instructions on the battery panel:

Move Red ON/OFF toggle switch up to turn power ON.

Select desired Cycles Per Minute (CPM) with ◀▶ (default value is 4 CPM, lower CPM for deeper wells, higher CPM possible with shallow wells).

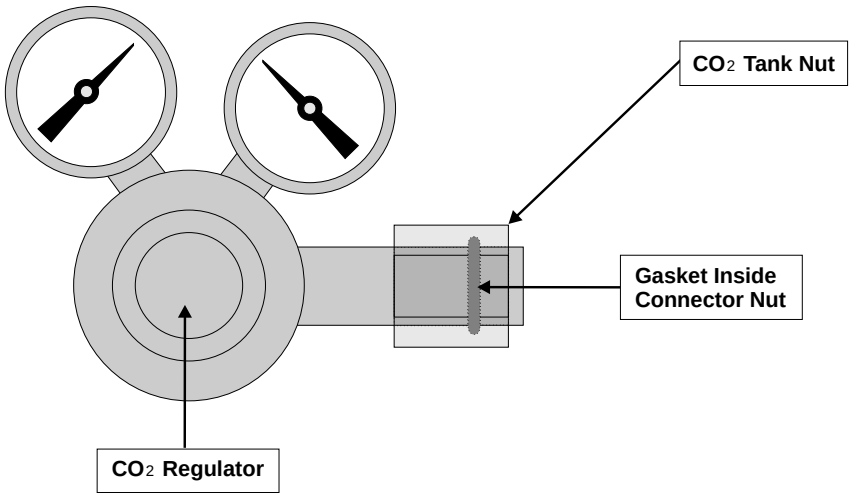
Turn throttle to set depth on gauge to 10-20 feet deeper than the pump location in the well.

Press Cycle to START pumping.

When water discharge begins, adjust throttle until a slow, steady flow-stream is achieved.

Press ▼ ▲ keys to set the desired purge flow rate.

To collect samples, continue purge flow, or use II key to directly control sample flow and pause.

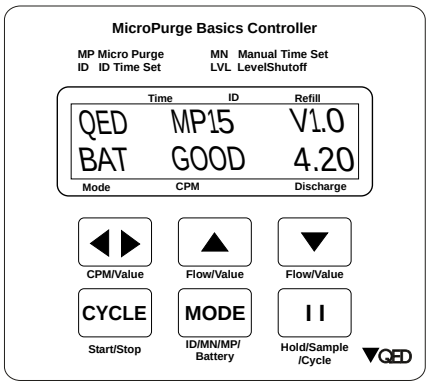


Operation

Turning the MP15 Display On - The MP15 is powered on by moving the Red ON/OFF toggle switch (located above the control port) up to the ON position. When the Red power toggle switch is moved upward the MP15 displays an opening screen for 5 seconds, after which it displays the default MicroPurge screen. At this point the MP15 is in MicroPurge mode (MP) but not cycling the pump. This initial state allows the user to adjust time and throttle settings before the pump starts to operate. Pressing the Cycle key begins pump cycling. Times and modes may be adjusted while the pump is cycling or before. Pressing the Cycle key a second time will stop pump cycling. *Note: All user-entered time settings are lost when the MP15 is turned off. Also, the MP15 does not automatically power down so make sure the Red power toggle is turned Off (down position) during storage.*

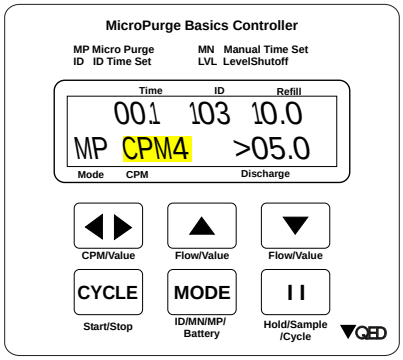
Opening Display - The opening display is shown for 5 seconds and displays the controller name, the version number and the battery voltage, as shown in Figure 1. Figure 1 shows that the battery is GOOD, that the battery voltage is 4.20 volts and that the software version in the controller is 1.0. Battery voltage must be greater than 3.6 volts for the unit to operate. If the unit fails to cycle replace the 3-AA batteries with fresh cells. The opening screen is displayed for 5 seconds, if you wish to by pass the opening screen, hitting any key, such as the CPM key will bring you to the default MP display.

Figure 1 Opening Screen



MicroPurge Mode Most MP15 users will leave the controller in the default MicroPurge (MP) mode. See Figure 2 for an example of the MP15 in MP mode. MP mode lets you to use the UP and DOWN keys to directly increase and decrease pump flow rates. The MP15 has a broad range of other CPM settings to ensure the availability of a time setting that will match your specific conditions. (MP mode also displays an ID, with a value of 1 to 165 that matches the flow settings (CPM) and refill and discharge times you have set). This ID should be noted alongside the well identification (QED provides custom weatherproof ID badges for purchasers of our MP series of well caps) for quick setting of the optimal controller settings on the next visit by using the MP15 in ID mode.

Figure 2 MP15 MicroPurge Mode



Using CPM The MP15 introduces a revolutionary, simpler way to control bladder pump flow rate and achieve the low-flow method used by experts. Up/down arrow keys are used to adjust pump flow even at very low rates, with excellent control and repeatability.

With previous bladder pump controllers, a leading low-flow technique called for selecting the number of pump cycles per minute, then adjusting the bladder pump discharge and refill times to achieve the desired volume per cycle. These adjustments were inter-related, complex, and varied by operator. The new MicroPurge Mode (MP) of the MP15 builds in a "cycles per minute", or CPM, method of flow control.

With this method, the number of complete pump cycles per minute is fixed, within a range of 1 to 6; 4 CPM is the default value which appears at startup. Each time the up/down arrow keys are pressed, the pump refill and discharge times are both automatically adjusted to maintain the selected CPM value. Each adjustment increases or decreases the volume pumped per cycle, and the per-minute flow rate is the volume per cycle X the CPM value.

For example, with a 4 CPM setting, 60 ml volume per cycle equates to 4 X 60 = 240 ml/min flow rate. A single press of the Flow up-arrow key could change the volume per cycle to 80 ml, for example, resulting in a new, increased flow rate of 4 X 80 = 320 ml/min. And the MP15 assigns a unique identification value to each setting, the ID value, which can be directly set during later sampling events.

"MP" displayed in the lower left corner of the display indicates MicroPurge mode. The default CPM setting of 4 cycles per minute is a good starting point for wells with depths from 25-100ft. MicroPurge mode starts at a time setting of 10 seconds refill and 5 seconds discharge, close to optimal for many wells. This startup settings corresponds to a 4 cycles per minute setting (CPM4) and an ID setting of 103.

Using the CPM key will change the CPM setting on the controller. The range of CPM settings is CPM1 through CPM6. CPM changes like this each time you hit the CPM key: 4 5 6 1 2 3 4 5, etc. The UP and DOWN keys change the flow rate directly, by altering the refill and discharge times *within* a CPM setting. *Note: changes in settings that are entered while the controller is cycling are reflected on the next cycle change (so a long refill time of 15 seconds will time out before a new refill time becomes valid).*

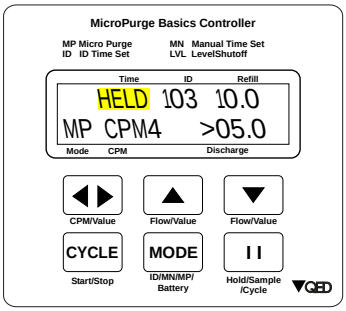
Here is an example of the use of the UP (faster) key:

Key Press	Refill (sec)	Discharge (sec)	ID
---	10.0	5.0	103
1	9.5	5.5	104
2	9.0	6.0	105
3	8.5	6.5	106

Each of the 165 possible ID settings corresponds to a unique ID that is associated with CPM, refill and discharge time values. For typical usage, only the UP/DOWN arrow keys are required to set flow, and the ID number is provided for easy, direct return to past settings. Appendix 1 lists all possible ID settings and the default refill and discharge time settings for each CPM. Appendix 1 also shows how the refill and discharge time will change within a CPM setting as you press the UP or DOWN keys.

Sample Collection The PAUSE key (II) is used to freeze the controller action to allow the user time to collect a sample or carry out other steps that might be difficult if the controller continued to automatically cycle and cause the pump to produce water. While the controller is cycling, pressing the PAUSE key causes the controller to immediately enter the Hold state. Drive air is vented from the pump (this is the pump refill cycle) and the pump fills and waits. Pressing the PAUSE key a second time causes the controller to immediately enter the Sample state. Drive air is directed to the pump causing the pump to discharge its volume of liquid. Bladder pumps typically hold 400-500ml of liquid, so use of the Hold and Sample states allow the full volume of the pump to be discharged into a sample container. Pressing PAUSE once again returns the MP15 to its normal Automatic Cycling state. During Hold and Sample a HELD is displayed to remind you that the controller is in a paused state. Figure 3 shows an example of the MP15 in MP mode, but HELD in the Sample state. *Note: Pressing the Cycle key also freezes controller cycling. However, using the Cycle key rather than the Pause key causes the startup screen to be displayed upon restart. Use of the Pause key is recommended for typical operation.*

Figure 3 MP15 Held State (MP mode)



OPERATION

Warning: in the HELD SAMPLE state the pump, tubing and hoses are all under pressure. DO NOT attempt to disconnect or disassemble any part of the system when it is under pressure. The system is under pressure if the pressure gauge shows a value greater than 0 and the RED Discharge Cycle Indicator is showing.

Flow Throttle Use The flow throttle is used during sampling to regulate the pressure applied to the pump. Turning the throttle clockwise increases the pressure and counterclockwise decreases the pressure. The pressure gauge shows the approximate pressure applied to the pump and reads in units of Feet-H_2O. This allows easy adjustment of the throttle giving pressures that will produce gentle, non-turbulent flow (normally 10-20 Feet- H_2O deeper than pump depth). For traditional, high volume purging pressure may be increased with the throttle to maximize pump flow during well purging.

Use with the MP30 Automatic Drawdown Control The MP15 may optionally be used with the MP30 MicroPurge Drawdown / Water Level Meter. See Figure 4 for an example of the MP15 in MP mode with the controller in a level paused state enacted by an MP30 meter.

Figure 4 MP15 Level Paused State (MP mode)

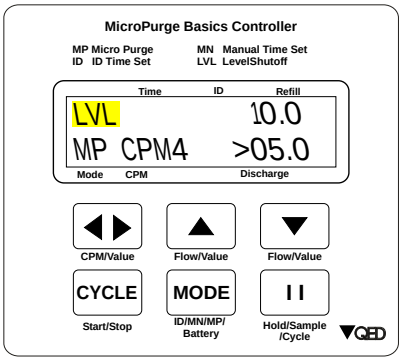


Figure 5 MP15 MP30 Use

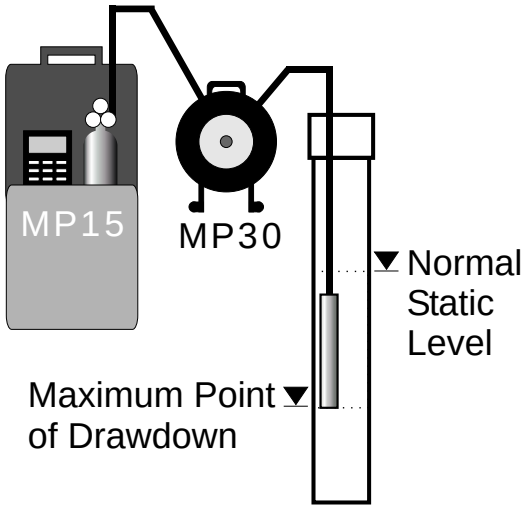
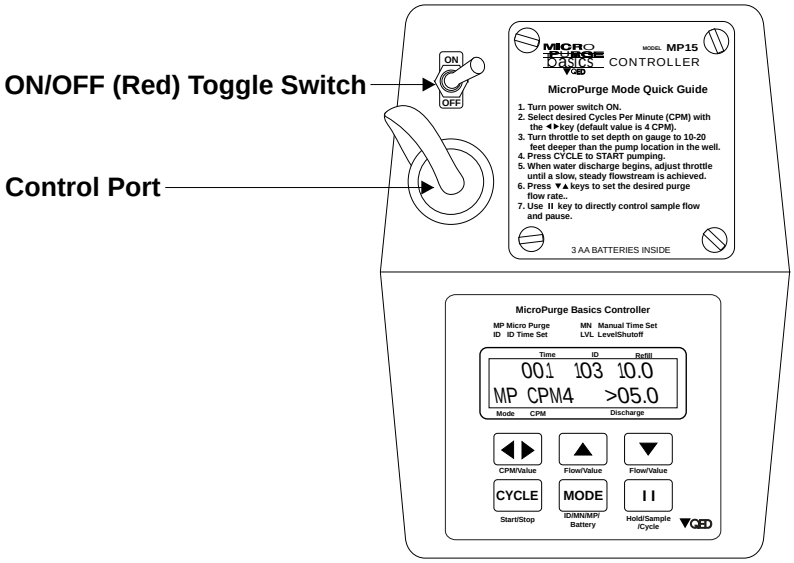


Figure 6 MP15 MP30 Use



OPERATION

The MP15 and MP30 are connected with a cable (see Figures 5 and 6). The MP30 is switched into "DRAWDOWN CONTROL" mode and the water level probe is lowered to the desired maximum drawdown level. Limiting the maximum drawdown depth limits the differential head driving flow into the well and the velocity of the water flowing into the well from the surrounding formation important in MicroPurge sampling. The MP15 and MP30 work together to automatically adjust the pump operation so as to maintain drawdown at the set level. When the water level drops below the probe, the MP30 sends a signal to the MP15 to pause pumping. Both the MP15 and the MP30 give visual signals (and the MP30 emits an audio signal) that pump operation has stopped because of too much drawdown. Once the level recovers, the MP30 signals the MP10 to resume pump operation. The MP15 resumes by starting in the refill leg of the pump cycle.

The normal operating mode for using the MP30 with the MP15 is:

1. Use the MP30 in standard WLM mode to determine the static water level in the well
2. Decide what the maximum drawdown for that well is during sampling
3. Lower the probe to the maximum drawdown level
4. Switch the MP30 into Drawdown Control mode
5. Begin pumping with the MP15
6. Observe the interactions between the two devices, if the MP30 is frequently pausing the MP15, it may be appropriate to slow the flow down (using the DOWN key in MP mode) to better match pump flow to well recharge.

When switched into "DRAWDOWN CONTROL" mode, the MP30 has a flashing red light and an optional (can be switched off by the user) audio alarm to indicate when the probe is in the dry state. A submerged probe in all modes is indicated by a solid green light. When the MP15 is paused by the MP30 the MP15 display indicates this as shown in Figure 4.

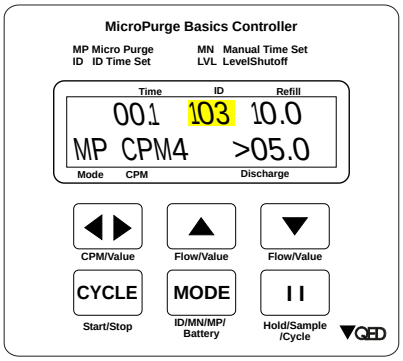
If the MP30 is signaling the MP15 too frequently, the operator can slow down the pump flow rate by using the DOWN key (effectively increasing the pump refill time period). MP30 probe position may also be varied to provide a buffer zone for your draw-down limit and gauge rate of pumping effect on water level in the well.

If the selected maximum drawdown level is being reached even with the lowest desirable pump flow rate more drawdown may be required to attain equilibration, or a passive sampling approach may be required. In passive sampling, used where well recovery is extremely slow, samples are taken after just a few pump strokes sufficient to purge the pump and tubing volumes.

Additional information on the MP30 is given in the MP30 O&M manual

ID Mode Figure 6 shows an example of the MP15 in ID time set mode. Once you use the MP10 in MP mode and found proper settings for your wells, subsequent sampling events are speeded along by using the controller in ID mode. Once the controller is turned on, a single press of the MODE key places the controller in ID time set mode (the default initial mode is MP mode). This mode allows the user to enter a 3-digit ID, which then is translated into the correct flow settings (CPM and refill / discharge time settings) for that well.

Figure 7 MP15 ID Set Mode

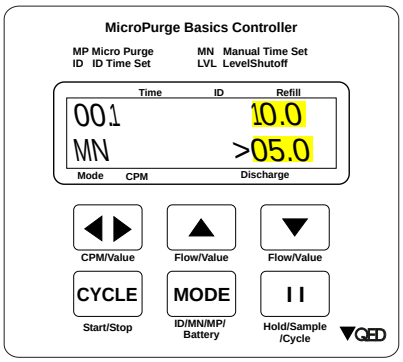


In this mode the CPM and UP, DOWN keys function differently. The CPM key becomes a key used to scroll between the one's and the ten's digits of the ID. The UP and DOWN keys are used to change the ID number (the MP15 has IDs that range from 1-165) up or down in value. Sampling in ID mode is the same as explained, above, for MP mode.

Appendix 1 lists all possible ID settings and the default refill and discharge time settings for each CPM. Appendix 1 also shows how the refill and discharge time will change within a CPM setting as you press the UP or DOWN keys. As you change IDs you will see the CPM change and the refill and discharge time setting change. *Note: changes in time settings that are entered while the controller is cycling are reflected on the next cycle change (so a long refill time of 15 seconds will time out before a new refill time becomes valid).*

User Set Mode A final controller mode, User Set mode (MN on the display), is useful for manually setting refill and discharge times on the controller as in traditional controllers (like previous model QED pump controllers). An example of the MP15 in User Set mode is shown in Figure 7. User set mode is also used when the wells being sampled are at extreme depths or there are other conditions where one of the 165 possible preset times of ID and MP modes will not match your needs. MN mode is entered when the MODE key is pressed twice from the default MP mode. As shown in Figure 7, the display indicates MN mode in the lower left corner and CPM and ID are not displayed.

Figure 8 MP15 User Set Mode (MN mode)



In User Set mode the CPM and UP, DOWN keys function differently than MP mode. The CPM key becomes a key used to select the digits of the refill and discharge time settings found at the rightmost positions on the display. The UP and DOWN keys are used to adjust the digit value up or down. By selecting and adjusting digits up and down a user can quickly set any time from 00.1 seconds to 99.9 seconds. Sampling in User Set mode is the same as explained, above, for MP mode.

The MP15 does not attempt to translate a user set time into a corresponding ID or CPM. Also, any settings you have entered in MP or ID modes are lost once you press the MODE key to enter MN mode. *Note: changes in time settings that are entered while the controller is cycling are reflected on the next cycle change (so a long refill time of 15 seconds will time out before a new refill time becomes valid).*

MP15 Battery - The MP15 features sophisticated power-supply circuitry that optimizes battery life. A fresh set of AA batteries will provide more than 100 hours of controller operation at normal operating temperatures. As ambient temperatures drop below 15-20F (-9C to -6C), the ability of the alkaline batteries to deliver energy is affected. Continuous operation may be difficult in extremely cold conditions. Once the batteries and MP15 warm, additional cycle capacity will be regained from a set of batteries. drop below 15-20F (-9C to -6C), the ability of the alkaline batteries to deliver energy is affected. Continuous operation may be difficult in extremely cold conditions. Once the batteries and MP15 warm, additional cycle capacity will be regained from a set of batteries.

Replace alkaline batteries by removing the 4 thumbscrews located on the battery cover and inserting 3 fresh cells. The MP15 battery holder includes space for **3 spare AA cells** so you should never be without power in the field. Properly dispose of the spent alkaline cells.

Note: If you are storing the MP15 for more than 3 months, remove the AA batteries to prevent leakage. The MP15 power supply is automatically shut off by closing the lid. Make sure the lid is closed during storage

OPERATION

MP15 CO2 Cylinder Capacity- The CO2 cylinder on the MP15 Control & Power Pack is intended to provide a versatile combination of portability and operating capacity. The chart below shows the continuous operating times that can be expected for the conditions shown, which are influenced most by pump depth and secondarily by liquid flow rate. The actual number of wells which can be purged and sampled with a single charge of the CO2 cylinder will depend on the purge and sample procedures followed at each well. Actual initial charge level, ambient temperature and the volume of the air hose and tubing will also affect CO2 consumption and capacity, (**see Appendix 2 / Page 25**).

Troubleshooting

Use the following troubleshooting table to assist in troubleshooting the MP15:

Symptom	Possible Cause	Action / Fix
Display not showing	Low or dead batteries Batteries installed wrong	Check battery voltage on opening display (>3.6 volts required) Replace batteries Check battery connection
Controller not cycling	Low or dead batteries	See, above
	Lid not open	Open lid
	Temperature below 10F	Warm controller
	MP15 not STARTED with CYCLE key MP15 in HELD mode	Operate CYCLE and/or PAUSE key to return MP15 to cycling state
	MP15 in LEVEL hold	Make sure MP30 probe is submerged when in MP mode
Air not cycling through controller	Throttle turned too low	Turn throttle clock-wise to produce pressure
	Air source not delivering air	Verify air source
Pump not pumping	Throttle turned too low	Turn throttle clock-wise to produce pressure
	Time settings not correct	Try different CPM settings (lower CPM for deeper wells) and/or different refill and discharge time settings
	Air source pressure too low	Verify air source pressure
Battery life too short	Controller left on while strored	Turn MP15 off before storing and remove batteries when storing more than 1 month
	Temperature below 10F	Warm controller

SPECIFICATIONS

MP15 Specifications

Temperature Range:	Operating range of -20F to 150F
Humidity:	Circuitry sealed to provide operation to 100% humidity
Protection:	Circuitry protected against transient surges introduced from improper battery installation or switch connections.
Display:	LCD display, 32-character (2 lines, 16 characters, each)
Window:	Non-glare, double hardened optical acrylic
Battery type:	Sealed NiCd battery pack and 3, user replaceable, AA alkaline cells
Expected NiCd life:	Worst case > 6 years, unit still operational with AA cells
NiCd capacity:	3.6Vdc @600 mA-hr
Drain:	**Unit off:** 2mA **Unit on:** 4mA **Valve Cycle:** 6mA
Reserve:	100 hours operating time (1sec/1sec cycles) with fresh AA alkaline cells At 65F (approx.)
Emergency battery:	3 AA cells stored within battery compartment and optional connection cabling.

For additional assistance contact QED Service at:

Phone:	1-800-624-2026 1-734-995-2547
Fax:	1-734-995-1170
E-mail:	service@qedenv.com
24-Hour Service Hot Line:	1-800-272-9559

QED Monitoring System WARRANTY

QED ENVIRONMENTAL SYSTEMS, INC. ("QED") warrants to the original purchaser of its products that, subject to the limitations and conditions provided below, the products, materials and/or workmanship shall reasonably conform to descriptions of the products and shall be free of defects in materials and workmanship. Any failure of the products to conform to this warranty will be remedied by QED in the manner provided herein.

This warranty shall be limited to the duration and the conditions set forth below. Warranty duration is calculated from the original date of purchase.

1. Dedicated-Use System Products 10-year warranty on dedicated bladder pumps equipped with QED inlet screens, and purge pumps used in periodic, non-continuous groundwater sampling (up to 52 samples events per year.) All other components, equipment and accessories are warranted for one year.

2. Portable-Use Systems - Controllers and Water Level Meters are warranted for one year. Hose reels, pumps
   and caps are warranted for ninety (90) days. Tubing and Purge Mizers are covered by a ninety-(90) day material and workmanship warranty. There will be no warranty for application on tubing and Purge Mizers when used as part of a Portable System.

3. Separately Sold Parts and Spare Parts Kit - Separately sold parts and spare parts are warranted for ninety (90) days. Repairs performed by QED are warranted for ninety (90) days from date of repair or for the full term of the original warranty, whichever is longer.

Buyers' exclusive remedy for breach of said warranty shall be as follows: if, and only if, QED is notified in writing within the applicable warranty period of the existence of any such defect in the said products, and QED upon examination of any such defects, shall find the same to be within the term of and covered by the warranty running from QED to Buyer, QED will, at its option, as soon as reasonably possible, replace or repair any such product, without charge to Buyer. If QED for any reason, cannot repair a product covered hereby within four (4) weeks after receipt of the original Purchaser's/Buyer's notification of a warranty claim, then QED's sole responsibility shall be, at its option, either to replace the defective product with a comparable new unit at no charge to the Buyer, or to refund the full purchase price. In no event shall such allegedly defective products be returned to QED without its consent, and QED's obligations of repair, replacement or refund are conditioned upon the Buyer's return of the defective product to QED.

IN NO EVENT SHALL QED ENVIRONMENTAL SYSTEMS, INC. BE LIABLE FOR CONSEQUENTIAL OR INCIDENTAL DAMAGES FOR BREACH OF SAID WARRANTY.

The foregoing warranty does not apply to major sub-assemblies and other equipment, accessories, and parts manufactured by others, and such other parts, accessories, and equipment are subject only to the warranties, if any, supplied by the respective manufacturers. QED makes no warranty concerning products or accessories not manufactured by QED. In the event of failure of any such product accessory, QED will give reasonable assistance to Buyer in obtaining from the respective manufacturer whatever adjustments is reasonable in light of the manufacturer's own warranty.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED OR STATUTORY (INCLUDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE). WHICH OTHER WARRANTIES ARE EXPRESSLY EXCLUDED HEREBY, and of any other obligations or liabilities on the part of QED, and QED neither assumes nor authorizes any person to assume for it any other obligation or liability in connection with the said products, materials and/or workmanship.

It is understood and agreed that QED shall in no event be liable for incidental or consequential damages resulting from its breach of any of the terms of this agreement, not for special damages, nor for improper selection of any product described or referred to for a particular application.

This warranty will be void in the event of unauthorized disassembly of component assemblies. Defects in any equipment that result from abuse, operation in any manner outside the recommended procedures, use and applications other than for intended use, or exposure to chemical or physical environmental beyond the designated limits of materials and construction will also void this warranty. QED shall be released from all obligations under all warranties if any product covered hereby is repaired or modified by persons other than QED's service personnel unless such repair by others is made with the written consent of QED.

WARRANTY

This warranty will be void in the event of unauthorized disassembly of component assemblies. Defects in any equipment that result from abuse, operation in any manner outside the recommended procedures, use and applications other than for intended use, or exposure to chemical or physical environmental beyond the designated limits of materials and construction will also void this warranty. QED shall be released from all obligations under all warranties if any product covered hereby is repaired or modified by persons other than QED's service personnel unless such repair by others is made with the written consent of QED.

If any product covered hereby is actually defective within the terms of this warranty, Purchaser must contact QED for determination of warranty coverage. If the return of a component is determined to be necessary, QED will authorize the return of the component, at owner's expense. If the product proves not be defective within the terms of this warranty, then all costs and expenses in connection with the processing of the Purchaser's \ claim and all costs for repair, parts and labor as authorized by owner hereunder shall be borne by the Purchaser.

RESPONSIBILITY OF THE PURCHASER

The original Purchaser's sole responsibility in the instance of a warranty claim shall be to notify QED of the defect, malfunction, or other manner in which the terms of this warranty are believed to be violated. You may secure performance of obligations hereunder by contacting the Customer Service Department of QED and:

1. Identifying the product involved (by model or serial number or other sufficient description that will allow QED to determine which product is defective).

2. Specifying where, when, and from whom the product was purchased.

3. Describing the nature of the defect or malfunction covered by this warranty.

4. Sending the malfunction component, after authorization by QED to:

QED Environmental Systems Inc.
6155 Jackson Road
Ann Arbor, MI 48103
(800) 624-2026
(734) 995-2547
www.qedenv.com
info@qedenv.com

Appendix 1 ID Data Table

NOTE: Bold Shaded values are default for that CPM

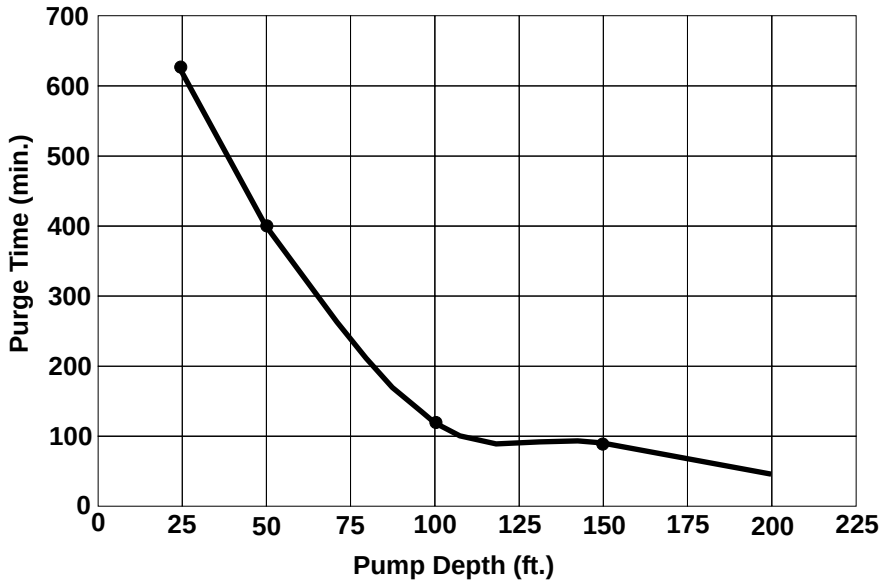
CYCLES / min (CPM)																	
1 / min			2 / min			3 / min			4 / min			5 / min			6 / min		
ID	Disch (sec)	Refill (sec)	ID	Disch (sec)	Refill (sec)	ID	Disch (sec)	Refill (sec)	ID	Disch (sec)	Refill (sec)	ID	Disch (sec)	Refill (sec)	ID	Disch (sec)	Refill (sec)
1	1	59	41	1	29	66	1	19	95	1	14	114	1	11	145	1	9
2	2	58	42	2	28	67	1.5	18.5	96	1.5	13.5	115	1.2	10.8	146	1.2	8.8
3	3	57	43	3	27	68	2	18	97	2	13	116	1.4	10.6	147	1.4	8.6
4	4	56	44	4	26	69	2.5	17.5	98	2.5	12.5	117	1.6	10.4	148	1.6	8.4
5	5	55	45	5	25	70	3	17	99	3	12	118	1.8	10.2	149	1.8	8.2
6	6	54	46	6	24	71	3.5	16.5	100	3.5	11.5	119	2	10	150	2	8
7	7	53	47	7	23	72	4	16	101	4	11	120	2.2	9.8	151	2.2	7.8
8	8	52	48	8	22	73	4.5	15.5	102	4.5	10.5	121	2.4	9.6	152	2.4	7.6
9	9	52	49	9	21	74	5	15	103	5	10	122	2.6	9.4	153	2.6	7.4
10	10	50	50	10	20	75	5.5	14.5	104	5.5	9.5	123	2.8	9.2	154	2.8	7.2
11	11	49	51	11	19	76	6	14	105	6	9	124	3	9	155	3	7
12	12	48	52	12	18	77	6.5	13.5	106	6.5	8.5	125	3.2	8.8	156	3.2	6.8
13	13	47	53	13	17	78	7	13	107	7	8	126	3.4	8.6	157	3.4	6.6
14	14	46	54	14	16	79	7.5	12.5	108	7.5	7.5	127	3.6	8.4	158	3.6	6.4
15	15	45	55	15	15	80	8	12	109	8	7	128	3.8	8.2	159	3.8	6.2
16	16	44	56	16	14	81	8.5	11.5	110	8.5	6.5	129	4	8	160	4	6
17	17	43	57	17	13	82	9	11	111	9	6	130	4.2	7.8	161	4.2	5.8
18	18	42	58	18	12	83	9.5	10.5	112	9.5	5.5	131	4.4	7.6	162	4.4	5.6
19	19	41	59	19	11	84	10	10	113	10	5	132	4.6	7.4	163	4.6	5.4
20	20	40	60	20	10	85	10.5	9.5				133	4.8	7.2	164	4.8	5.2
21	21	39	61	21	9	86	11	9				134	5	7	165	5	5
22	22	38	62	22	8	87	11.5	8.5				135	5.2	6.8			
23	23	37	63	23	7	88	12	8				136	5.4	6.6			
24	24	36	64	24	6	89	12.5	7.5				137	5.6	6.4			
25	25	35	65	25	5	90	13	7				138	5.8	6.2			
26	26	34				91	13.5	6.5				139	6	6			
27	27	33				92	14	6				140	6.2	5.8			
28	28	32				93	14.5	5.5				141	6.4	5.6			
29	29	31				94	15	5				142	6.6	5.4			
30	30	30										143	6.8	5.2			
31	31	29										144	7	5			
32	32	28															
33	33	27															
34	34	26															
35	35	25															
36	36	24															
37	37	23															
38	38	22															
39	39	21															
40	40	20															

APPENDIX 2

MP15 Purge Capacity*

Pump Depth (ft.)	Purge Time (min.)
50	400
100	120
150	90
200	50

*Purge times based on 200 ml/min flow rate,full 5 LB. CO2 cylinder: consult QED for more detail.



Equipment SOP - 4

Sample Pro ¾" Portable Micro Purge Pump

Sample Pro

Portable MicroPurge® Pumps PATENT PENDING QED

Sample Pro 3/4" Portable MicroPurge Pump

User's Guide

P/N 95192 REV. 1-28-03

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Introduction

The Sample Pro 3/4” Portable MicroPurge® Pump, (Figure 1) is the first pump designed specifically to meet the practical needs of sampling small diameter wells: easy to adjust to low-flow purging rates and easy to decontaminate between sampling points. Decon is made easier by the pump having fewer parts, disassembly without tools, and quick-change, disposable bladders. The Portable MicroPurge Pump is compact and can pump from a 5-gallon bucket. The pump is operated by compressed gas and a bladder pump control unit, and is ideally used with the MicroPurge **basics** models MP10 and MP15 controllers. The compressed gas is on the outside of the bladder and the pumped liquid is on the inside of the bladder, so there is no contact between the sample and the gas.

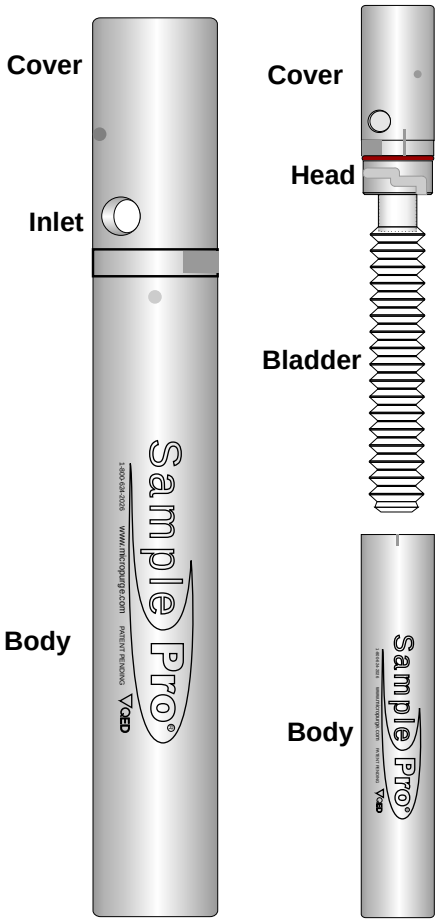


Figure 1

Description

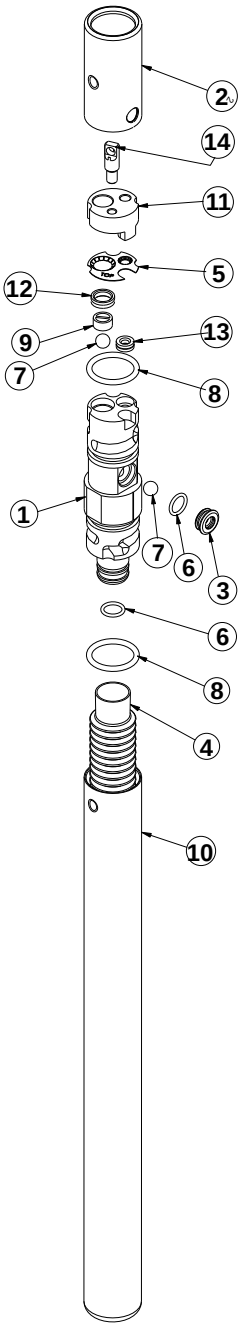
Figure 2 (Page 3) shows the main components of the Portable MicroPurge Pump and the assembled pump. The body twists off for quick change of the disposable polyethylene (PE) bladder. The bladder simply pushes on to provide a leak-tight seal for most applications without the use of clamps.

The cap of the pump twists off for full disassembly of the inlet and outlet check valves and the tubing connection components.

The pump uses 1/8” O.D. tubing for compressed gas supply and 1/4” O.D. tubing for the sample discharge. Tubing connections to the pump are made via push-in fittings built into the top of the pump.

The push-in connections provide excellent pull out strength when used with QED tubing, so that use of a support cable is not required. However a connection eye is provided on the top of the pump and tubing for use of a cable when preferred. The connection eye is threaded into the top plate of the pump and can easily be removed or reinstalled as desired. ***The push-in fittings on the SamplePro pump are designed to provide at least 25 lbs. combined pullout strength when used with QED tubing. QED is not responsible for loss of the pump if non-QED tubing is used.***

FIGURE 2



Item No.	QTY	Part No.	Description
1	1	38437EP	Head
2	1	38434EP	Cover
3	1	38439EP	Inlet
4	1	38424	Bladder PE
5	1	38436	Grab Plate 1/4” Tube x 1/8” Tube
6	3	38470	O-Ring, Viton
7	2	38471	Ball, Teflon
8	2	35172	O-Ring, Viton
9	1	38438EP	Ball Stop
10	1	38440EP	Body
11	1	38435	Plate 1/4” Tube x 1/8” Tube
12	1	38677	Seal Discharge
13	1	38676	Seal Air Supply
14	1	38833	3/4 Sample Pro Eye Bolt

Assembly

Use Figure 2, (Page 3) to identify main pump components and Figure 3, (below) to identify O-ring locations. Detailed exploded view drawing of the upper end of the pump are shown on pages 7 and 8.

1. See **F**igure 3 (below) to identify locations where O-rings are to be installed and install all O-rings.
2. Connect the bladder to the pump head. The PE bladder pushes onto the pump head barb until the bladder fully covers the barb.
3. Attach the pump head to the body by engaging the bayonet dimples into the grooves and twisting them together until the engagement snap is felt and head and body alignment marks line up.
4. With the pump on its side, insert the inlet check ball (same as the discharge check ball) into the side of the pump head, then press in the inlet valve seat by pushing with your thumb. Pre-wetting the parts with distilled water is recommended to aid assembly.
5. With the pump vertical, insert the discharge check ball into the top of the pump head, place the discharge ball stop into place above the check ball, using the supplied needle nose pliers, see Figure 5, (Page 6).
6. For the push-in tubing fittings, place the thin metal lock disk in the "TOP" up position on the top of the pump head, with the lock disk edge slots lined up with the posts on the pump head. Then place the thick, upper plate on top of the lock disk, again with the slots and posts lined up. Finally, twist the pump cap onto the pump head until the engagement snap is felt and the hole in the side of the pump cap lines up with the inlet port. Cover and body alignment marks will line up.

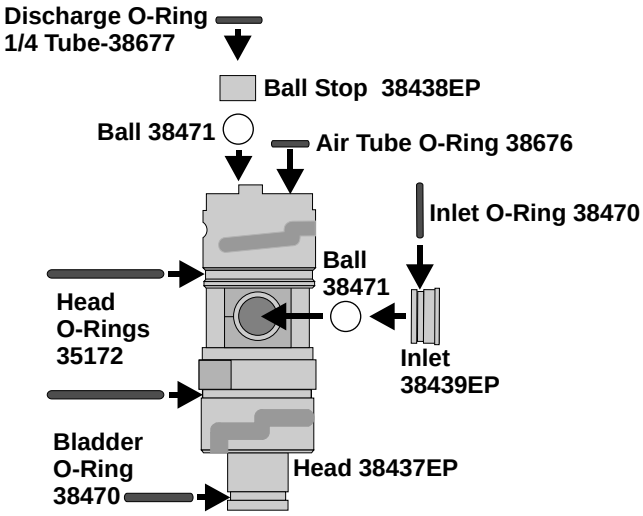


Figure 3

Attaching Tubing

A tubing insertion tool is provided to make the small-diameter tubing used on this pump easier to grip and push into the pump. The tool is shown in Figure 4.

1. Cut both tubes to equal length; cutting the tubes at a slight angle will make insertion easier.
2. Grip the ¼” tube **ONLY** in the large groove in the insertion tool, leaving ¾-1” of tubing extending from the end of the gripping jaw.
3. Hold the insertion tool at the jaw end of the tool, **FORWARD** of the tool’s pivot point, squeezing the jaws together.
4. Push the ¼” tube into the pump while rocking the tool slightly. Watch and feel for the tube to push ¼” past the point of initial resistance into the pump.
5. Pull back on the tube to check that it is inserted firmly.
6. Repeat for the 1/8” air tube.

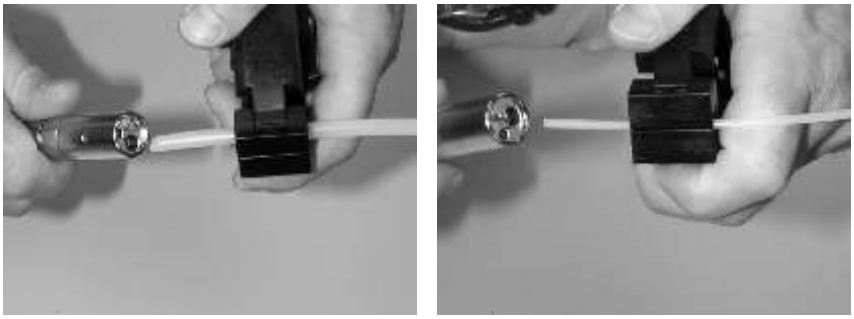


Figure 4

Disassembly

Use Figure 2, (Page 3) to identify main pump components and Figure 3, (Page 4) to identify O-ring locations.

1. Reverse assembly sequence, taking care to position pump to retain check balls during removal of valve seats and stops. A screwdriver can be used if necessary to remove the inlet valve seat.
2. Pull the PE bladder off of the pump head barb by pulling firmly, then discard.

Cleaning / Decontamination Note

If it is desired to operate the pump outside the well, such as in a pail for decontamination purposes, the operating pressure of the pump should be reduced to 35 PSI or less to avoid rupturing the bladder

Using the Supplied Needlenose Pliers for Assembly/Disassembly

Needlenose pliers are provided to make handling of certain smaller parts easier to handle during cleaning assembly and disassembly. **Figures 5** demonstrates placement of the check ball stop into the pump head**.**

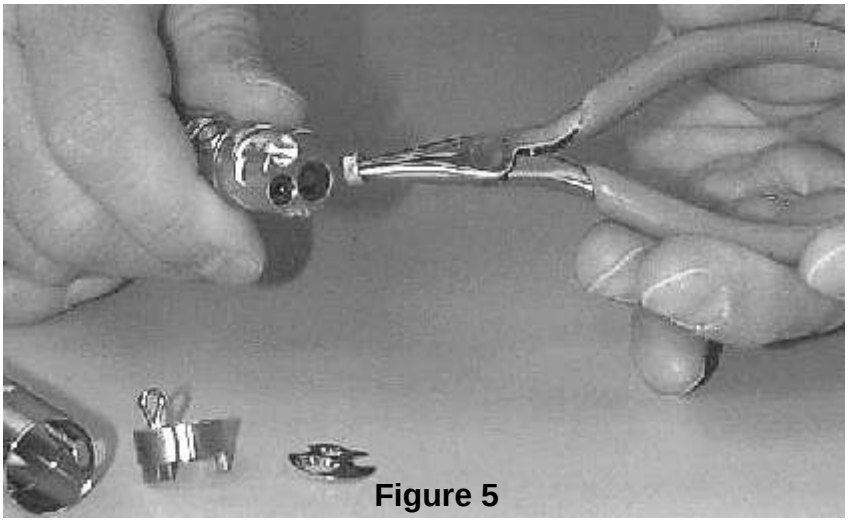
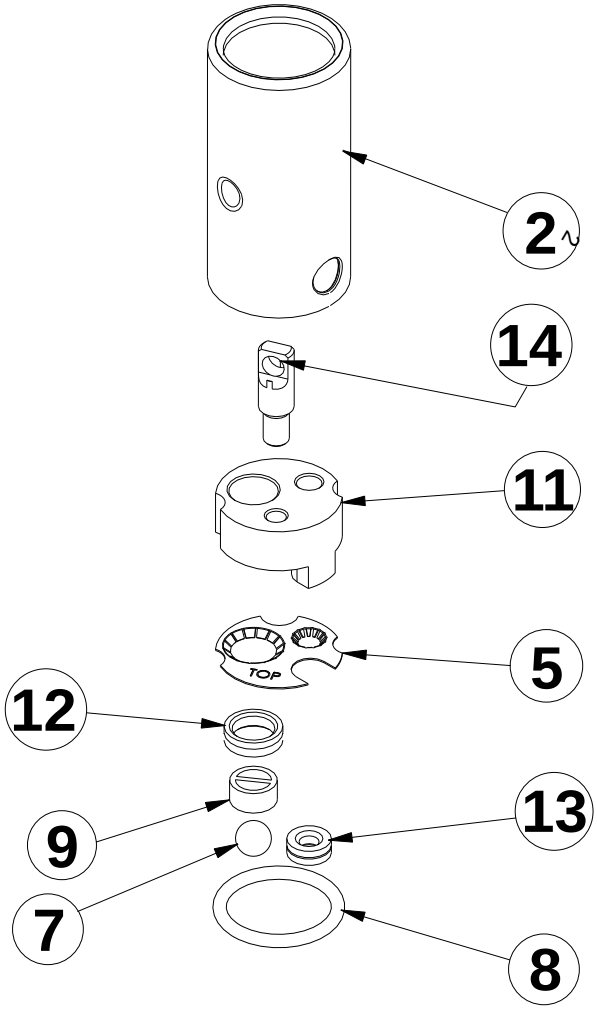
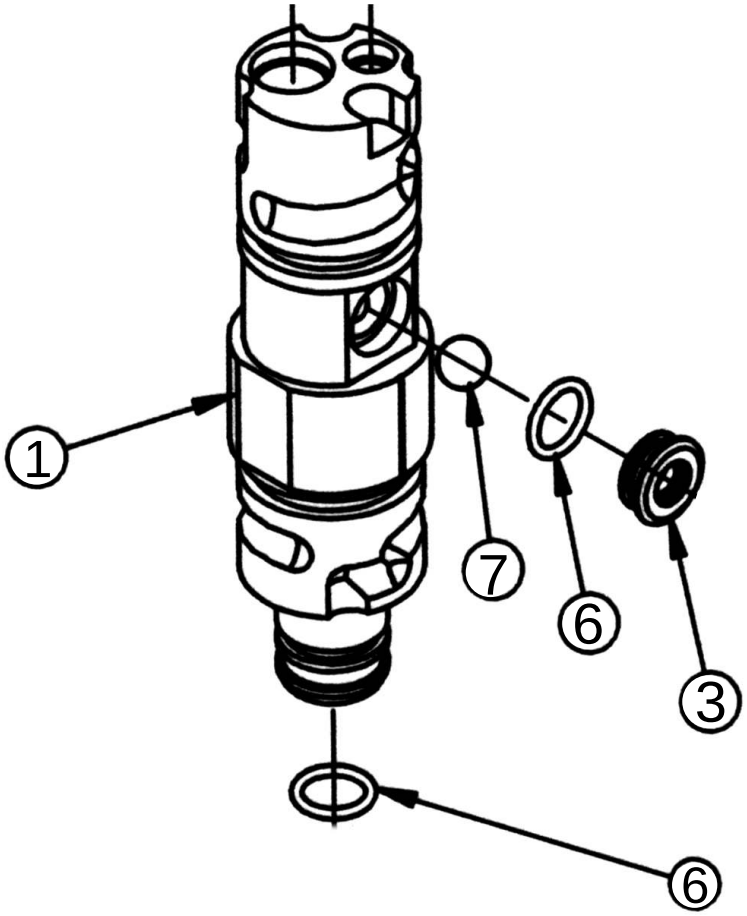


Figure 5



Item No.	QTY	Part No.	Description
2	1	38434EP	Cover
5	1	38436	Grab Plate 1/4” Tube x 1/8” Tube
7	1	38471	Ball, Teflon
8	1	35172	O-Ring, Viton
9	1	38438EP	Ball Stop
11	1	38435	Plate
12	1	38677	Seal Discharge
13	1	38676	Seal Air Supply
14	1	38833	3/4 Sample Pro Eye Bolt

FIGURE 7

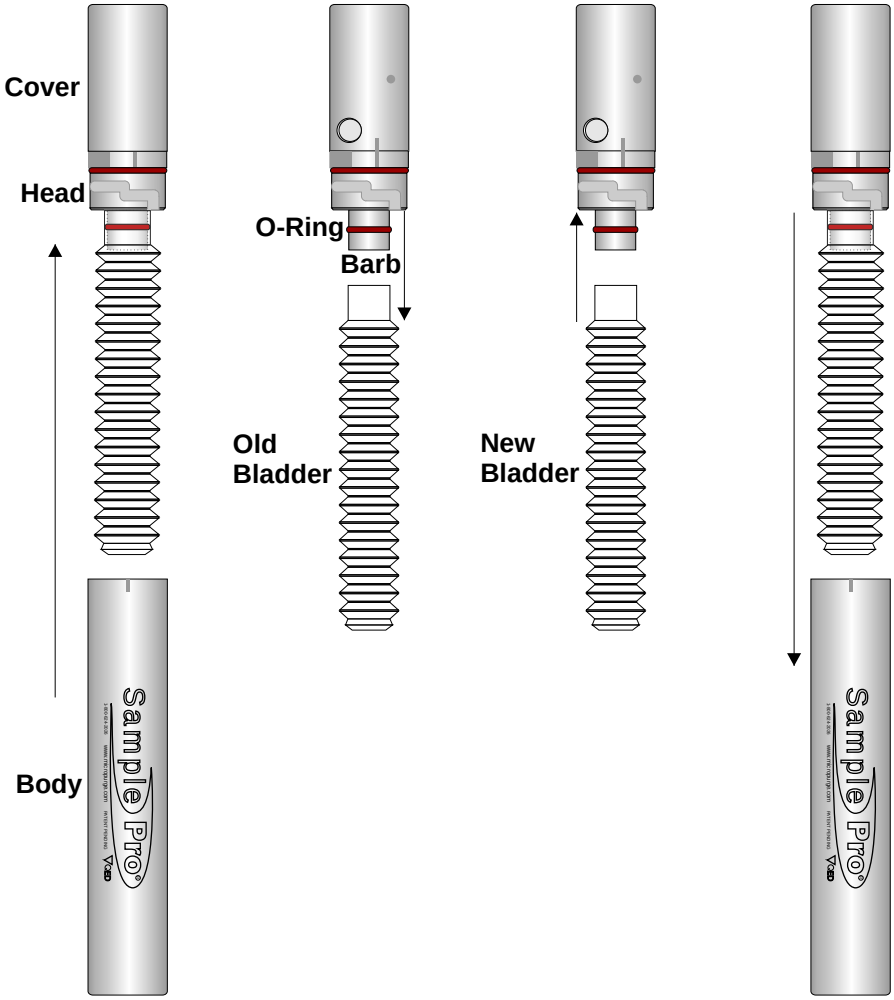


Item No.	QTY	Part No.	Description
1	1	38437EP	Head
3	1	38439EP	Inlet
6	2	38470	O-Ring, Viton
7	1	38471	Ball, Teflon

BLADDER REPLACEMENT

1. Pull bladder down to remove it from the pump head.
2. Inspect the condition of the barb o-ring and replace it if necessary. Failure of this o-ring could cause the water sample to be contaminated by pump drive air.
3. Install the new bladder by pushing it onto the pump head barb until the bladder fully covers the barb, making sure the barb o-ring does not roll out of its groove.

NOTE: For reasons of contamination and leak integrity, these bladders are designed for one-time use only. QED cannot be held responsible for cross contamination or leakage failures if bladders are reused.



SPECIFICATIONS

Materials:

Body - 303 stainless steel
Inlet & Discharge Housing - 303 Stainless Steel
Bladder - Polyethylene
O-rings - Viton

Fittings:

Push-in Type
Air - 1/8" (3.2 mm) O.D.
Discharge - 1/4" (6.4 mm) O.D., 3/16" (4.7 mm) I.D.

Maximum Lift: 200 Feet (61 m)

Pump Volume: .33 Ounces (10 Milliliters)

For additional assistance contact QED Service at:

Phone: 1-800-624-2026 1-734-995-2547
Fax: 1-734-995-1170
E-mail: service@qedenv.com
24-Hour Service Hot Line: 1-800-272-9559

IMPORTANT WARRANTY NOTE

The push-in and compression fittings and tubing on the SamplePro pump are designed to provide at least 25 lbs. combined pullout strength when used with QED tubing. QED is not responsible for loss of the pump if non-QED tubing is used. Re-use of the lock plate or old tube end and/or use of other brands of tubing may significantly reduce pull-out strength and cause loss of pump in the well.

QED ENVIRONMENTAL SYSTEMS, INC. ("Q.E.D.") warrants to the original purchaser of its products that, subject to the limitations and conditions provided below, the products, materials and/or workmanship shall reasonably conform to descriptions of the products and shall be free of defects in materials and workmanship. Any failure of the products to conform to this warranty will be remedied by Q.E.D. in the manner provided herein.

This warranty shall be limited to the duration and the conditions set forth below. All warranty durations are calculated from the original date of purchase.

1. Dedicated-Use Systems Products- 10 year warranty on dedicated bladder pumps equipped with Q.E.D. inlet screens, and purge pumps used in periodic, non continuous groundwater sampling (up to 52 sampling events per year.) All other components, equipment and accessories are warranted for one year.

2. Portable-Use Systems- Pumps, Controllers and water level meters are warranted for one year. Hose reels and Caps are warranted for ninety (90) days. Tubing and Purge Mizers are covered by a ninety (90) day material and workmanship warranty. There will be no warranty for application on tubing and Purge Mizers when used as part of a Portable System.

3. Separately sold parts and Spare Parts Kits- Separately sold parts and spare parts kits are warranted for ninety (90) days. Repairs performed by Q.E.D. are warranted for ninety (90) days from date of repair or for the full term of the original warranty, whichever is longer.

Buyers' exclusive remedy for breach of said warranty shall be as follows:if, and only if, Q.E.D. is notified in writing within applicable warranty period of the existence of any such defect in the said products, and Q.E.D. upon examination of any such defects, shall find the same to be within the term of and covered by the warranty running from Q.E.D. to Buyer, Q.E.D. will, at its option, as soon as reasonably possible, replace or repair any such product, without charge to Buyer. If Q.E.D. for any reason, cannot repair a product covered hereby within four (4) weeks after receipt of the original Purchaser's/Buyer's notification of a warranty claim, then Q.E.D.'s sole responsibility shall be, at its option, either to replace the defective product with a comparable new unit at no charge to the Buyer, or to refund the full purchase price. In no event shall such allegedly defective products be returned to Q.E.D. without its consent, and Q.E.D.'s obligations of repair, replacement or refund are conditioned upon the Buyer's return of the defective product to Q.E.D.

IN NO EVENT SHALL Q.E.D. ENVIRONMENTAL SYSTEMS, INC. BE LIABLE FOR CONSEQUENTIAL OR INCIDENTAL DAMAGES FOR BREACH OF SAID WARRANTY.

The foregoing warranty does not apply to major sub-assemblies and other equipment, accessories and parts manufactured by others, and such other parts, accessories, and equipment are subject only to the warranties, if any, supplied by the respective manufacturers. Q.E.D. makes no warranty concerning products or accessories not manufactured by Q.E.D. In the event of failure of any such product accessory, Q.E.D. will give reasonable assistance to the Buyer in obtaining from the respective manufacturer whatever adjustment is reasonable in light of the manufacturer's own warranty.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED OR STATUTORY (INCLDING BUT NOT LIMITED TO THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE), WHICH OTHER WARRANTIES ARE EXPRESSLY EXCLUDED HEREBY, and of any other obligations or liabilities on the part of Q.E.D.,neither assumes nor authorizes any person to assume for it any other obligation or liability in connection with said products, materials and/or workmanship.

It is understood and agreed that Q.E.D. shall in no event be liable for incidental or consequential damages resulting from its breach of any of the terms of this agreement, nor for special damages, nor for improper selection of any product described or referred to for a particular application.

This warranty will be void in the event of unauthorized disassembly of component assemblies. Defects in any equipment that result from abuse, operation in any manner outside the recommended procedures, use and applications other than for intended use, or exposure to chemical or physical environment beyond the designated limits of materials and construction will also void this warranty. Q.E.D. shall be released from all obligations under all warranties if any product covered hereby is repaired or modified by persons other than Q.E.D.'s service personnel unless such repair by others is made with the written consent of Q.E.D.

If any product covered hereby is actually defective within the terms of this warranty, Purchaser must contact Q.E.D. for determination of warranty coverage. If the return of a component is determined to be necessary, Q.E.D. will authorize the return of the component, at owner's expense. If the productproves not to be defective within the terms of this warranty, then all costs and expenses in connection with the processing of the Purchaser's claim and all costs for repair, parts and labor as authorized by owner hereunder shall be borne by the purchaser.

RESPONSIBILITY OF THE PURCHASER

The original Purchaser's sole responsibility in the instance of a warranty claim shall be to notify Q.E.D. of the defect, malfunction, or other manner in which the terms of this warranty are believed to be violated. You may secure performance of obligations hereunder by contacting the Customer Service Department of Q.E.D. and:

1. Identifying the product invovled (by model or serial number or other sufficent description that will allow Q.E.D. to determine which product is defective).
2. Specifying where, when, and from whom the product was purchased.
3. Describing the nature of the defect or malfunction covered by this warranty.
4. Sending the malfunctioning component, after authorization by Q.E.D. to:

QED Environmental Systems, Inc.
6155 Jackson Rd.
Ann Arbor, Michigan 48103

Equipment SOP – 5

Multi Water Quality Checker Model U-50 Series

Multi Water Quality Checker
U-50 Series

Instruction Manual

CODE:GZ0000144342C

Preface

This manual describes the operation of the Multi Water Quality Checker, U-50 Series.
Be sure to read this manual before using the product to ensure proper and safe operation of the instrument. Also safely store the manual so it is readily available whenever necessary.

Product specifications and appearance, as well as the contents of this manual are subject to change without notice.

■ Warranty and Responsibility

HORIBA warrants that the Product shall be free from defects in material and workmanship and agrees to repair or replace free of charge, at HORIBA's option, any malfunctioned or damaged Product attributable to HORIBA's responsibility for a period of one (1) year from the delivery unless otherwise agreed with a written agreement. In any one of the following cases, none of the warranties set forth herein shall be extended;

- Any malfunction or damage attributable to improper operation
- Any malfunction attributable to repair or modification by any person not authorized by HORIBA
- Any malfunction or damage attributable to the use in an environment not specified in this manual
- Any malfunction or damage attributable to violation of the instructions in this manual or operations in the manner not specified in this manual
- Any malfunction or damage attributable to any cause or causes beyond the reasonable control of HORIBA such as natural disasters
- Any deterioration in appearance attributable to corrosion, rust, and so on
- Replacement of consumables

HORIBA SHALL NOT BE LIABLE FOR ANY DAMAGES RESULTING FROM ANY MALFUNCTIONS OF THE PRODUCT, ANY ERASURE OF DATA, OR ANY OTHER USES OF THE PRODUCT.

■ Trademarks

Generally, company names and brand names are either registered trademarks or trademarks of the respective companies.

 © 2008 – 2009 HORIBA, Ltd.

Conformable Directive

This equipment conforms to the following directives and standards:

Directives: the EMC Directive 2004/108/EC

Standards: [the EMC Directive]
EN61326-1:2006 Class B, Portable test and measurement equipment

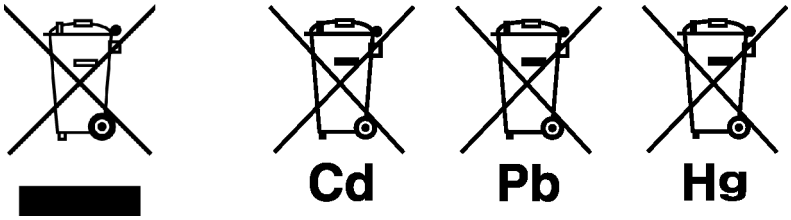
Information on Disposal of Electrical and Electronic Equipment and Disposal of Batteries and Accumulators

The crossed out wheeled bin symbol with underbar shown on the product or accompanying documents indicates the product requires appropriate treatment, collection and recycle for waste electrical and electronic equipment (WEEE) under the Directive 2002/96/EC, and/or waste batteries and accumulators under the Directive 2006/66/EC in the European Union.

The symbol might be put with one of the chemical symbols below. In this case, it satisfies the requirements of the Directive 2006/66/EC for the object chemical.

This product should not be disposed of as unsorted household waste.
Your correct disposal of WEEE, waste batteries and accumulators will contribute to reducing wasteful consumption of natural resources, and protecting human health and the environment from potential negative effects caused by hazardous substance in products.

Contact your supplier for information on applicable disposal methods.



FCC Rules

Any changes or modifications not expressly approved by the party responsible for compliance shall void the user's authority to operate the equipment.

WARNING

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.
Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

For your safety

Warning messages are described in the following manner. Read the messages and follow the instructions carefully.

● Meaning of warning messages

⚠ DANGER	This indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury. This signal word is to be limited to the most extreme situations.
⚠ WARNING	This indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
⚠ CAUTION	This indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury. It may also be used to alert against unsafe practices. Without safety alert indication of hazardous situation which, if not avoided, could result in property damage.

● Symbols

❗	Description of what should be done, or what should be followed
⃠	Description of what should never be done, or what is prohibited

■ Safety Precautions

This section provides precautions to enable you to use the product safely and correctly and to prevent injury and damage. The terms of DANGER, WARNING, and CAUTION indicate the degree of imminency and hazardous situation. Read the precautions carefully as it contains important safety messages.

⚠ WARNING
Do not disassemble or modify the meter. May cause overheating or fire, resulting in accidents.

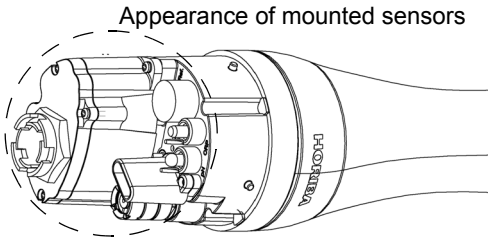
⚠ CAUTION
The pH and ORP sensors are made of glass. Handle them carefully to avoid breakage.
Do not ingest the DO, pH or ORP standard solutions. If it comes into contact with the eyes, rinse thoroughly with water. If swallowed, consult a physician.
Keep away from water when using USB communication. Improper use may result in fire or damage.

Points of concern

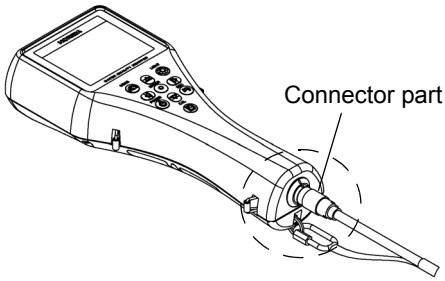
Use of the equipment in a manner not specified by the manufacturer may impair the protection provided by the equipment. It may also reduce equipment performance.

Sensor probe

- Do not immerse the sensor probe in seawater or other samples with high salinity. Doing so may erode metallic parts. After use, promptly wash the sensor probe thoroughly in water.
- Do not immerse the sensor probe in alcohol, organic solvent, strong acid, strong alkaline, and other similar solutions.
- Do not subject to strong shocks.
- Do not perform measurement in environments of magnetic fields. Measurement errors may result.
- The sensor probe is no longer waterproof when the sensors are not mounted.

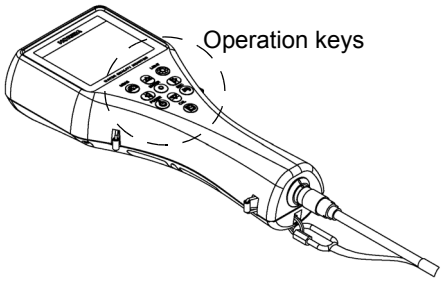


- Does not support measurement of samples containing fluorine.
- To disconnect the sensor cable or interface cable, pull them out with holding the connector part. Do not pull the cable part; it may cause breakage.



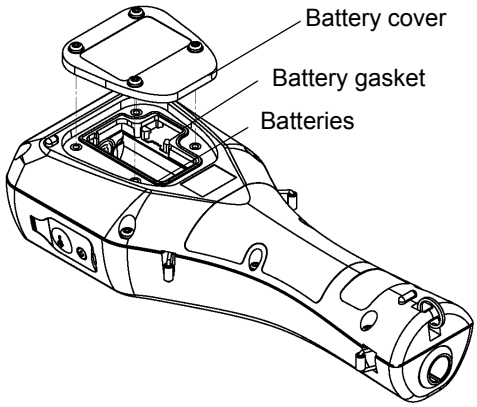
Control unit

- Do not subject to strong shocks.
- The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.



- The control unit is no longer waterproof when the USB cable is connected.
- When operating the control unit only, protect the connector with the connector cap provided.

- Remove the batteries when not using the control unit for an extended period of time. Battery fluid leakage may cause equipment failure.
- Do not wipe the control unit with organic solvents or powder polish. The surface may deteriorate or its printing may disappear. If the display becomes dirty, wipe the dirt off with a soft cloth soaked in neutral detergent.
- Do not turn the power OFF or disconnect the cable during calibration or setting. Memory data may be erased.
- To perform measurement, connect the sensor probe cable before turning the power ON.
- Do not remove the battery gasket or twist it.
- When opening the battery case, make sure that no foreign matter is attached to the battery gasket.
- Do not use any unspecified batteries; it may cause breakage.



Measurement

- Do not pull the cable when lowering the sensor probe into the sample during measurement. Lower the sensor probe into the sample on a chain or string.
- Before lowering the sensor probe into the sample, do not connect the hook on the unit to a human body.
- The correct values are not displayed if the sensor is not mounted when the measurement display is activated.
- Perform DO measurement with no air bubbles in the internal solution.
- Do not reuse a membrane cap of DO sensor.
- Use the spanner for DO sensor provided to attach or remove the DO sensor.
- Avoid both U-53 and U-53G turbidity measurement in air, since the rubber wiper will quickly become damaged.
- Avoid turbidity measurement in direct sunlight, since the readout may be affected.

Calibration

During atmosphere calibration for the DO electrode with DO salinity compensation set to automatic, values are compensated based on electrical conductivity, but calibration is performed normally.

Location of use and storage

- Storage temperature: −10°C to 60°C
- Relative humidity: Under 80% and free from condensation

Store the meter in locations void of dust, strong vibrations, direct sunlight, corrosive gases, near air conditioners or windy areas.

Disposal of the product

When disposing of the product, follow the related laws and/or regulations of your country for disposal of the product.

Description in this manual

Note

This interprets the necessary points for correct operation and notifies the important points for handling the unit.

Reference

This indicates where to refer for information.

Tip

This indicates reference information.

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1 About this Unit

The U-50 Series Multi Water Quality Checker features an integrated control unit and sensors. It is capable of making a maximum of eleven simultaneous measurements for various parameters, and is perfect for use in the field. The U-50 Series is designed with on-site ease-of-use in mind, provides a wide variety of functions, and can be used for water quality measurements and inspections of river water, groundwater, and waste water.

2 Device Information

2.1 Measurement parameters

Parameters	Model				
	U-51	U-52	U-52G	U-53	U-53G
pH (pH)	✓	✓	✓	✓	✓
pH (mV)	✓	✓	✓	✓	✓
Oxidation reduction potential (ORP)	✓	✓	✓	✓	✓
Dissolved oxygen (DO)	✓	✓	✓	✓	✓
Electrical conductivity (COND)	✓	✓	✓	✓	✓
Salinity (SAL) [expressed as electrical conductivity]	✓	✓	✓	✓	✓
Total dissolved solids (TDS) [expressed as electrical conductivity]	✓	✓	✓	✓	✓
Seawater specific gravity (SG) [expressed as electrical conductivity]	✓	✓	✓	✓	✓
Water temperature (TEMP)	✓	✓	✓	✓	✓
Turbidity (TURB) [LED transmission/front 30° scattering method]	–	✓	✓	–	–
Turbidity (TURB) [tungsten lamp 90° transmission/scattering method] with wiper	–	–	–	✓	✓
Water depth (DEP)	–	–	✓	✓	✓
GPS	–	–	✓	–	✓

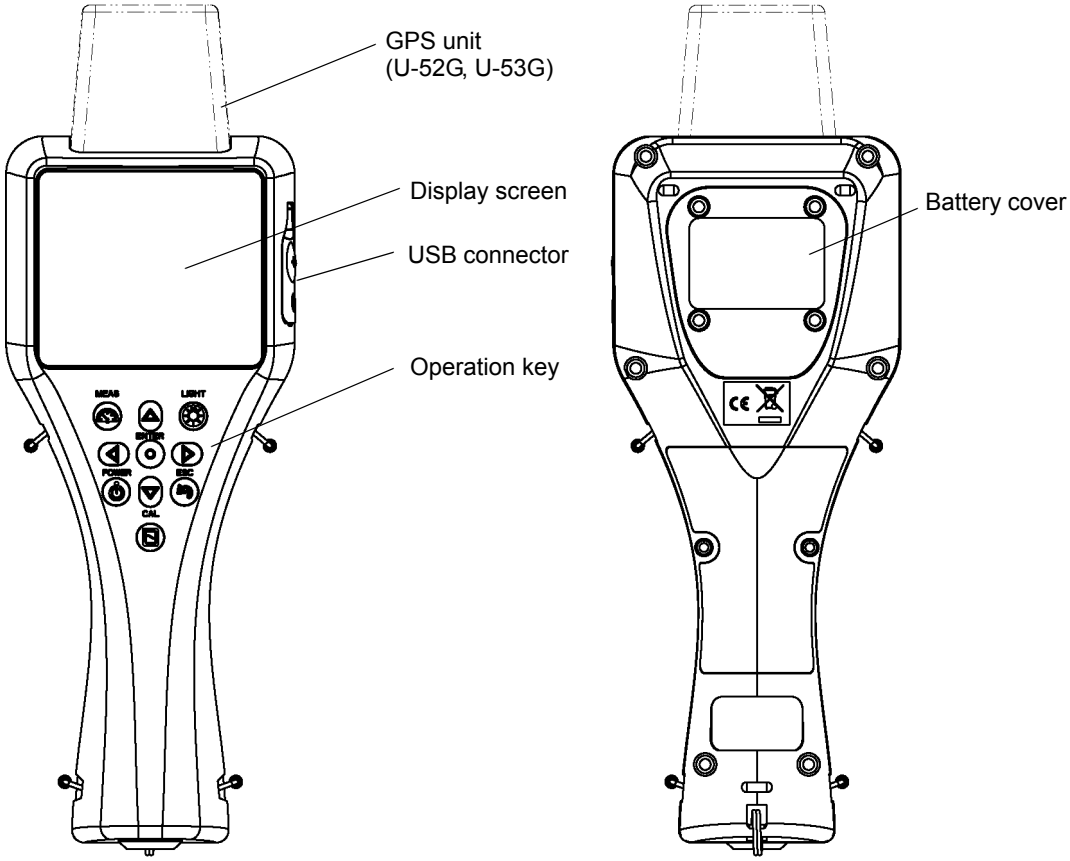
"✓" indicates a measurable parameter.

2.2 Packing list

Parts Name	Quantity	Note
Control unit	1	
Sensor probe	1	
pH sensor (#7112)	1	
ORP sensor (#7313)	1	
Reference electrode (#7210)	1	
DO sensor (#7543)	1	
Turbidity sensor (#7800)	1	With U-52/U-52G only. Attached to the sensor probe.
Turbidity sensor (#7801)	1	With U-53/U-53G only. Attached to the sensor probe.
pH 4 standard solution (#100-4)	1	500 mL
pH reference internal solution (#330)	1	250 mL
DO sensor internal solution set (#306)	1	Internal solution (50 mL), Sandpaper (#8000, #600), Syringe
DO Membrane spare parts set	1	
Spanner for DO sensor	1	
Cleaning brush	1	
calibration cup	1	transparent calibration cup, black calibration cup
Back pack	1	
Strap	1	
Alkaline batteries	4	LR14
Silicon grease	1	
Instruction manual	1	

2.3 Parts name and functions

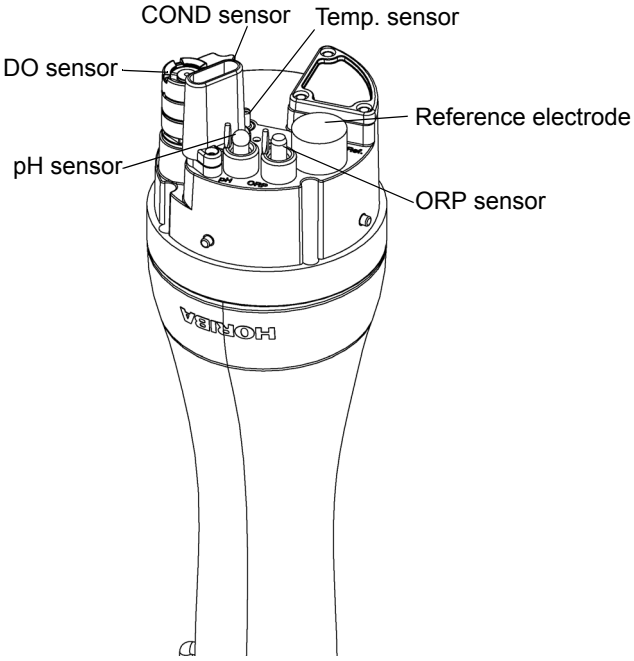
Display



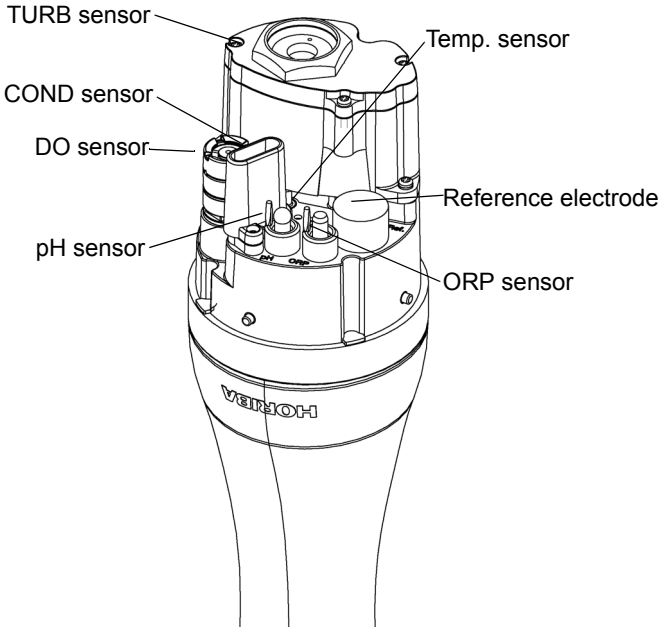
Front view

Back view

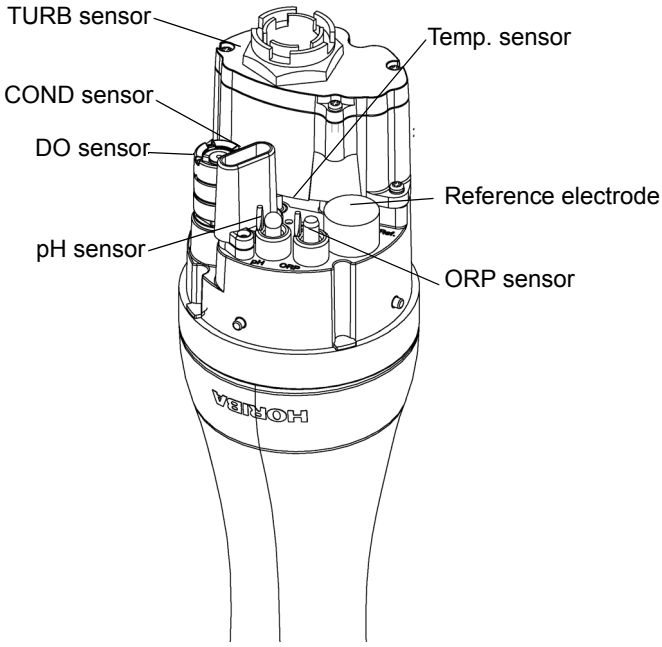
Sensor probe (U-51)



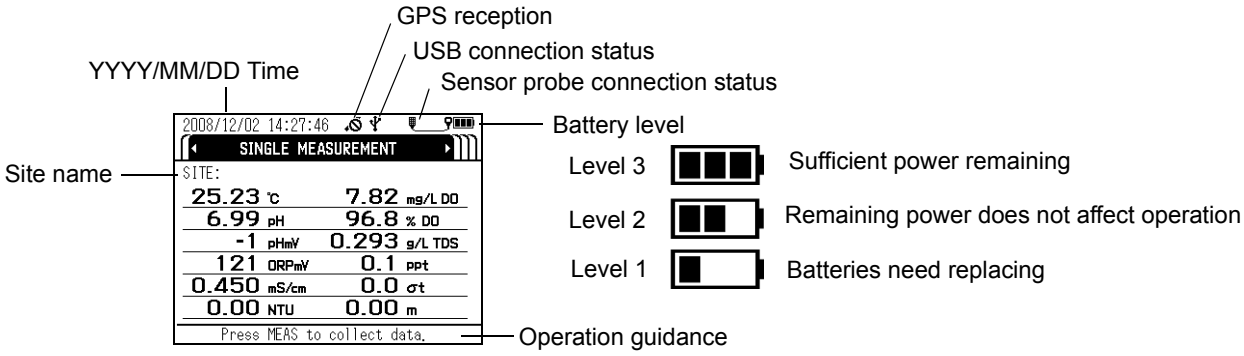
Sensor probe (U-52)



Sensor probe (U-53)



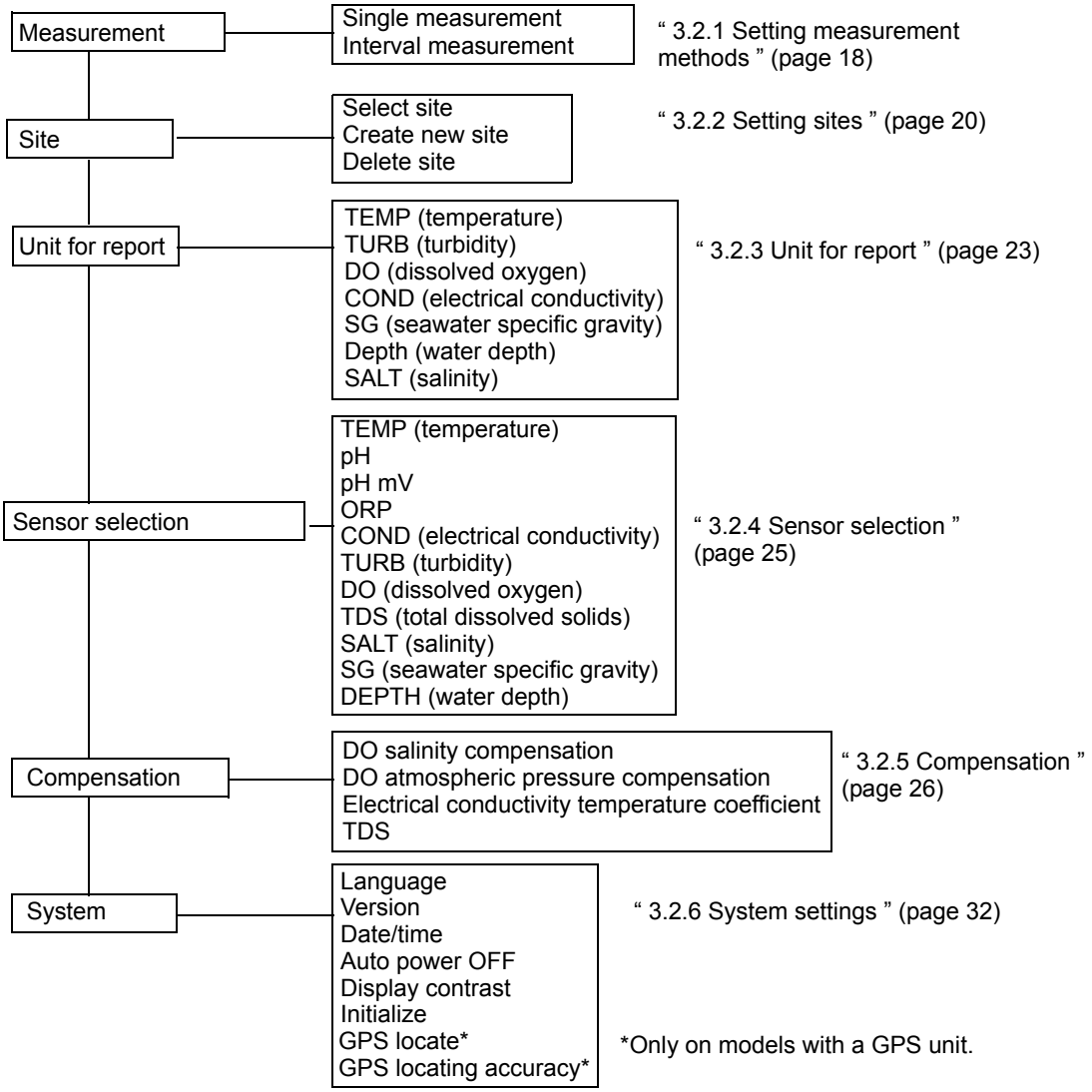
Display screen



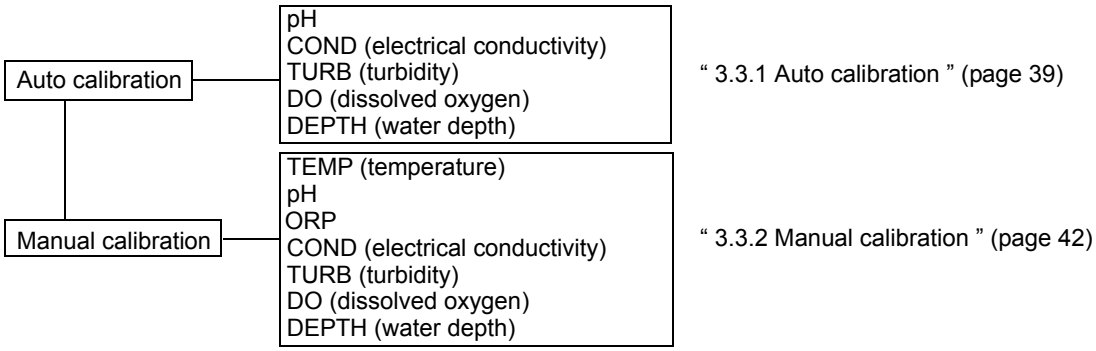
Operation key

	Key name	description
POWER	POWER key	Turns the system's power ON/OFF. The initial screen appears immediately after turning the power ON. Press and hold down the POWER key for about 3 seconds to turn the power ON and OFF.
MEAS	MEAS key	When pressed in the measurement screen, used to set the measurement values of all the measurement parameters. Measurement values flash until the data stabilizes.
		When pressed in the setting, calibration or data operation screen, returns to the measurement screen.
ENTER	ENTER key	Used to execute functions, set entered values or store data in memory.
CAL	CAL key	Switches to the calibration screen.
ESC	ESC key	Returns to the immediately preceding operation.
LIGHT	LIGHT key	Turns the backlight ON/OFF. ● Using the backlight shortens battery life. ● The backlight does not light for about 3 seconds after power ON. ● When the sensor probe is connected while the display's backlight is lit, the backlight goes out for about 3 seconds.
	Left key	Moves the cursor to the left.
	Right key	Moves the cursor to the right.
	Up key	Moves the cursor up.
	Down key	Moves the cursor down.

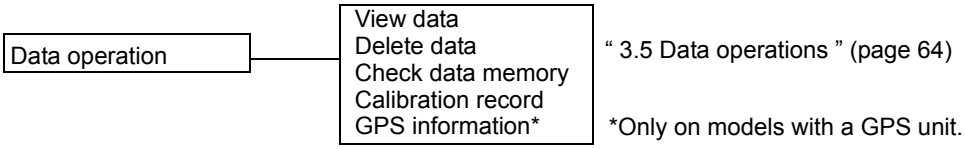
2.4 Setting menu items



2.5 Calibration menu items



2.6 Data operation menu items



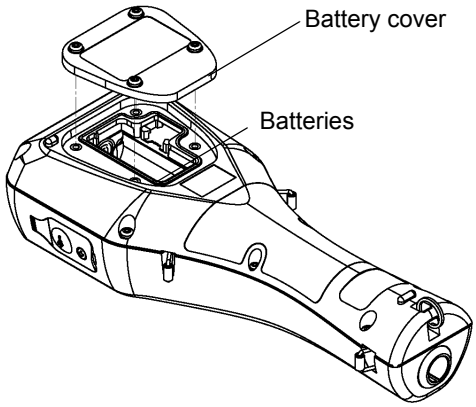
3 Basic Operation

3.1 System setup

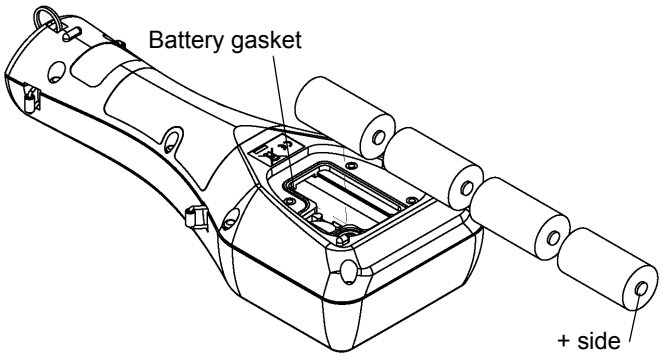
3.1.1 Inserting and replacing the batteries

The control unit is shipped without batteries. Follow the steps below to insert the batteries when using the system for the first time or replacing old batteries.

1. **Loosen the 4 screws on the battery cover by using No. 2 Phillips head screwdriver and remove the cover.**



2. **If replacing the batteries, discard the old batteries.**
3. **Insert new batteries in the control unit.**
   Check that the battery gasket is not dirty or twisted.



4. **Replace the battery cover and fasten it with the 4 screws.**
   Tighten the screws to less than 0.5 N·m.

Note

- **Data and settings will not be lost when the batteries are replaced.**
- **If dirty or twisted, the battery gasket will fail to keep the batteries dry. Check its condition before closing the cover.**
- **To ensure long service life, replacing the battery gasket periodically (once a year) is recommended.**

Precautions when using dry cell batteries

- **Batteries to use: LR14 alkaline dry cell batteries (C-size dry cell batteries) or rechargeable nickel-metal hydride dry cell batteries (C-size)**
  Do not use manganese batteries.
- **Dry cell batteries used incorrectly may leak or burst. Always observe the following**
  - Orient the batteries correctly (positive and negative ends in correct positions).
  - Do not combine new and used batteries, or batteries of different types.
  - Remove the batteries when not using the system for a prolonged period.
  - If batteries leak, have the system inspected at your nearest Horiba service station.

● Battery life

- The battery life for continuous operation when using C-size alkaline dry cell batteries is about 70 hours.
- Using the backlight consumes a proportionate amount of battery power, shortening battery life.
- Searching position information using the GPS unit consumes a proportionate amount of battery power, shortening battery life.
- Nickel-metal hydride secondary batteries can be used, but the battery life is not guaranteed since it will vary according to usage (number of times data is saved, number of charges and amount of each charge). In general, secondary batteries have one-half to one-third the life of C-size alkaline batteries.
- The 70-hour battery life figure applies to a control unit operating temperature of 20°C or more. The battery characteristics shorten the battery life at operating temperatures lower than 20°C, so check the remaining battery level, and replace the batteries before it reaches Level 1.
- The batteries packed with the system at the time of shipment are for checking operation. Their life is not guaranteed.
- The 70-hour battery life figure is the amount of operating time the batteries can provide until the system stops operating. The system may fail during operation if the remaining battery level is low, so it is a good idea to check the remaining battery level and replace the batteries with new ones well before the batteries run out completely.

U-51/52

Battery life: 70 hours (backlight off)

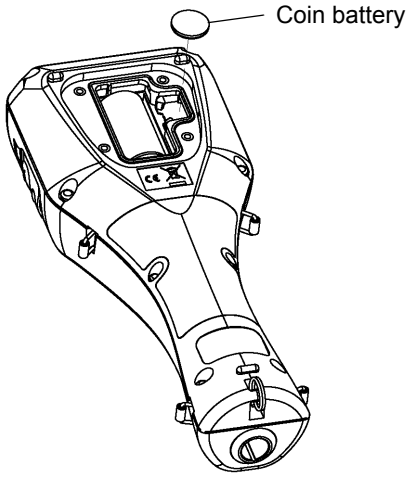
U-53

Battery life: 500 measurements (backlight off)

- Since U-53 is designed for turbidity measurement with wiper, its battery life is estimated in terms of the number of turbidity measurement sequences performed.
- Battery power is also consumed by measurement operations other than turbidity measurement.
- The battery life when turbidity measurement is not performed is about 70 hours.

3.1.2 Replacing the coin battery

- Coin battery to use: CR-2032
- The coin battery is only for the clock. It will provide problem-free operation for three years, but when using the clock continuously, it should be replaced every two years as a precaution.
- When replacing the coin battery for the clock, leave the control unit ON. If the coin battery is replaced when the control unit is turned OFF, the clock will be reset to the default settings.



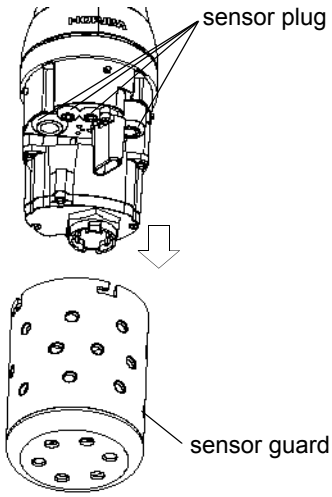
3.1.3 Attaching sensors

Note

- **When attaching or replacing a sensor, wipe any moisture off the sensor probe and sensor.**
- **Be sure to keep water out of sensor connectors. If moisture comes in contact with a sensor connector, blow-dry it with dry air.**
- **The sensor probe is not waterproof when the sensor is not mounted.**
- **Take care not to tighten the sensor too much.**

Attaching the pH sensor

1. **Remove the sensor guard.**

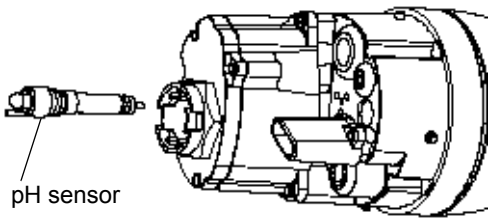


2. **Remove the sensor plug.**
3. **Coat the pH sensor O-ring with a thin layer of silicon grease (part No. 3014017718).**

Note

Be sure no grease from the O-ring gets on the sensor connector. If the sensor connector gets grease on it, wipe it off with a soft cloth soaked in alcohol.

4. **Make sure there is no moisture on the sensor probe's sensor connector (marked "pH").**
5. **Fasten the pH sensor securely by hand.**



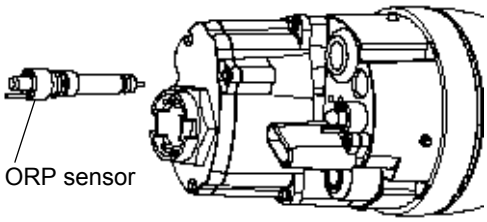
6. **Clean the sensor with an alcohol-soaked cloth.**

- **Attaching the ORP sensor**
  1. **Remove the sensor guard.**
  2. **Remove the sensor plug.**
  3. **Coat the ORP sensor O-ring with a thin layer of grease (part No. 3014017718).**

Note

Be sure no grease from the O-ring gets on the sensor connector. If the sensor connector gets grease on it, wipe it off with a soft cloth soaked in alcohol.

  4. **Make sure there is no moisture on the sensor probe's sensor connector (marked "ORP").**
  5. **Fasten the ORP sensor securely by hand.**



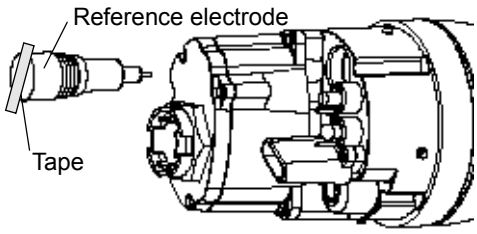
  6. **Clean the sensor with an alcohol-soaked cloth.**

- **Attaching the reference electrode**
  1. **Remove the sensor guard.**
  2. **Remove the sensor plug.**
  3. **Coat the reference electrode O-ring with a thin layer of grease (part No. 3014017718).**

Note

Be sure no grease from the O-ring gets on the sensor connector. If the sensor connector gets grease on it, wipe it off with a soft cloth soaked in alcohol.

  4. **Make sure there is no moisture on the sensor probe's sensor connector (marked "REF").**
  5. **Fasten the reference electrode securely by hand.**
  6. **Remove the tape from the liquid junction part of the reference electrode.**



Attaching the dissolved oxygen (DO) sensor

1. **Remove the membrane cap mounted on the DO sensor beforehand, and replace it with the new membrane cap provided. Replace the internal solution with fresh solution. The main component of the internal solution is potassium chloride (KCl), so the old solution can be disposed of down a sink or other drain.**

Reference

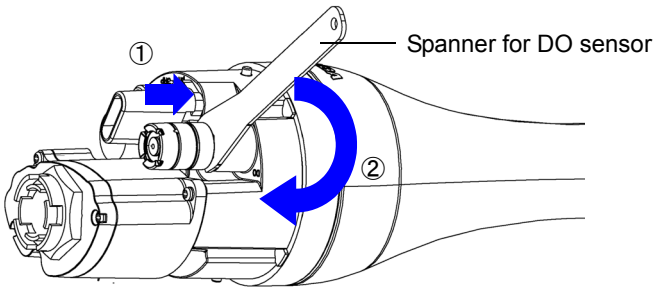
“ 4.5 Replacing the membrane cap ” (page 87)

2. **Screw in the DO sensor to attach it, allowing the internal solution to overflow slightly.**
3. **Use a soft cloth to wipe off the internal solution that overflowed onto the DO sensor.**
4. **Remove the sensor guard.**
5. **Remove the sensor plug.**
6. **Coat the DO sensor O-ring with a thin layer of grease (part No. 3014017718).**

Note

Be sure no grease from the O-ring gets on the sensor connector. If the sensor connector gets grease on it, wipe it off with a soft cloth soaked in alcohol.

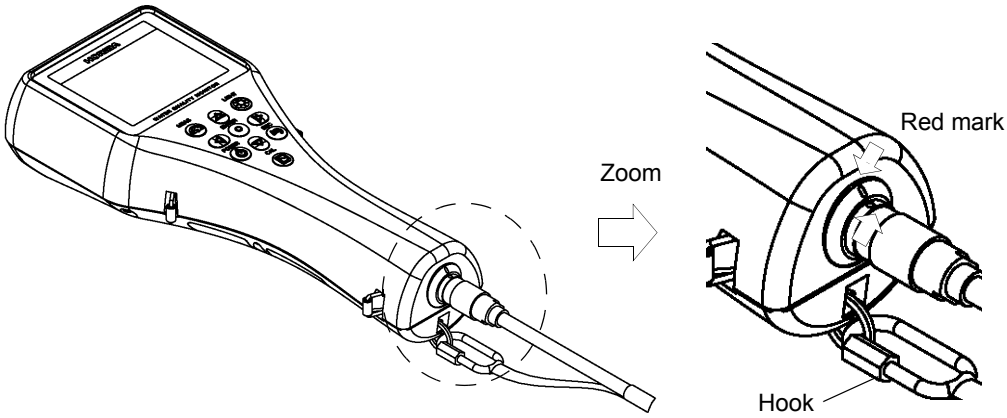
7. **Make sure there is no moisture on the sensor probe’s sensor connector (marked "DO").**
8. **Fasten the DO sensor securely using the spanner for DO sensor.**
   - Hold the DO sensor with the provided spanner for DO sensor and push the sensor down. (Step 1 in figure below)
   - Screw the DO sensor in place. (Step 2 in figure below)



3.1.4 Connecting the control unit and sensor probe

Note

Connect the control unit with its power OFF.

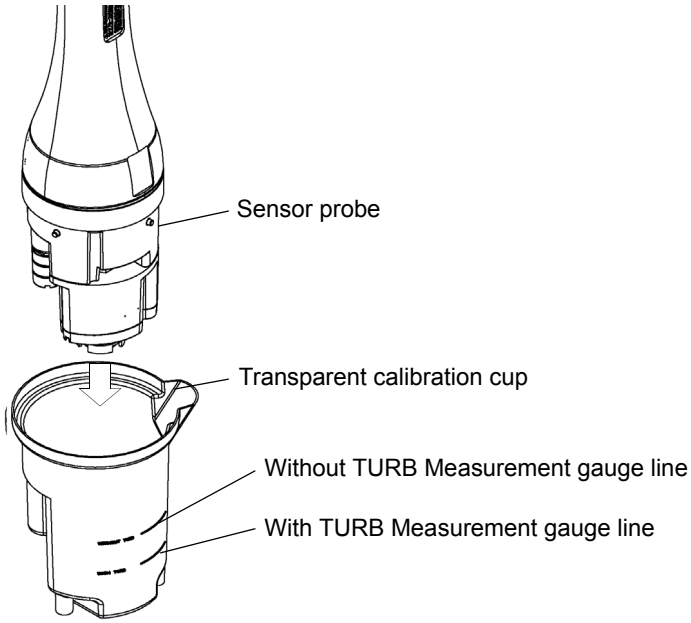


1. **Align the red mark on the connector, and press the connector in until you hear it click.**
2. **Connect the cable's hook to the display.**

3.1.5 Conditioning

Carry out the steps below when using the unit for the first time or when the system has not been used for 3 months or longer.

1. **Fill the transparent calibration cup to the line with pH 4 standard solution.**
   The transparent calibration cup has With TURB Measurement and Without TURB Measurement gauge lines.
2. **Insert the sensor probe in the transparent calibration cup.**



Note

Check that all sensors are attached.

3. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON. Leave the unit for at least 20 minutes to condition the sensors.**

Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

Tip

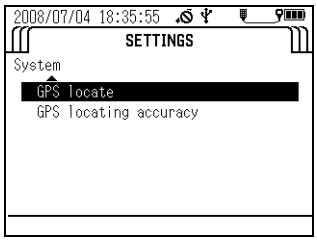
- **The procedure for immersing the sensor probe in the pH standard solution is the same as that described in " 3.3.1 Auto calibration " (page 39).**
  Auto calibration can be performed using the same pH 4 standard solution that was used in the conditioning procedure.
- **Immersing the sensor in the standard solution is generally required for sensor conditioning, but a voltage supply is required for DO sensor conditioning. Turning ON the power of the control unit is necessary during sensor conditioning.**

3.1.6 GPS (U-52G, U-53G)

The GPS position measurement precision is proportional to the GPS position measurement time. When the position measurement precision increases, the position measurement time also increases. See " ● GPS locating accuracy" (page 17) for how to set the position measurement precision. See " ● GPS locate" (page 15) below for how to check acquired GPS data.

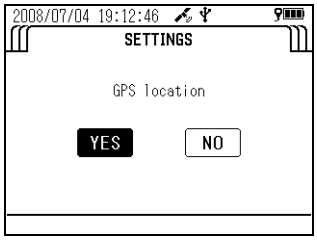
● **GPS locate**

1. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
2. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**
3. **Press the down (▽) key to move the cursor to "GPS locate", then press the ENTER key.**



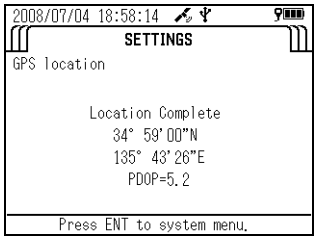
4. **The message "Press ENT key to start position measurement." appears. Press the ENTER key.**

5. **The message "Execute GPS position measurement?" appears. Move the cursor to "YES", then press the ENTER key.**

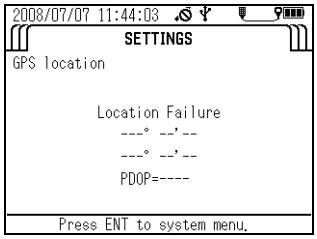


6. **The message "Warming up. Please wait." appears. Wait until the system has finished warming up (about 10 seconds).**

- Position measurement starts automatically when warmup has finished. Position measurement is performed up to 10 times.
- The GPS location complete screen appears after successful position measurement.

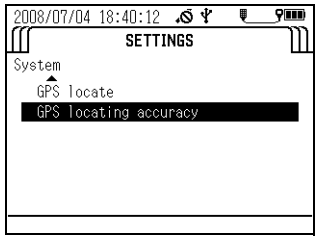


- The GPS location failure screen appears after position measurement has failed. Redo the measurement in a location free from obstacles, or wait for the meteorological conditions to improve before redoing the measurement.

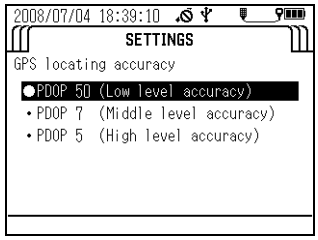


● GPS locating accuracy

1. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
2. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**
3. **Press the down (▽) key to move the cursor to "GPS locating accuracy", then press the ENTER key.**



4. **The screen below appears. Move the cursor to the locating accuracy, then press the ENTER key. The black circle (●) indicates the currently set precision.**



3.2 Settings

3.2.1 Setting measurement methods

This section describes how to set the measurement method.

Measurement methods

● U-51/U-52

Single measurement	Pressing the MEAS key acquires the 5-second average for the selected measurement parameter.
Interval measurement	Pressing the MEAS key acquires and saves the 5-second average for the selected measurement parameter in the set interval. The measurement interval can be set to any value between 10 seconds and 24 hours.

● U-53

The U-53 turbidity sensor uses a tungsten lamp. The lamp lights for about 10 seconds, and the average measurement value acquired during this interval is displayed.

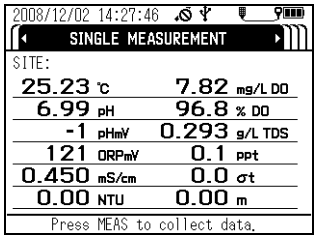
Single measurement	Pressing the MEAS key acquires the 5-second average for the selected measurement parameter after wiper operation. The 10-second average is acquired when measuring turbidity.
Interval measurement	Pressing the MEAS key acquires and saves the 5-second average for the selected measurement parameter in the set interval. The 10-second average is acquired when measuring turbidity. The measurement interval can be set to any value between 10 seconds (final check of this value required; 30 seconds may be better for U-52) and 24 hour.

Reference

“ 3.4 Measurement ” (page 61)

Operation method

1. **Press and hold down the control unit’s POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.

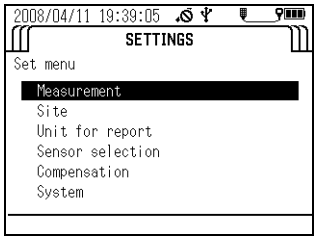


Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

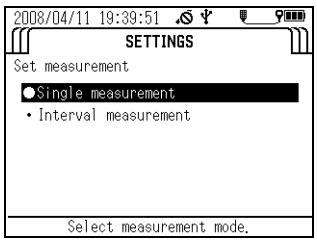
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

3. **Press the down (▽) key to move the cursor to "Measurement", then press the ENTER key.**



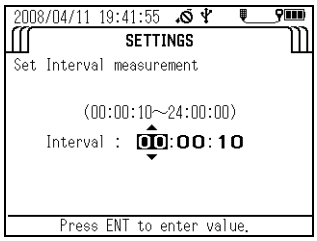
4. **Press the down (▽) key to move the cursor to the desired measurement mode. Press the ENTER key to save the setting.**

The black circle (●) indicates the currently selected measurement mode.



5. **If you selected "Interval measurement", the display switches to the screen used to set the measurement interval. Press the up (△) and down (▽) keys to set the measurement interval.**

The measurement interval can be set to any value between 10 seconds and 24 hours in the case of the U-51 and U-52, or between 30 seconds and 24 hours in the case of the U-53.



3.2.2 Setting sites

The site function allows position data to be connected to corresponding measurement data. Sites have the following specifications and features:

Site names: Text data consisting of up to 20 one-byte alphanumeric characters, spaces, etc.
Site names can be used for control unit searches and as labels for computer processing.
Site names allow measurement data to be saved with a name corresponding to the actual location where it was measured.

You can use site information as a search key when viewing data uploaded by a PC or data saved in the control unit (see “ 3.5 Data operations ” (page 64)).

- **Selecting sites**

  You can select previously created sites. The black circle (●) indicates the name of the currently selected site. No sites are created at new purchasing or after initialization. Select a site after first creating one from the "Create new site" menu.

- **Creating new sites**

  You can create and save new sites. Up to 20 site names can be registered.

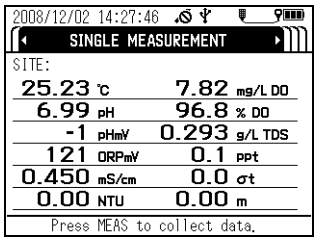
- **Deleting sites**

  You can select a previously created site and delete it.

● **Operation methods**

- **Selecting a site**

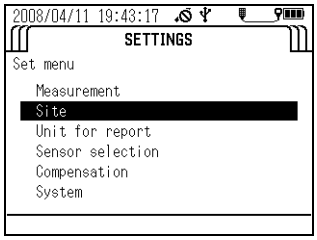
  1. **Press and hold down the control unit’s POWER key for about 3 seconds to turn the power ON.**
     The "MEASUREMENT" screen appears after about 10 seconds.



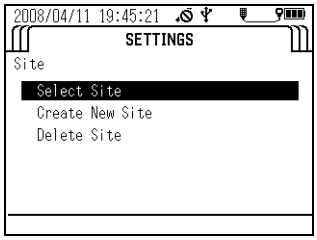
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

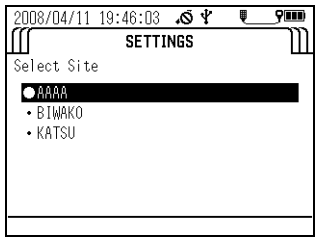
  2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
  3. **Press the down (▽) key to move the cursor to "Site", then press the ENTER key.**



4. **Press the down (▽) key to move the cursor to "Select Site", then press the ENTER key to display the names of the currently saved sites.**

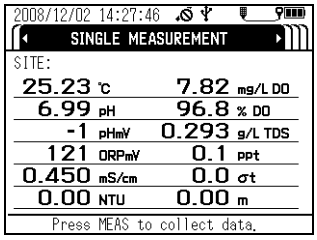


The black circle (●) indicates the currently selected site.



● **Creating a new site**

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
The "MEASUREMENT" screen appears after about 10 seconds.

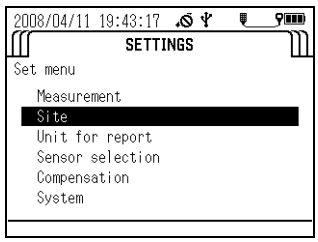


Note

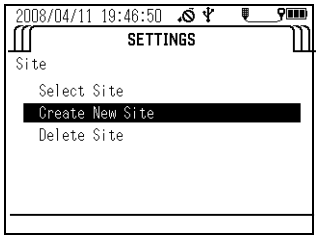
The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

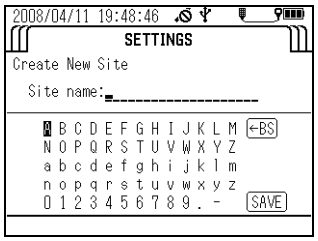
3. **Press the down (▽) key to move the cursor to "Site", then press the ENTER key.**



4. **Press the down (▽) key to move the cursor to "Create New Site", then press the ENTER key.**
   Enter the desired site name (up to 20 alphanumeric non-Asian width characters).

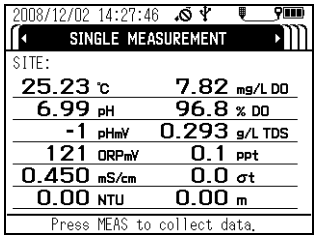


5. **Press the up (△), down (▽), right (▷), and left (◁) keys to move the cursor to each letter or number to use in the name, then press the ENTER key to confirm the entered characters. To delete incorrectly entered characters, move the cursor to "BS" and press the ENTER key to start deleting from the last character. When you have finished entering the name, save it by moving the cursor to "SAVE" and pressing the ENTER key.**



● **Deleting a site**

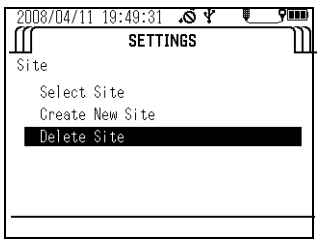
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

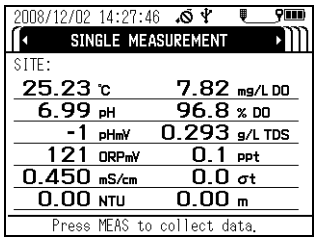
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**



3. **Press the down (▽) key to move the cursor to "Site", then press the ENTER key.**

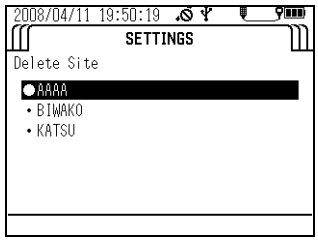
4. **Press the down (▽) key to move the cursor to "Delete Site", then press the ENTER key.**

   A list of the currently saved sites appears. The black circle (●) indicates the currently selected site.



5. **Press the down (▽) key to move the cursor to the site to delete, then press the ENTER key to delete it.**

   The currently selected site can be deleted after a different site has been selected from the site selection menu or after all unselected sites have been deleted. The same site name cannot be registered more than once.



3.2.3 Unit for report

Note

Units can only be selected when the sensor probe is connected.

Follow the steps below to set the measurement units of measurement parameters. No units are displayed if a measurement parameter has not been selected in the measurement parameter selection screen (see “ 3.2.4 Sensor selection ” (page 25)).

1. **Press and hold down the control unit’s POWER key for about 3 seconds to turn the power ON.**

   The "MEASUREMENT" screen appears after about 10 seconds.

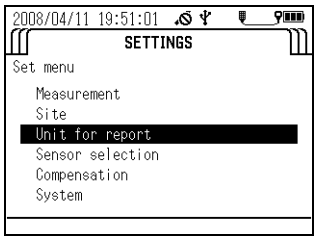
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

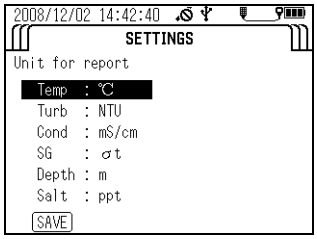
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

3. **Press the down (▽) key to move the cursor to "Unit for report", then press the ENTER key.**

A list of the currently selected measurement parameters and their units appears. Note that measurement parameters not selected (in the measurement parameter selection screen) are not displayed.

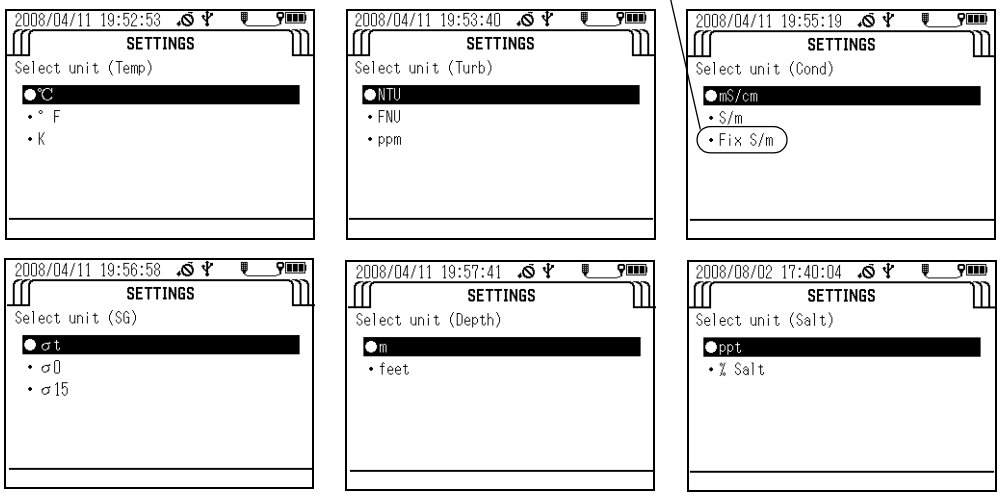


4. **Press the up (△) and down (▽) keys to move the cursor to the item to change, then press the ENTER key.**

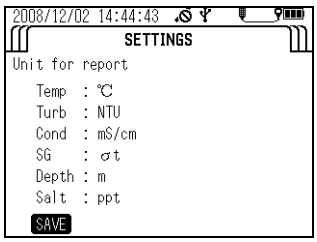


5. **A list of the units that can be selected appears. The black circle (●) indicates the currently selected unit. Press the up (△) and down (▽) keys to move the cursor to the desired unit, then press the ENTER key.**

Fix S/m: Fixes S/m with no auxiliary units for any measurement range.



6. **To save the changes, press the up (△) and down (▽) keys to move the cursor to SAVE, then press the ENTER key. If you do not want to save the changes, press the ESC key.**



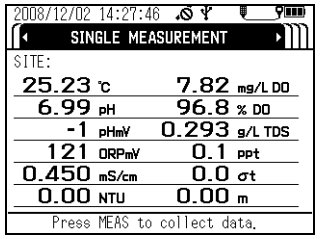
3.2.4 Sensor selection

Note

Measurement parameters can only be selected when the sensor probe is connected.

You can set between 1 and 11 measurement parameters to display in the control unit screen. Follow the steps below to select the desired measurement parameters.

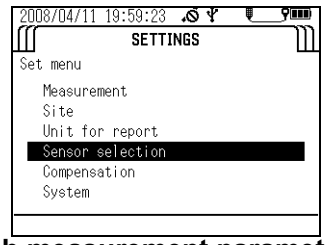
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



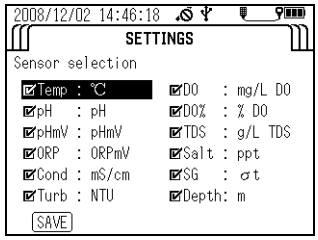
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "Sensor selection", then press the ENTER key.**
   A list of the measurement parameters that can be set and the currently set units are displayed.



4. **Move the cursor to each measurement parameter to change, then press the ENTER key.**
   A check in the check box of a measurement parameter indicates it will be displayed.
5. **To save the changes, press the up (△), down (▽), left (◁) and right (▷) keys to move the cursor to SAVE, then press the ENTER key. If you don't want to save the changes, press the ESC key.**



Note

Available measurement parameters differ according to product specifications.

3.2.5 Compensation

Note

Compensation settings can only be made when the sensor probe is connected.

U-50 series have following functions of compensation.

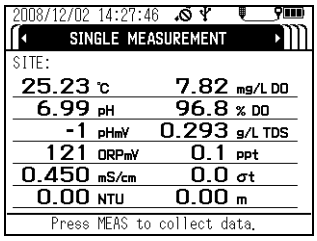
- Salinity compensation and atmospheric pressure compensation for dissolved oxygen (DO)
- Temperature compensation for conductivity (COND)
- Setting total dissolved solid (TDS) coefficient for TDS

● Salinity compensation (DO)

The dissolved oxygen (DO) value is presented higher than actual value if salinity compensation is not added, because the increase of salinity gives higher DO value. To obtain correct value salinity compensation is needed. The following modes are available for calculation of salinity compensation.

AUTO:	Salinity compensation is performed automatically with salinity converted from conductivity.
Value input:	Press the up (△) and down (▽) keys to enter a setting value when the salinity is known.

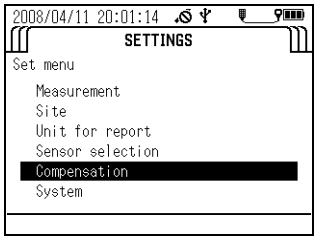
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



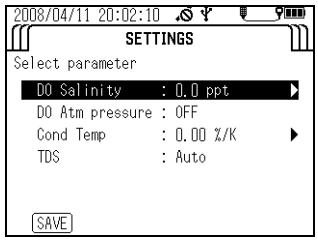
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

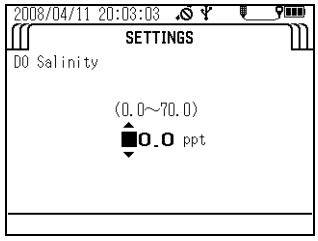
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "Compensation", then press the ENTER key.**



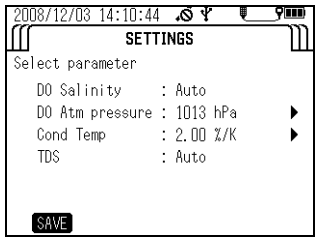
4. **Press the down (▽) key to move the cursor to "DO Salinity", then press the ENTER key to toggle the setting between "Auto" and "Input mode".**
Default: Auto



5. **If you selected "Input mode", press the right (▷) key to display the compensation value input screen. Press the up (△) and down (▽) keys to enter the desired value, then press the ENTER key to set it.**



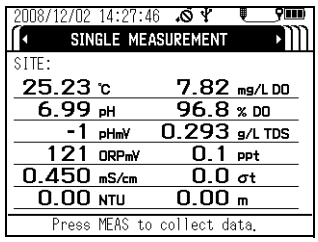
6. **To save the change, press the up (△) and down (▽) keys to move the cursor to SAVE, then press the ENTER key. If you don't want to save the change, press the ESC key.**



● Atmospheric pressure compensation (DO)

Differences in the atmospheric pressure of the measurement location influence the Dissolved Oxygen (DO) measurement. By setting (input) the actual atmospheric pressure of the measurement location into the control unit, it is possible to standardize the measured Dissolved Oxygen (DO) value to a value at the standard atmospheric pressure (1013 hPa).

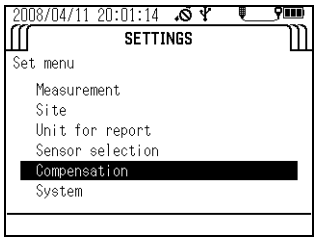
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
The "MEASUREMENT" screen appears after about 10 seconds.



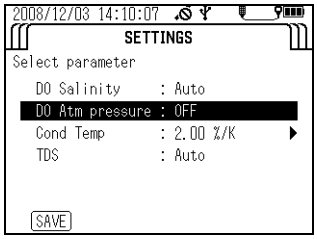
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

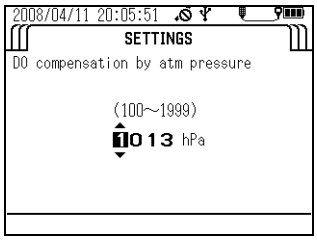
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "Compensation", then press the ENTER key.**



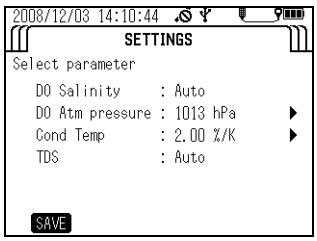
4. **Press the down (▽) key to move the cursor to "Cond Temp", then press the ENTER key to toggle the setting between "OFF" and "Input mode".**
   Default: OFF



5. **If you selected "Input mode", press the right (▷) key to display the compensation value input screen. Press the up (△) and down (▽) keys to enter the desired value, then press the ENTER key to set it.**



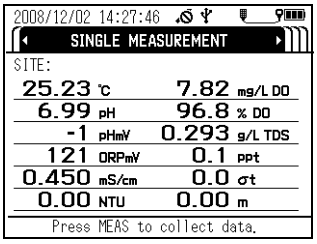
6. **To save the change, press the up (△) and down (▽) keys to move the cursor to SAVE, then press the ENTER key. If you don't want to save the change, press the ESC key.**



Temperature compensation for conductivity (COND)

Sample conductivity (COND) varies with temperature, and this control unit uses a temperature compensation coefficient to automatically standardize the conductivity (COND) at 25°C. The initial setting coefficient is 2%/K, which is the generally used.

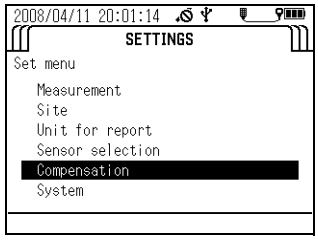
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



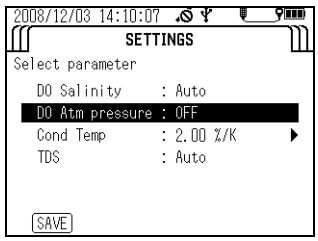
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

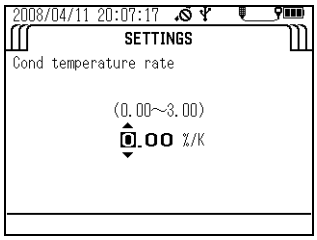
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "Compensation", then press the ENTER key.**



4. **Press the down (▽) key to move the cursor to "Cond Temp", then press the ENTER key to toggle the setting between "OFF" and "Input mode".**
   Default: 2.00%/K

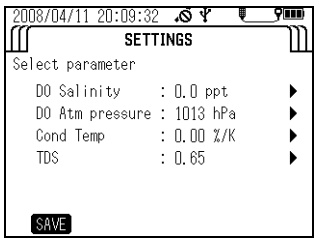


5. **If you selected "Input mode", press the right (▷) key to display the compensation value input screen. Press the up (△) and down (▽) keys to enter the desired value, then press the ENTER key to set it.**



6. **To save the change, press the up (△) and down (▽) keys to move the cursor to SAVE, then press the ENTER key.**

If you don't want to save the change, press the ESC key.

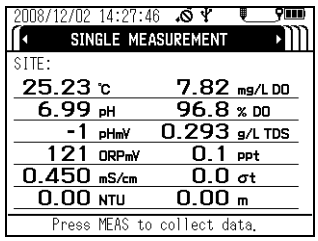


Setting a total dissolved solid (TDS) coefficient

The total dissolved solid amount (TDS) is a converted value obtained by multiplying the conductivity (COND) by a known coefficient. The coefficient initially set for the control unit is based on a conversion for KCl and $CaCO_3$ solutions and it depends on the conductivity (COND) value as shown below.

Conductivity (COND) (S/m)	Conversion coefficient
< 0.05	0.65
0.05 to 0.5	0.64
0.5 to 1	0.63
1 to 3	0.62
3 to 5	0.61
> 5	0.60

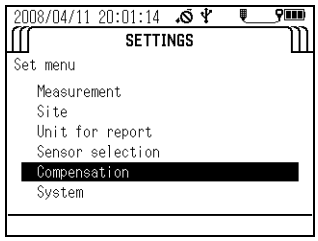
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



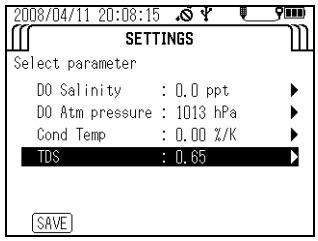
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

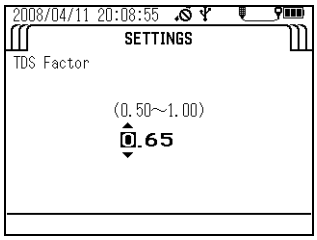
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "Compensation", then press the ENTER key.**



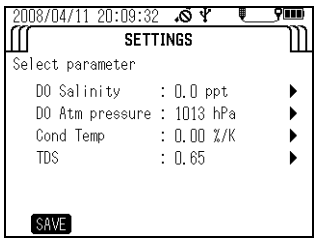
4. **Press the down (▽) key to move the cursor to "TDS", then press the ENTER key to toggle the setting between "AUTO" and "Input mode".**
   Default: Auto



5. **If you selected "Input mode", press the right (▷) key to display the compensation value input screen. Press the up (△) and down (▽) keys to enter the desired value, then press the ENTER key to set it.**



6. **To save the change, press the up (△) and down (▽) keys to move the cursor to SAVE, then press the ENTER key. If you don't want to save the change, press the ESC key.**



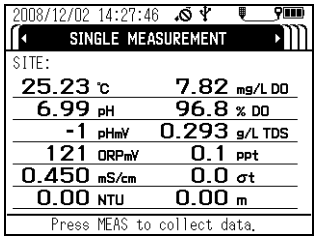
3.2.6 System settings

The system settings let you change the display language, check the system software version, set the date/time, set the auto power OFF time, set the display contrast, and initialize the settings.

● Display language

Follow the steps below to select either English or Japanese as the display language.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
The "MEASUREMENT" screen appears after about 10 seconds.

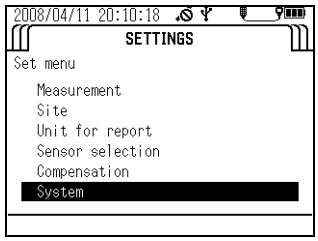


Note

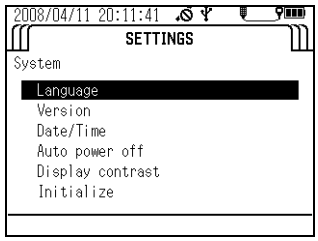
The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

3. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**

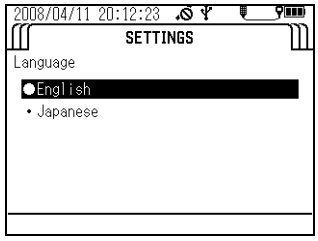


4. **Press the down (▽) key to move the cursor to "Language", then press the ENTER key.**



5. **A list of the supported display languages appears. Press the up (△) and down (▽) keys to move the cursor to the desired language, then press the ENTER key.**

The black circle (●) indicates the currently selected display language.



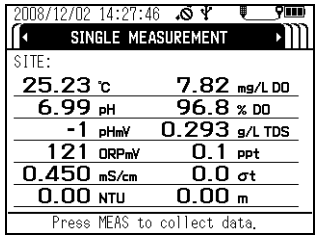
● Version

Follow the steps below to display the program No. and version of the control unit and sensor probe software.

The program No. and version of the sensor probe software will not be displayed if the sensor probe is not connected.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**

The "MEASUREMENT" screen appears after about 10 seconds.

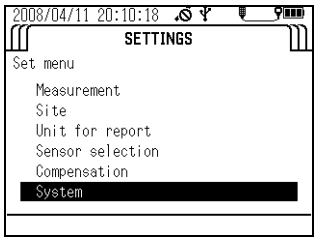


Note

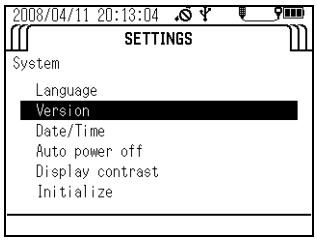
The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

3. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**



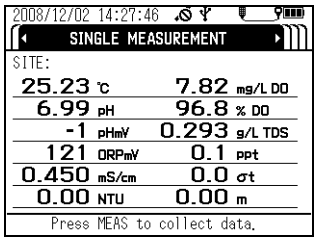
4. **Press the down (▽) key to move the cursor to "Version", then press the ENTER key.**
The program No. of the control unit and sensor probe software appears.



● Setting the date/time

Follow the steps below to set the date and time.

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
The "MEASUREMENT" screen appears after about 10 seconds.

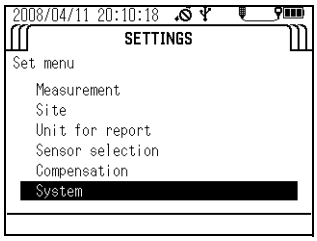


Note

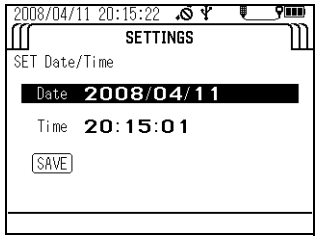
The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**

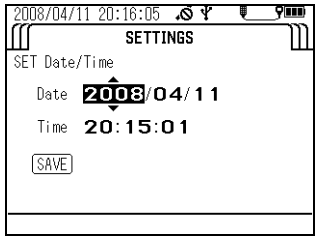
3. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**



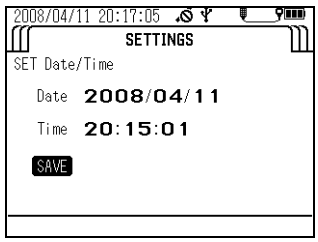
4. **Press the down (▽) key to move the cursor to "Date/time", then press the ENTER key.**



5. **Move the cursor to the date, then press the ENTER key.**
6. **Press the right (▷) key to move the cursor to the year, month, day, hour, minute and second, and press the up (△) and down (▽) keys to enter each value.**



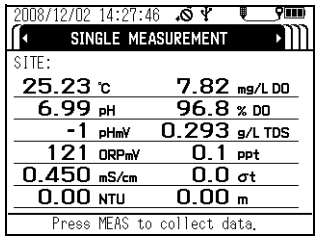
7. **When finished entering settings, press the ENTER key to move the cursor to SAVE, then press the ENTER key again to save the settings.**



● Setting the auto power OFF time

Follow the steps below to set the time for the auto power OFF function (which turns the power OFF automatically when no operation is performed for the preset amount of time).

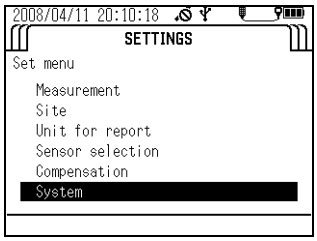
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



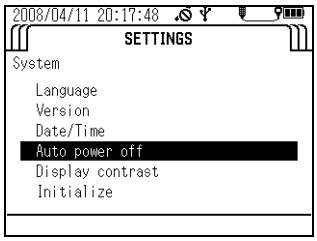
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

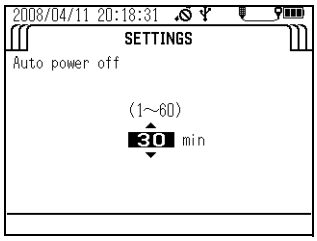
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**



4. **Press the down (▽) key to move the cursor to "Auto power off", then press the ENTER key.**



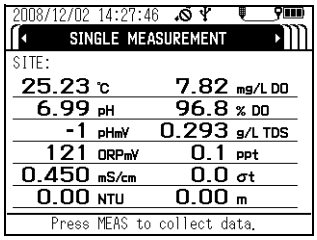
5. **Press the up (△) and down (▽) keys to select the desired time setting, then press the ENTER key.**
   You can select OFF, or settings of 1, 2, 5, 10, 20, 30 or 60 minutes.
   Default: 30 minutes



Display contrast

Follow the steps below to adjust the display's contrast.

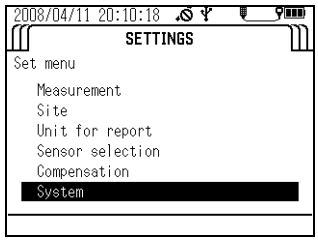
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



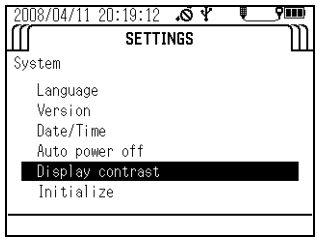
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

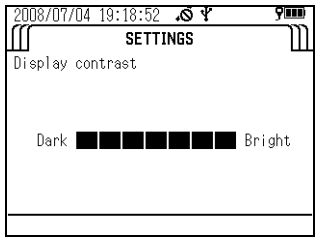
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**



4. **Press the down (▽) key to move the cursor to "Display contrast", then press the ENTER key.**



5. **Press the left (◁) and right (▷) keys to adjust the contrast.**
   Adjustment can be made in 26 steps.

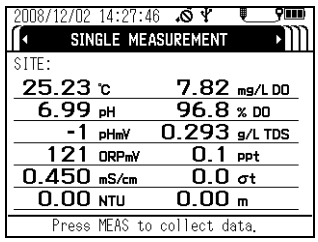


6. **Press the ENTER key.**

Initialization

Follow the steps below to restore all the settings except date/time to their factory defaults. Factory default calibration data for the electrical conductivity and turbidity sensors will also be deleted at the same time.

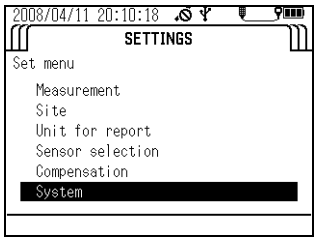
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



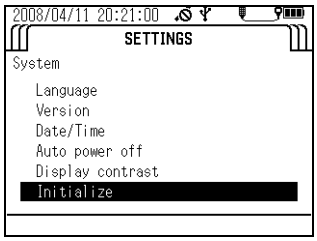
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

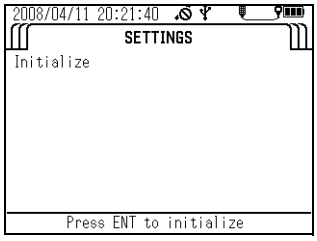
2. **Press the right (▷) key to switch the display to the "SETTINGS" screen.**
3. **Press the down (▽) key to move the cursor to "System", then press the ENTER key.**



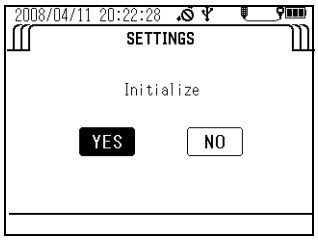
4. **Press the down (▽) key to move the cursor to "Initialize", then press the ENTER key.**



5. **Press the ENTER key again.**



6. **A confirmation message appears asking whether to execute initialization. Press the left (◁) key to move the cursor to YES, then press the ENTER key.**
   The message "Initialize Complete" appears to indicate the process has finished.



3.3 Calibration

To obtain correct measurement values, the sensors need to be calibrated using standard solution before measurement. You can select simultaneous auto calibration of the pH, COND and TURB sensors in pH4 standard solution and DO and DEP sensors simultaneously in air, or manual calibration of individual measurement parameters. You can check the result of the previous calibration using the procedure on “ 3.5.4 Checking the calibration record ” (page 70).

Note

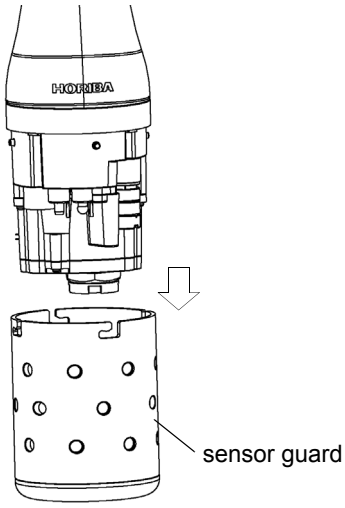
- **Wait at least 20 minutes after turning the system power ON before calibrating the DO sensor.**
- **Make the DO and COND compensation settings before calibration since these settings are applied during calibration.**
- **You can select only the desired parameters for calibration and calibrate just those parameters (see “ 3.2.4 Sensor selection ” (page 25)).**
- **Use about 200 mL of standard solution in the calibration cup.**
- **Calibration data is stored in the sensor probe.**

3.3.1 Auto calibration

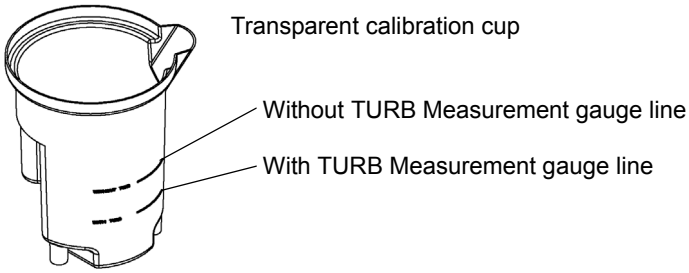
Tip

- **The following parameters are calibrated (at 25°C):**
  pH: Set to 4.01 (zero-point calibration); the span is adjusted to the factory default value.
  COND: 0.449 S/m (4.49 mS/cm, span calibration); the zero point is adjusted to the factory default value.
  TURB: 0 NTU (zero-point calibration); the span is adjusted to the factory default value.
  DO: 8.92 mg/L (span calibration); the zero point is adjusted to the factory default value.
  DEP: 0 m (zero-point calibration); the zero point is adjusted to the factory default value.
- **If the air temperature changes, the readout value may not be stable. Ensure that the ambient air temperature is the same temperature as the calibration solution, because the internal probe temperature sensor and external temperature sensor (in the calibration solution) are used for the auto calibration. Allow the probe and standard solution to equilibrate for 1 hour if a thermometer is not available to verify that these temperatures are the same.**
- **Do not hold the probe while performing the auto calibration. Body temperature may elevate the internal temperature sensor measurement creating DO calibration error.**

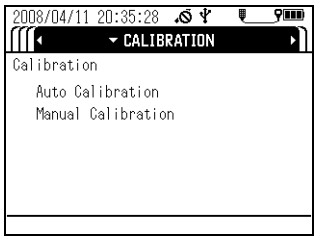
1. **Remove the sensor guard and wash the sensor probe 2 or 3 times with deionized water.**



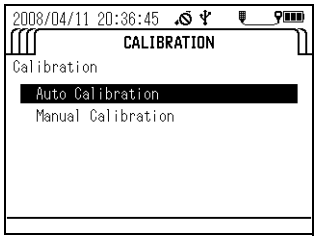
2. **Remove the transparent calibration cup.**
3. **Fill the transparent calibration cup to the line with pH 4 standard solution.**
   The transparent calibration cup has With TURB Measurement and Without TURB Measurement gauge lines.



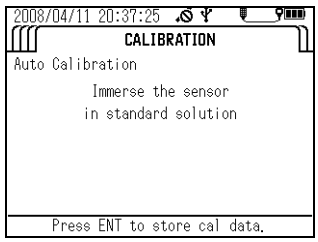
4. **Press the control unit's CAL key to set the calibration mode.**

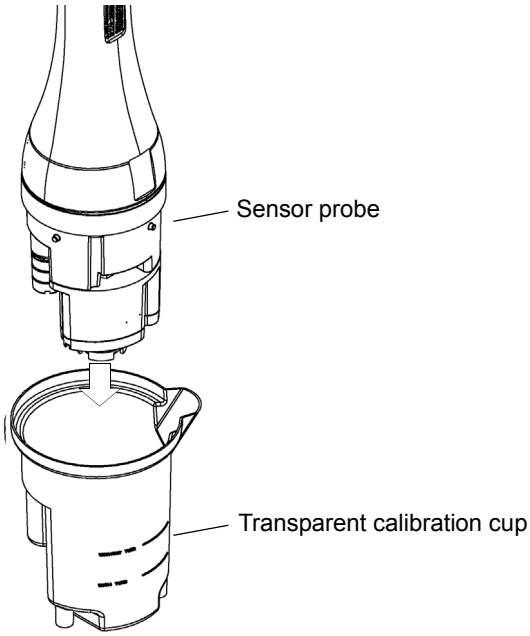


5. **Press the down (▽) key to move the cursor to "Auto Calibration", then press the ENTER key.**

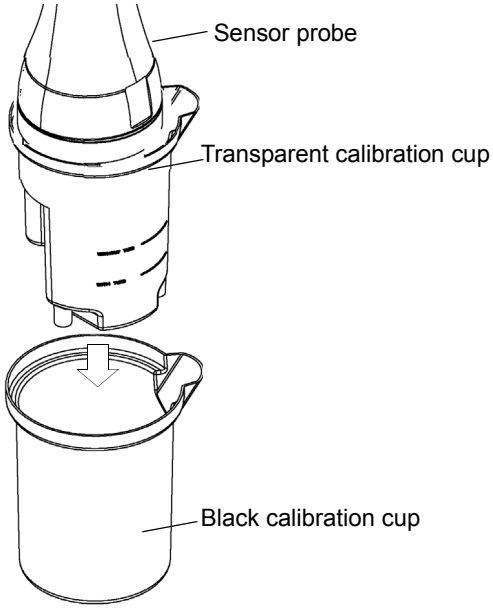


6. **Immerse the sensor probe in the transparent calibration cup.**
Check that the pH sensor, ORP sensor, reference electrode, COND sensor, TURB sensor and temperature sensor are submerged in the pH 4 standard solution and check that there are no air bubbles on the sensor.





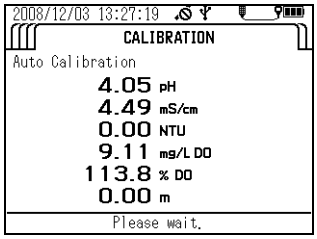
7. **With the sensor probe still in the transparent calibration cup, place the transparent calibration cup into the black calibration cup.**



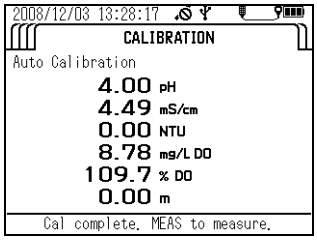
8. **When all the sensor values have stabilized, press the ENTER key to start calibration.**

Note

Do not remove the sensor probe from the calibration solution. U-53 turbidity data will display "----" until the calibration is completed.



Calibration is finished when the message "Cal complete. MEAS to measure." appears. Press the MEAS key to set the measurement screen, then start measurement.



If a calibration error occurs, start calibration after first resolving the issue according to the instructions in " 4.6 Troubleshooting " (page 89).

3.3.2 Manual calibration

The procedures below describe how to calibrate each sensor individually.

Note

The displayed units are the units set by selecting "Unit for report" in the "SETTINGS" screen.

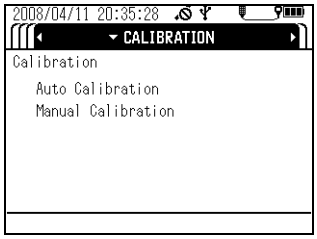
● **Temperature (TEMP) calibration**

1. **Fill a bucket or similar container with water of a known temperature, and insert the sensor probe in it.**

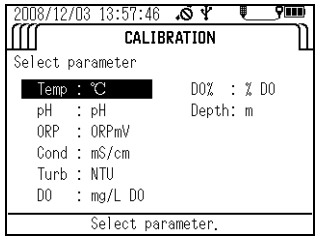
Wait 5 minutes before starting calibration to allow the sensor probe temperature to stabilize.

2. **Press the control unit's CAL key to set the calibration mode.**

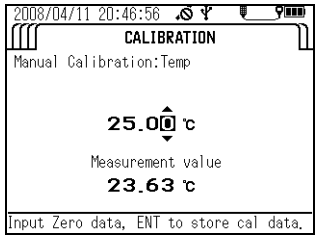
3. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**



4. **In the parameter selection screen, move the cursor to “Temp”, then press the ENTER key.**



5. **Press the up (△) and down (▽) keys to set the calibration value - the temperature of the water containing the submerged sensor probe.**



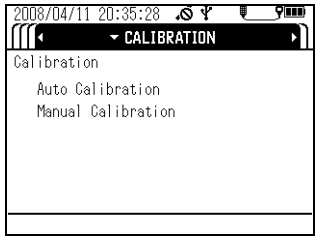
6. **Check that “Measurement value” has stabilized, then press the ENTER key to start calibration.**
   Calibration is finished when the message “Cal complete. CNT to measure.” appears.

● pH calibration

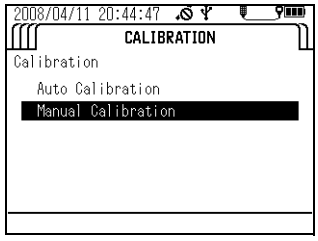
Note

You can select one calibration point (zero-point calibration) or two calibration points (zero-point calibration and span calibration). Carry out two calibration procedures to ensure good measurement precision throughout all measurement ranges.

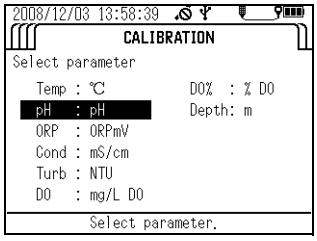
1. **Calibrate the zero point. Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with pH 7 standard solution.**
2. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**
3. **Press the control unit’s CAL key to set the calibration mode.**



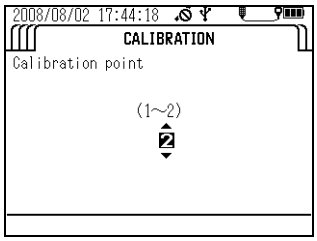
4. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**



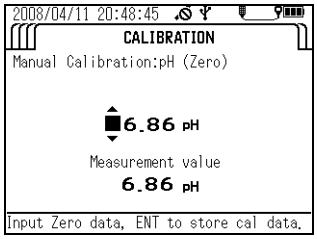
5. **In the parameter selection screen, move the cursor to "pH", then press the ENTER key.**



6. **Set the number of calibration points, then press the ENTER key.**



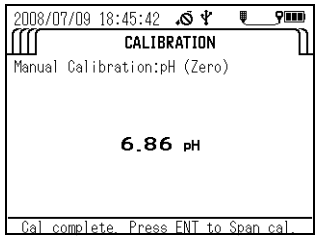
7. **Press the up (△) and down (▽) keys to set the pH value of the pH 7 standard solution containing the submerged sensor probe at the measurement temperature**



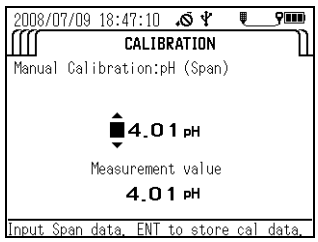
Temp. (°C)	pH 4 standard solution Phthalate	pH 7 standard solution Neutral phosphate	pH 9 standard solution Borate
0	4.01	6.98	9.46
5	4.01	6.95	9.39
10	4.00	6.92	9.33
15	4.00	6.90	9.27
20	4.00	6.88	9.22
25	4.01	6.86	9.18
30	4.01	6.85	9.14
35	4.02	6.84	9.10
40	4.03	6.84	9.07
45	4.04	6.84	9.04

8. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

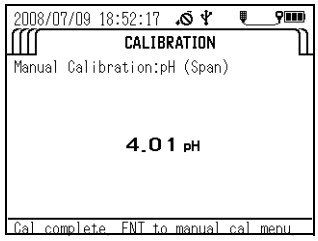
9. **Press the ENTER key to start the span calibration procedure when the message "Cal complete. Press ENT to Span cal." appears.**



10. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with pH 4 or pH 9 standard solution.**
11. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**
12. **Press the up (△) and down (▽) keys to set the pH value of the pH 4 or pH 9 standard solution containing the submerged sensor probe at the measurement temperature.**



13. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**
14. **Calibration is finished when the message "Cal complete. ENT to manual cal menu." appears. Press the ENTER key to return to the calibration parameter**

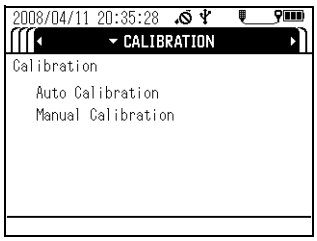


● ORP calibration

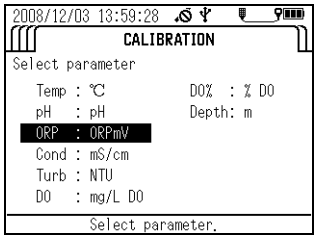
Note

- **If the prepared ORP standard solution is left in open air for one hour or more, the solution may be transformed. For this reason ORP standard solution cannot be stored.**
  Calibrate within one hour of preparing the solution.
- **When measuring sample with low concentrations of oxidants and reductants after conducting an operational check using a standard substance, the measured values may not stabilize or the results of measurement might not be repeatable. If this is the case, start the measurement after immersing the sensors in the sample water sufficiently.**
- **Note that when measuring the ORP of solution with extremely low concentrations of oxidants and reductants, such as tap water, well water, or water treated with purifying equipment, there may be less responsiveness, repeatability, and stability, in general.**
- **When alkaline ion water is left for 5 minutes, its ORP undergoes changes significantly. Always measure alkaline ion water promptly.**

1. **Fill a clean beaker with one bag of ORP standard powder No. 160-22 or No. 160-51. Add 250 mL of deionized water and agitate the solution thoroughly (there will be some excess quinhydrone (a black powder) that floats on the surface when agitating the solution). Fill the transparent calibration cup to the reference line with this standard solution.**
2. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**
3. **Press the control unit's CAL key to set the calibration mode.**
4. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**



5. **In the parameter selection screen, move the cursor to ORP, then press the ENTER key.**



6. **Press the up (△) and down (▽) keys to set the mV value of the ORP standard solution containing the submerged sensor probe at the measurement temperature.**

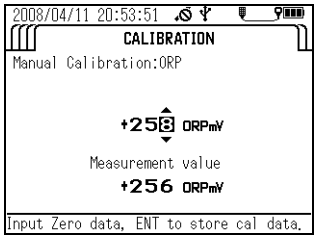


Table 1 Indicated value of ORP standard solution at various temperatures (mV)

Temperature	160-22	16051
5	+274	+112
10	+271	+107
15	+267	+101
20	+263	+95
25	+258	+89
30	+254	+83
35	+249	+76
40	+244	+69

7. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

8. **Calibration is finished when the message "Cal complete. ENT to manual cal menu." appears. Press the ENTER key to return to the calibration parameter selection screen.**

Conductivity (COND) calibration

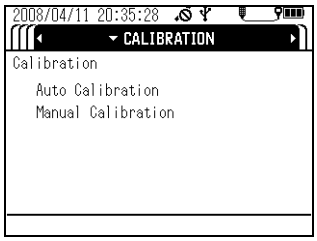
Note

- **To support a wide range of sample concentrations, electrical conductivity is divided into three measurement ranges: 0.0 mS/m to 99.9 mS/m, 0.090 S/m to 0.999 S/m, and 0.9 S/m to 9.99 S/m.**
- **When manually calibrating conductivity, you can select two calibration points (one zero-point calibration point and a span calibration point for one of the three measurement ranges) or four calibration points (one zero-point calibration point and span calibration points for all three measurement ranges). Carry out the four calibration points to ensure good measurement precision throughout all measurement ranges.**
- **Make the compensation setting before calibration since this setting is applied during calibration. (Refer to " 6.5.3 Temperature coefficient " (page 104)).**

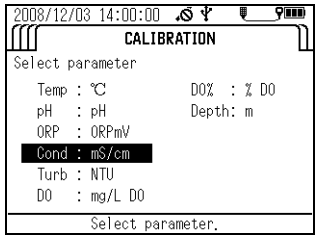
1. **Prepare the standard solution. Dry Potassium chloride (KCl) powder (high-grade commercially available) at 105°C for two hours, and leave it to cool in a desiccator.**
2. **Consult the following table and weigh potassium chloride (KCl), then prepare three standard potassium chloride (KCl) solutions following the procedure below.**

Potassium chloride (KCl) standard solution	Conductivity (COND) value	Potassium chloride (KCl) mass (g) at solution temperature of 25 °C	Calibration range
0.005 mol/L	71.8 mS/m (0.718 mS/cm)	0.373	0.0 mS/m to 99.9 mS/m (0.00 mS/cm to 0.999 mS/cm)
0.050 mol/L	0.667 S/m (6.67 mS/cm)	3.73	0.090 S/m to 0.999 S/m (1.00 mS/cm to 9.99 mS/cm)
0.500 mol/L	5.87 S/m (58.7 mS/cm)	37.2	0.9 S/m to 9.99 S/m (10.0 mS/cm to 99.9 mS/cm)

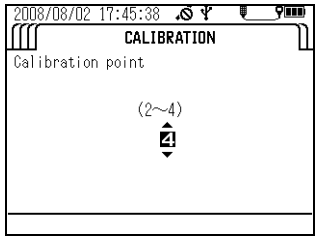
3. **Dissolve the weighed Potassium Chloride (KCl) in deionized water.**
4. **Put the dissolved Potassium Chloride (KCl) into a 1 L measuring flask, and fill to the 1 L mark with deionized water.**
5. **Calibrate the zero point. Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then remove all moisture from the sensor probe (it will be calibrated in air).**
6. **Press the control unit's CAL key to set the calibration mode.**
7. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**



8. **In the parameter selection screen, move the cursor to “Cond”, then press the ENTER key.**



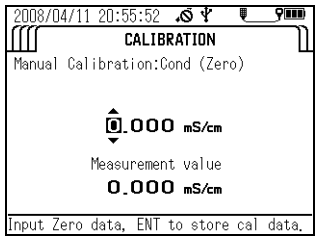
9. **Set the number of calibration points, then press the ENTER key.**



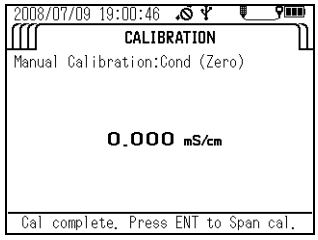
The instructions below assume that four calibration points have been set.

10. **Press the up (△) and down (▽) keys to set the "Cond" value to 0.0 mS/m (0.000 mS/cm).**

11. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**



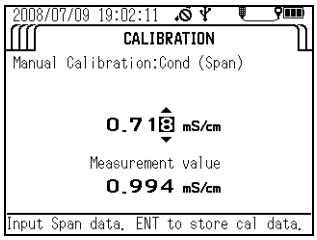
12. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the first span calibration procedure.**



13. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with 71.8 mS/m (0.718 mS/cm) standard solution.**

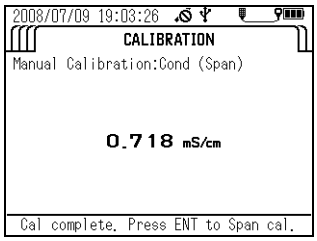
14. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**

15. **Press the up (△) and down (▽) keys to set the "Cond" value to 71.8 mS/m (0.718 mS/cm).**
Calibration range = 0 mS/m to 99.9 mS/m (0 mS/cm to 0.999 mS/cm)



16. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

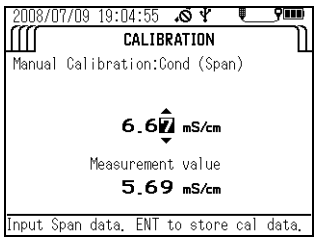
17. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the next span calibration procedure.**



18. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with 0.667 S/m (6.67 mS/cm) standard solution.**

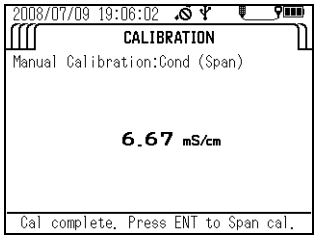
19. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**

20. **Press the up (△) and down (▽) keys to set the "Cond" value to 0.667 S/m (6.67 mS/cm).**
Calibration range = 0.100 S/m to 0.999 S/m (1.00 mS/cm to 9.99 mS/cm)



21. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

22. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the next span calibration procedure.**

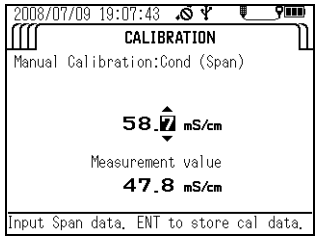


23. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with 5.87 S/m (58.7 mS/cm) standard solution.**

24. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**

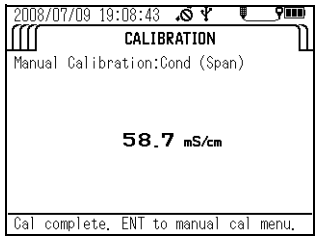
25. **Press the up (△) and down (▽) keys to set the "Cond" value to 5.87 S/m (58.7 mS/cm).**

Calibration range = 1.00 S/m to 10.00 S/m(10.0 mS/cm to 100.0 mS/cm)



26. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

27. **Calibration is finished when the message "Cal complete. ENT to manual cal menu." appears. Press the ENTER key to return to the calibration parameter selection screen.**



Turbidity (TURB) calibration

Note

- **To support a wide range of sample concentrations, turbidity is divided into three measurement ranges: 0.0 to 9.9 NTU, 10 to 100 NTU, and over 100 NTU.**
- **When manually calibrating turbidity, you can select two calibration procedures (one zero-point calibration procedure and a span calibration procedure for one of the three measurement ranges), three calibration procedures (one zero-point calibration procedure and a span calibration procedure for two of the three measurement ranges) or four calibration procedures (one zero-point calibration procedure and span calibration procedures for all three measurement ranges). Carry out the four calibration procedures to ensure good measurement precision throughout all measurement ranges.**
- **Always use the calibration cup provided. Using other containers can create effects from ambient light that cause incorrect calibration.**

Preparing the standard solutions

1. **Weigh out 5.0 g of hydrazine sulfate (commercial special grade or above), and dissolve it in 400 mL of deionized water. Dissolve 50 g of hexamethylene tetramine (commercial special grade or above) in 400 mL of deionized water in anther flask.**
2. **Mix the two solutions and add deionized water until the total solution volume is 1000 mL, and mix well. Store this solution at a temperature of 25°C ±3°C for 48 hours.**
   The turbidity value (TURB) of this solution is equivalent to 4000 NTU.
3. **Dilute 4000 NTU-solution 5 times (use a pipette to measure 50 mL of the 4000 NTU solution and pour it into a 250 mL measuring flask, and fill up to 250 mL meniscus)**
   The turbidity value (TURB) of this solution is equivalent to 800 NTU.
4. **Dilute 800 NTU solution 10 times (use a pipette to measure 25 mL of the 800 NTU solution and pour it into a 250 mL measuring flask, and fill up to 250 mL meniscus)**
   The turbidity value (TURB) of this solution is equivalent to 80 NTU.
5. **Dilute 80 NTU solution 10 times (use a pipette to measure 25 mL of the 80 NTU solution and pour it into a 250 mL measuring flask, and fill up to 250 mL meniscus)**
   The turbidity value (TURB) of this solution is equivalent to 8 NTU.

Note

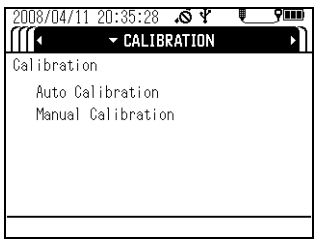
Instead of the standard solutions above, you can use other standard solutions of known concentration measured with other standard instruments.

U-52, U-53 turbidity calibration

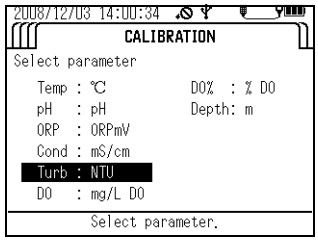
Set the number of calibration points.

You can set between 2 and 4 points.

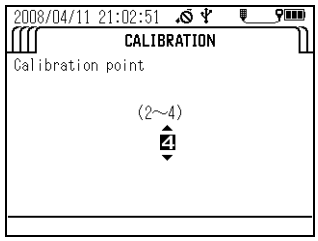
1. **Press the control unit's CAL key to set the calibration mode.**
2. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**



3. **In the parameter selection screen, move the cursor to "Turb", then press the ENTER key.**



4. **Press the up (△) and down (▽) keys to set the number of calibration points, then press the ENTER key.**

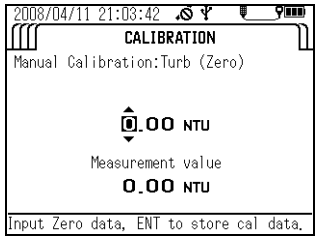


The instructions below assume that four calibration points have been set.

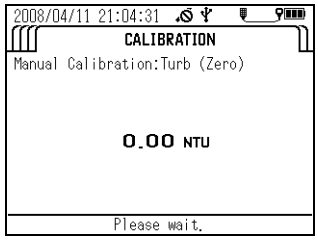
5. **Calibrate the zero point. Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with deionized water.**

6. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**

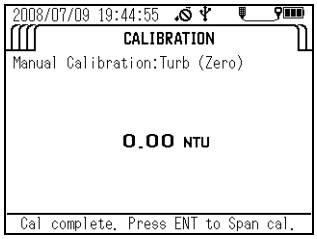
7. **Press the up (△) and down (▽) keys to set the "Turb" value to 0.0 NTU.**



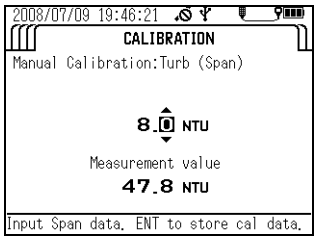
8. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**



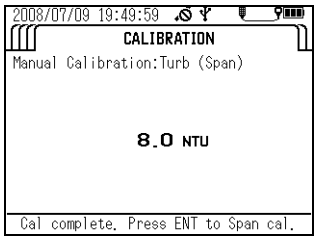
9. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the first span calibration procedure.**



10. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with 8 NTU standard solution, or a standard solution of known concentration between 0.1 and 10 NTU.**
11. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**
12. **Press the up (△) and down (▽) keys to set the "TURB" value to 8 NTU, or to the known concentration of the standard solution between 0.1 and 10 NTU. (Input range = 0 NTU to 9.9 NTU (U-51) or 0 NTU to 9.99 NTU (U-52))**

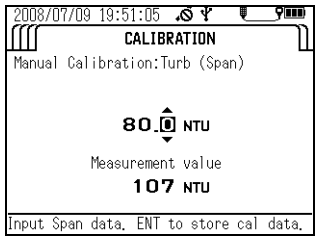


13. **Check that "Current measurement value" has stabilized, then press the ENTER key to start calibration.**
14. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the next span calibration procedure.**



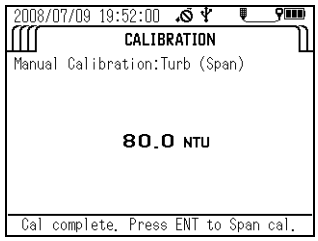
15. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with 80 NTU standard solution, or a standard solution of known concentration between 10 and 100 NTU.**
16. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**

17. **Press the up (△) and down (▽) keys to set the "Turb" value to 80 NTU, or to the known concentration of the standard solution between 10 and 100 NTU. (Input range = 10.0 NTU to 99.9 NTU)**



18. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

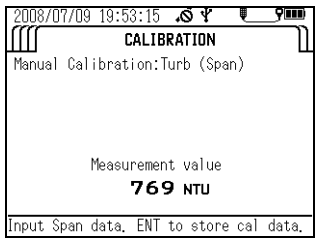
19. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the next span calibration procedure.**



20. **Wash the transparent calibration cup 2 or 3 times with deionized water, then fill it to the reference line with 800 NTU standard solution, or a standard solution of known concentration 100 NTU above.**

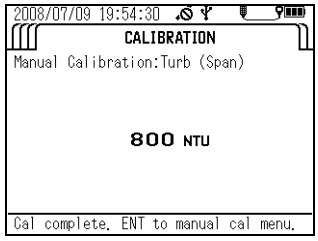
21. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the transparent calibration cup.**

22. **Press the up (△) and down (▽) keys to set the "TURB" value to 800 NTU, or to the known concentration of the standard solution 100 NTU above.**
(Input range = 100 NTU to 800 NTU (U-51), 100 NTU to 1000 NTU (U-52))



23. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**

24. **Calibration is finished when the message "Cal complete. ENT to manual cal menu." appears. Press the ENTER key to return to the calibration parameter selection screen.**

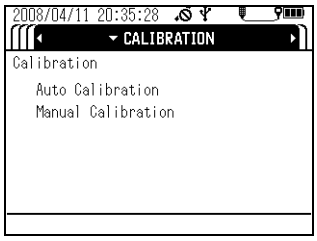


Dissolved oxygen (DO) calibration

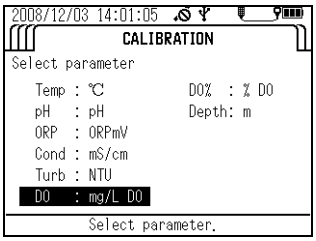
Note

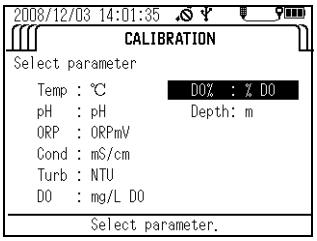
- **You can select one calibration procedure (span calibration) or two calibration procedures (zero-point calibration and span calibration). Carry out the two calibration procedures to ensure good measurement precision throughout all measurement ranges.**
- **It is necessary to prepare new solution before calibration of the Dissolved Oxygen (DO) sensor.**
- **The calibration cup (included) cannot be used to manually calibrate the DO sensor. Use a suitable bottle in which the DO sensor and the temperature sensor can be immersed.**
- **Wait at least 20 minutes after turning the system power ON before calibrating the DO sensor.**
- **Make the compensation setting before calibration since the setting is applied during calibration.**
- **The DO sensor is affected by flow. When performing span calibration with saturated dissolved oxygen water, move the cable slowly up and down (move the sensor probe at a rate of roughly 20 to 30 cm a second) or agitate the saturated dissolved oxygen water.**

1. **Prepare the standard solution.**
   - Add about 50 g of sodium sulfite to 1000 mL of water (either deionized water or tap water) and stir the mixture to dissolve the sodium sulfite in it.
   - Pour 1 to 2 liters of water into a suitable flask (either deionized water or tap water). Using a air pump, feed air into the water and aerate the solution until oxygen is saturated.
2. **First, calibrate the zero point. Press the control unit's CAL key to set the calibration mode.**
3. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**

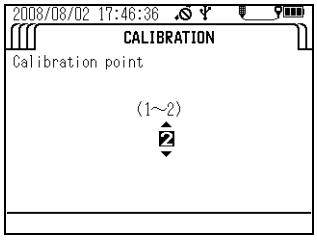


4. **In the parameter selection screen, move the cursor to DO or DO%, then press the ENTER key.**



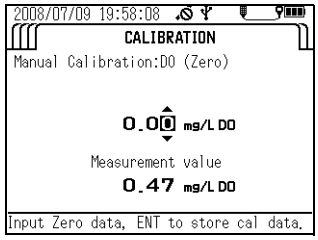


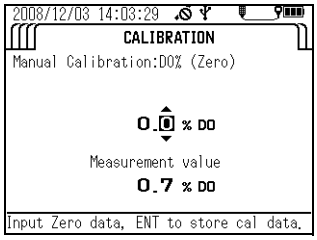
5. **Set the number of calibration procedures, then press the ENTER key.**



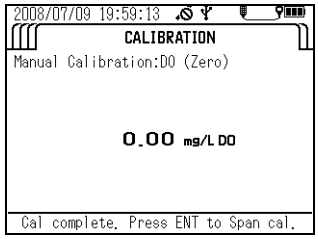
The instructions below assume that two calibration points have been set.

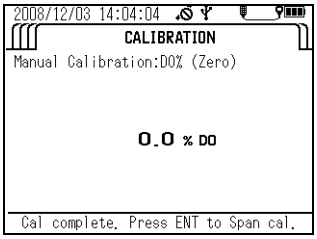
6. **Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then submerge the sensor probe in the bottle.**
7. **Press the up (△) and down (▽) keys to set the DO value to 0.00 mg/L or 0.0%.**



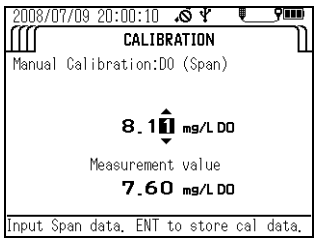


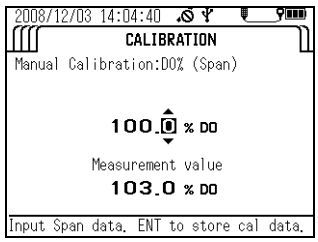
8. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**
9. **When the message "Cal complete. Press ENT to Span cal." appears, press the ENTER key to start the span calibration procedure.**



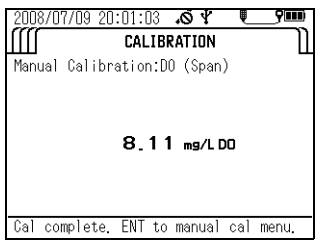


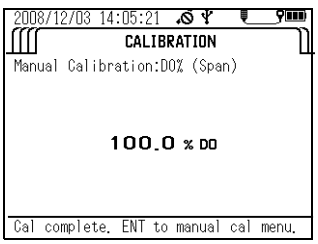
10. **Wash the sensor probe 2 or 3 times with deionized water to remove any dirt, then submerge the sensor probe in the container filled with the span solution.**
11. **Press the up (△) and down (▽) keys to set the DO value to the saturated dissolved oxygen value (mg/L) of the water at that temperature or the dissolved oxygen saturation ratio.**





12. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**
13. **Calibration is finished when the message "Cal complete. ENT to manual cal menu." appears. Press the ENTER key to return to the calibration parameter selection screen.**





Amounts of saturated dissolved oxygen in water at various temperatures (salinity=0.0%)

JIS K0101

Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)
0	14.16						
1	13.77	11	10.67	21	8.68	31	7.42
2	13.40	12	10.43	22	8.53	32	7.32
3	13.04	13	10.20	23	8.39	33	7.22
4	12.70	14	9.97	24	8.25	34	7.13
5	12.37	15	9.76	25	8.11	35	7.04
6	12.06	16	9.56	26	7.99	36	6.94
7	11.75	17	9.37	27	7.87	37	6.86
8	11.47	18	9.18	28	7.75	38	6.76
9	11.19	19	9.01	29	7.64	39	6.68
10	10.92	20	8.84	30	7.53	40	6.59

ISO5814

Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)
0	14.62				
1	14.22	11	11.03	21	8.91
2	13.83	12	10.78	22	8.74
3	13.46	13	10.54	23	8.58
4	13.11	14	10.31	24	8.42
5	12.77	15	10.08	25	8.26
6	12.45	16	9.87	26	8.11
7	12.14	17	9.66	27	7.97
8	11.84	18	9.47	28	7.83
9	11.56	19	9.28	29	7.69
10	11.29	20	9.09	30	7.56

● Span setting values for calibration in air

The software should display these values when auto calibration is performed.
Use this table to input values for manual span calibrations in air.

Tip

The DO measurement value of "air-saturated water" and air are different.
Due to the pressure difference against the membrane in air versus the membrane in water, the measurement value in air is about 10% higher than the value of air-saturated water on average.

Amounts of saturated dissolved oxygen in air at various temperatures

Following tables are applicable only to the air calibration of the U-50 DO sensor. Do not use them for other purpose.

Air calibration value in adopting evaluation based on JIS K0101

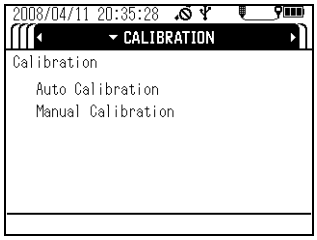
Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)	Temp (°C)	DO (mg/L)
0	15.58						
1	15.15	11	11.74	21	9.55	31	8.16
2	14.74	12	11.47	22	9.38	32	8.05
3	14.34	13	11.22	23	9.23	33	7.94
4	13.97	14	10.97	24	9.08	34	7.84
5	13.61	15	10.74	25	8.92	35	7.74
6	13.27	16	10.52	26	8.79	36	7.63
7	12.93	17	10.31	27	8.66	37	7.55
8	12.62	18	10.10	28	8.53	38	7.44
9	12.31	19	9.91	29	8.40	39	7.35
10	12.01	20	9.72	30	8.28	40	7.25

Air calibration value in adopting evaluation based on ISO5814

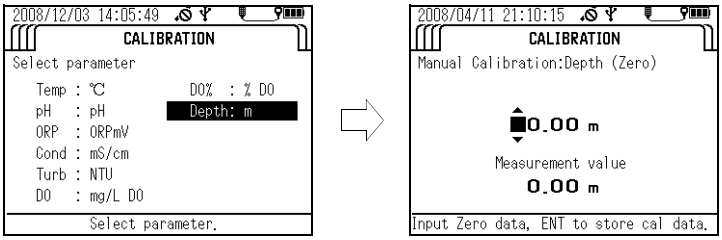
Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)	Temp. (°C)	DO (mg/L)
0	16.08				
1	15.64	11	12.13	21	9.80
2	15.21	12	11.86	22	9.61
3	14.81	13	11.59	23	9.44
4	14.42	14	11.34	24	9.26
5	14.05	15	11.09	25	9.09
6	13.70	16	10.86	26	8.92
7	13.35	17	10.63	27	8.77
8	13.02	18	10.42	28	8.61
9	12.72	19	10.21	29	8.46
10	12.42	20	10.00	30	8.32

Water depth (DEPTH) calibration

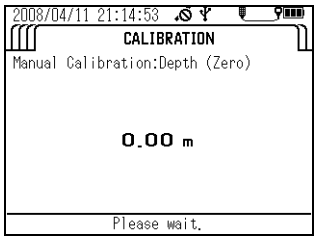
1. **Calibrate the zero point. Wash the sensor probe 2 or 3 times in deionized water to remove any dirt, then remove all moisture from the sensor probe (it will be calibrated in air).**
2. **Press the control unit's CAL key to set the calibration mode.**
3. **Press the down (▽) key to move the cursor to "Manual Calibration", then press the ENTER key.**



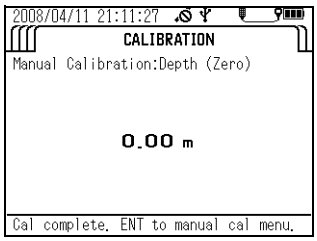
4. **In the parameter selection screen, move the cursor to "Depth", then press the ENTER key.**



5. **Press the up (△) and down (▽) keys to set the "Depth" value to 0.00 m.**
6. **Check that "Measurement value" has stabilized, then press the ENTER key to start calibration.**



7. **Calibration is finished when the message "Cal complete. ENT to manual cal menu." appears. Press the ENTER key to return to the calibration parameter selection screen.**



3.4 Measurement

You can perform measurement by either of the methods below.

- Storing data in memory manually with reference to the measurement value (single measurement)
- Having data stored in memory automatically and continuously
  U-51/U-52: Interval measurement (minimum memory interval of 10 seconds)
  U-53: Interval measurement (minimum memory interval of 30 seconds)

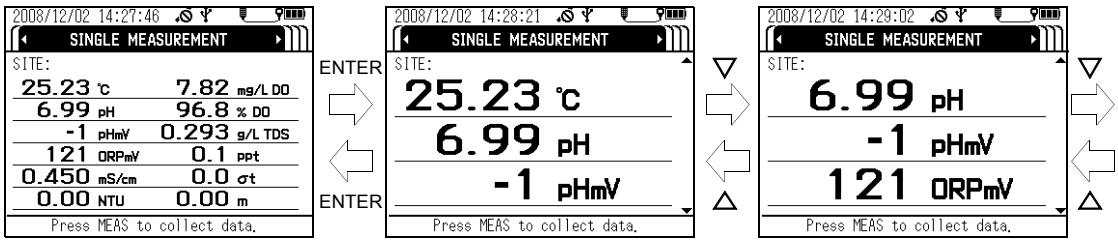
Select the measurement method that meets your requirements.

Note

- **Lower sensor probe slowly when submerging them in samples.**
- **Sensors may break if sensor probe are dropped from a height of 1 meter or more.**
- **Do not submerge sensor probe in water depths of over 30 meters. Sensor probe are only resistant to water pressure of up to 30 meters.**
- **After turning the power ON, check that the DO readout value has stabilized before starting measurement (takes around 20 minutes).**

Tip

- **When on the measurement screen, pressing the ENTER key enlarges the display and shows three measured values at a time.**
- **Pressing the up (△) and down (▽) keys scrolls through the measured values one item at a time.**
- **Pressing the ENTER key again reverts to the normal measurement screen display.**



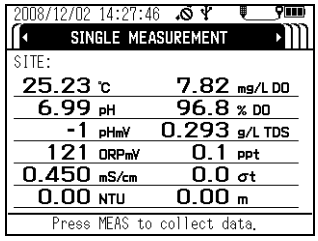
Measurement screen Normal Enlarged

3.4.1 Storing data in memory manually

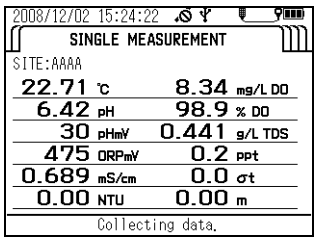
Follow the steps below to manually store data in memory while referring to the measurement value to check the readout value is stable.

● **U-51/U-52**

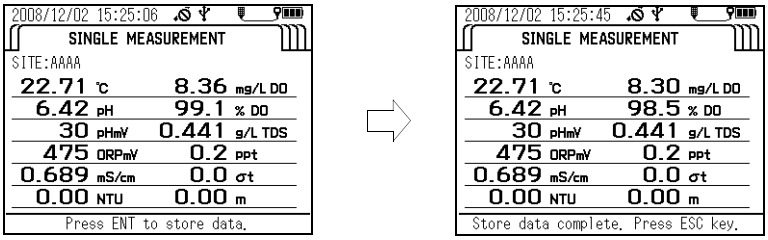
1. **Check that each sensor and sensor guard is mounted.**
2. **Check that "SINGLE MEASUREMENT" has been selected in the measurement screen.**



3. **Submerge the sensor probe in the sample, gently shaking them in the sample to remove any air bubbles from the sensors.**
   If the sample is non-flowing, move the cable slowly up and down (move the sensor probe at a rate of roughly 20 to 30 cm a second) to ensure that fresh sample is continuously supplied to the DO sensor.
4. **When the measurement values are stable, press the MEAS key to acquire the 5-second average.**



5. **Press the ENTER key to save the held measurement values, or press the ESC key to cancel the operation.**

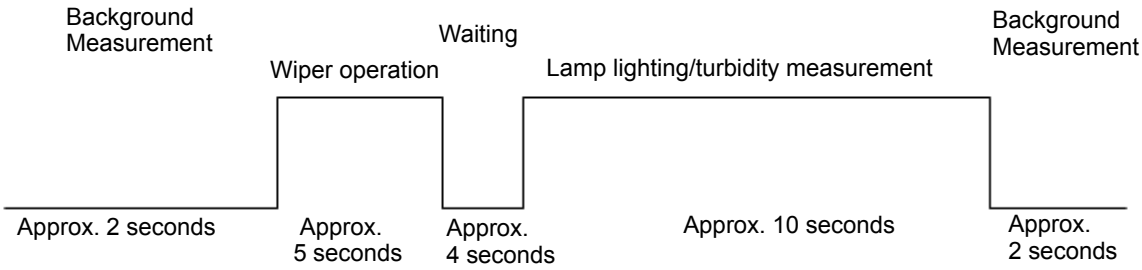


● U-53

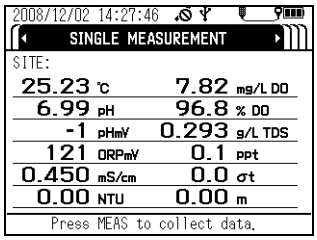
Note

Do not perform turbidity measurement in air as it may damage the wiper.

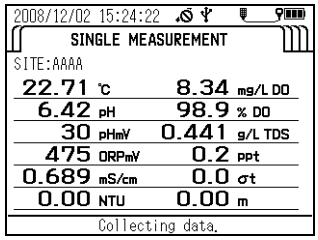
U-53 turbidity measurement follows the sequence below. The measurement values are held after each sequence.



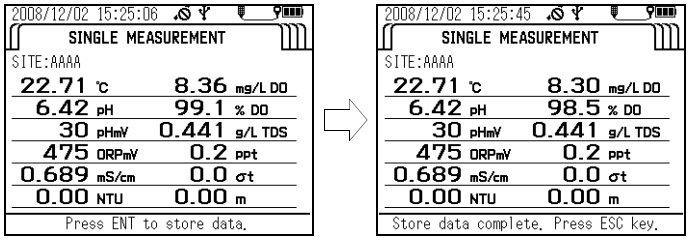
1. **Check that each sensor and sensor guard is mounted.**
2. **Check that "SINGLE MEASUREMENT" has been selected in the measurement screen.**



3. **Submerge the sensor probe in the sample, gently shaking them in the sample to remove any air bubbles from the sensors.**
   If the sample is non-flowing, move the cable slowly up and down (move the sensor probe at a rate of roughly 20 to 30 cm a second) to ensure that fresh sample is continuously supplied to the DO sensor.
4. **When the non-turbidity meter measurement values are stable, press the MEAS key to start the sequence above.**



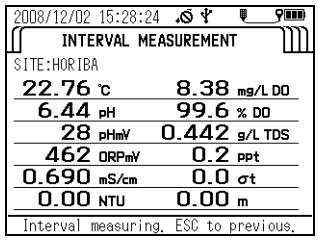
5. **When the sequence has finished, hold the measurement values. Press the ENTER key to store the held measurement values, or press the ESC key to cancel the operation.**



3.4.2 Automatic, continuous measurement

● **Interval measurement**

1. **Select the "Interval measurement" measurement setting (see “ 3.2.1 Setting measurement methods ” (page 18)).**
2. **Press the up (△) and down (▽) keys to set the interval value to the desired value (U-51/U-52: minimum interval: 10 seconds, U-53: minimum interval: 30 seconds), then press the ENTER key.**
   The measurement screen appears automatically, and the system becomes ready for measurement.
3. **Check that each sensor and sensor guard is mounted.**
4. **Submerge the sensor probe in the sample, gently shaking them in the sample to remove any air bubbles from the sensors.**
   If the sample is non-flowing, move the cable slowly up and down (move the sensor probe at a rate of roughly 20 to 30 cm a second) to ensure that fresh sample is continuously supplied to the DO sensor.
5. **Press the ENTER key to start measurement.**



3.5 Data operations

Use the procedures below to retrieve data stored in memory, delete all the data, check the remaining data memory capacity, and check the calibration record.

3.5.1 Displaying data

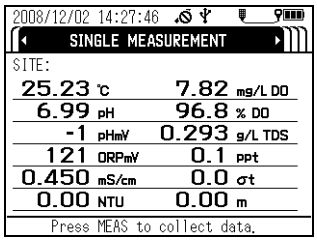
For maximum efficiency, there are 3 methods of displaying data.

- Displaying the data for a specified site
- Displaying the data for a specified date/time
- Displaying all the data

Use the method that best suits your requirements.

● **Displaying the data for a specified site**

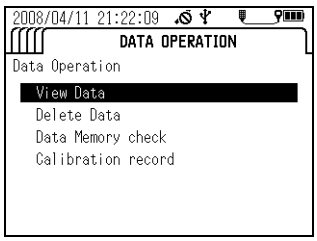
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



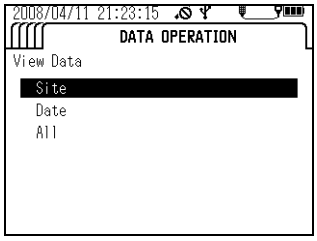
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key 3 times to display the "DATA OPERATION" screen.**
3. **Press the down (▽) key to move the cursor to "View Data", then press the ENTER key.**

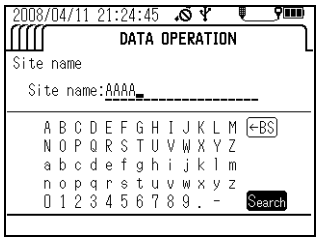


4. **Move the cursor to "Site", then press the ENTER key.**



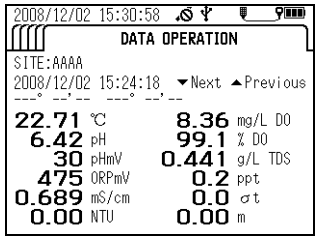
5. **Press the up (△), down (▽), left (◁) and right (▷) keys to enter the site to retrieve.**

6. **Move the cursor to "Search", then press the ENTER key.**



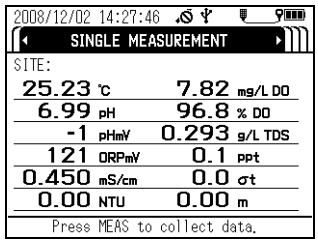
All site names that begin with the entered text are displayed.
The most recently measured data for the entered site is displayed.

7. **Press the up (△) and down (▽) keys to display earlier data.**



● Displaying the data for a specified date/time

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
The "MEASUREMENT" screen appears after about 10 seconds.

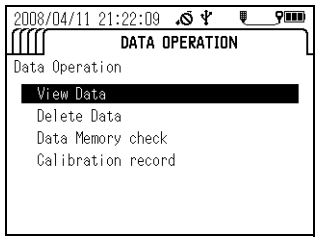


Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

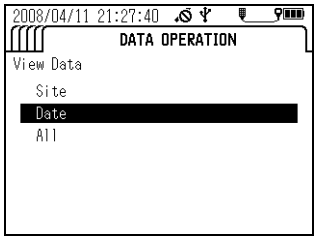
2. **Press the right (▷) key 3 times to display the "DATA OPERATION" screen.**

3. **Press the down (▽) key to move the cursor to "View Data", then press the ENTER key.**



4. **Move the cursor to "Date", then press the ENTER key.**

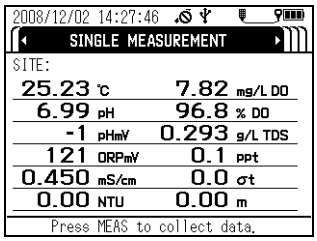
5. **With the cursor on the Date, press the ENTER key.**



6. **Press the up (△), down (▽), left (◁) and right (▷) keys to enter the desired date/ time, then press the ENTER key to apply the setting.**
7. **The cursor moves to "Search". Press the ENTER key to start the search.**
8. **Press the up (△) and down (▽) keys to display earlier data.**

● Displaying all the data

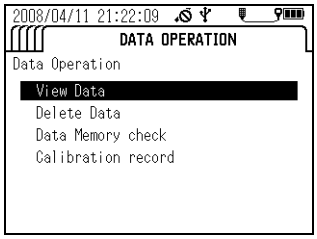
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



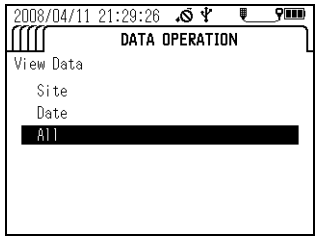
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key 3 times to display the "DATA OPERATION" screen.**
3. **Press the down (▽) key to move the cursor to "View Data", then press the ENTER key.**



4. **Move the cursor to "All", then press the ENTER key.**
The most recently measured data is displayed.

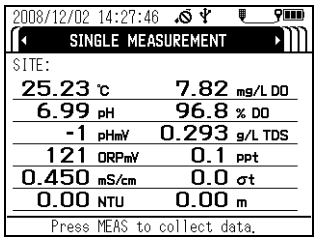


5. **Press the up (△) and down (▽) keys to display earlier data.**

3.5.2 Deleting data

Follow the steps below to delete all the data stored in memory.

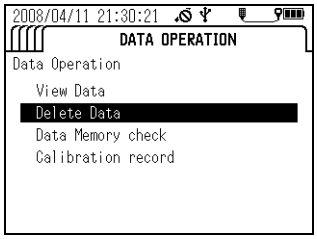
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



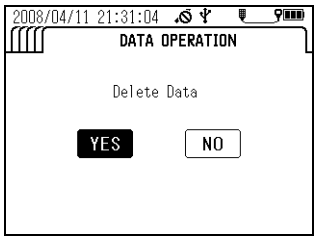
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key 3 times to display the "DATA OPERATION" screen.**
3. **Press the down (▽) key to move the cursor to "Delete Data", then press the ENTER key.**



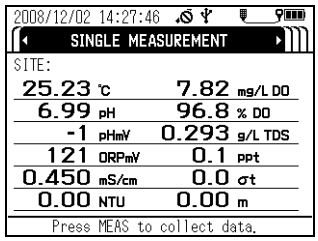
4. **Press the left (◁) key to move the cursor to YES, then press the ENTER key.**
   All the data has been deleted when the indicator appears along with the message "No data exists".



3.5.3 Checking the data memory

You can check the used data capacity and the remaining data capacity.

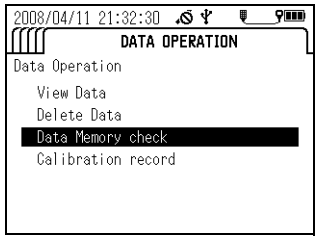
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



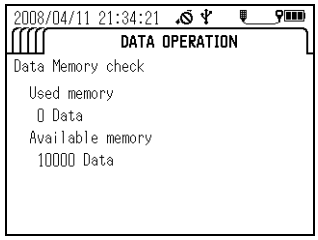
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key 3 times to display the "DATA OPERATION" screen.**
3. **Press the down (▽) key to move the cursor to "Data Memory Check", then press the ENTER key.**



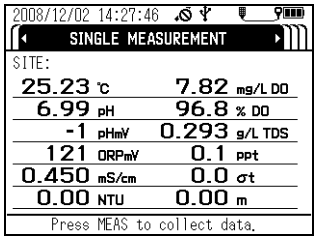
The amount of memory in use and amount of available memory are displayed.



3.5.4 Checking the calibration record

Follow the steps below to check the latest calibration history.

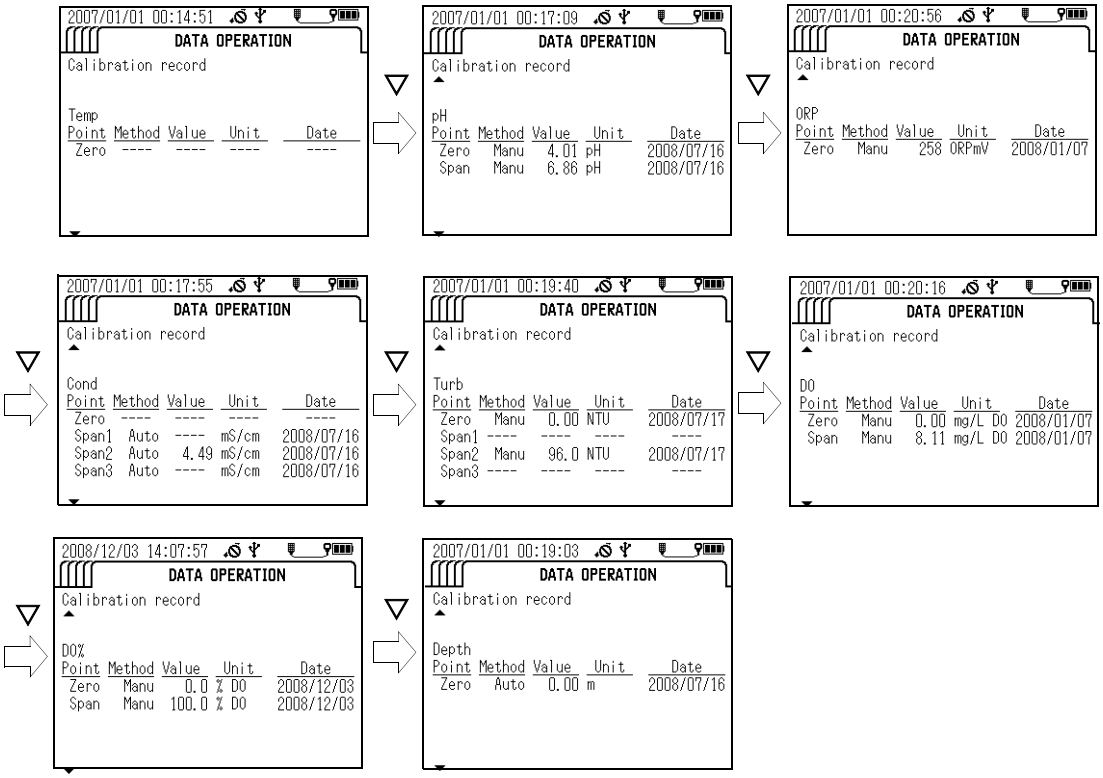
1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.



Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Press the right (▷) key 3 times to display the "DATA OPERATION" screen.**
3. **Press the down (▽) key to move the cursor to "Calibration record", then press the ENTER key.**
   The latest calibration record is displayed.



3.5.5 GPS data operations

The menu for GPS data operations appears on the display to which the GPS unit is mounted.

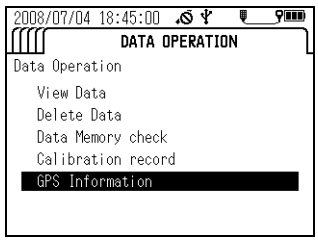
● GPS information

Follow the steps below to display acquired GPS information.

Note

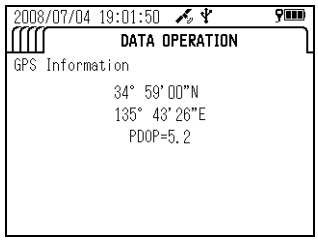
Turning the power OFF erases the GPS information.

1. **Press the right (▷) key to switch the display to the "DATA OPERATION" screen.**
2. **the down (▽) key to move the cursor to "GPS Information", then press the ENTER key.**

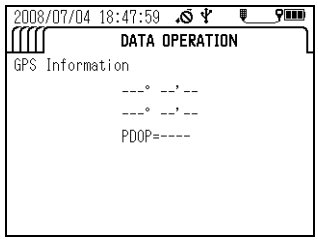


The last GPS information acquired is displayed.

● When received data exists

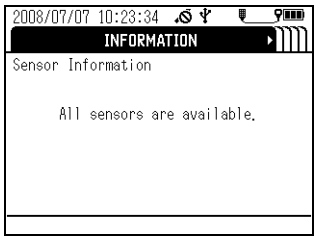


● When no received data exists

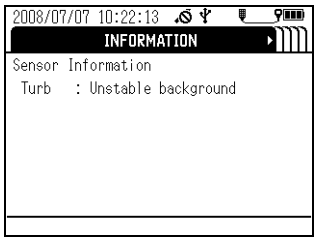


3.6 Sensor information

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power ON.**
   The "MEASUREMENT" screen appears after about 10 seconds.
2. **Press the left (◁) key once to display the "INFORMATION" screen.**
   The "Sensor Information" screen displays the sensor probe's status.
   - When the sensor probe is normal, the display below appears.



   - When there is a sensor probe problem, individual measurement parameters generate messages such as the one shown below. Follow the troubleshooting information to remove the problem before continuing to operate the system.

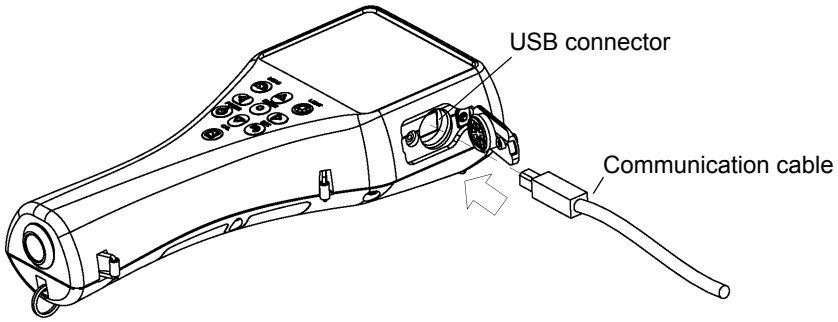


3.7 USB communication

The separately-sold, dedicated PC connection cable comes with data collection software. This software allows data to be downloaded from the control unit in CSV format.

This section contains instructions for communication commands used for USB communication.

● Connecting the cable



Dedicated cable

Part name: Communication cable (with data collection software)

Part no.: 3200174823

● Cautions when using USB communication

Take care to observe the following when using USB communication.

- Use the dedicated cable (with data collection software) or a commercially-available USB cable (A-B type) to connect to a PC.
- Be sure to match the transmission format on the control unit and the computer.
  The control unit uses the following transmission format:

Baud rate:	19200 bps
Number of stop bits:	1 bit
Data bit length:	8 bits
Parity:	None
Flow control:	None

Tip

If the transmission formats do not match, a communication error occurs and USB communication will not function normally. After changing the transmission format, restart the control unit and the computer.

- If received data is not sent back or an error occurs after a data request has been sent, adjust the program configuration so that it allows a little waiting time before a data request is sent again. This will enable more stable communication.
- The unit does not use DCD, CTS, or DSR signals. Take care of this when creating programs.

3.7.1 Communication settings

Baud rate:	19200 bps
Number of stop bits:	1 bit
Data bit length:	8 bits
Parity:	None
Flow control:	None

3.7.2 Commands

● Instant data requests

● Request command format

#	RD	@	XX	[CR]	[LF]
1	2	3	4		

1	Header	1 character
2	Command	2 characters
3	Delimiter character	1 character
4	Frame check sequence (FCS)	2 characters

The two ASCII-code characters created by converting the 8 bits of data created by successively combining the value of each character from # through @ in an exclusive OR (XOR) operation with the value of the next character.

Example: #RD@

(1)	0	XOR	35	(ASCII code of # symbol)	⇒	35
(2)	35	XOR	82	(ASCII code of R)	⇒	113
(3)	113	XOR	68	(ASCII code of D)	⇒	53
(4)	53	XOR	64	(ASCII code of @ symbol)	⇒	117 (decimal)
						↓
						75 (hex)
						↓
						Sets "75".

Example: 35 XOR 82 operation

35 in binary	⇒	0	0	1	0	0	0	1	1	
82 in binary	⇒	0	1	0	1	0	0	1	0	
XOR result		0	1	1	1	0	0	0	1	⇒ 113 (decimal)

Note: Set "XX" if you do not want to test for communication frame errors with FCS.

● Response format

#	RD	AAAAAAAAAAAAAAAAAAAA	X	X	XXXX	XX	X	X	XXXXX	X
1	2	3	4	5	6	7	8	9	10	11

XX	X	X	XXXXX	X	XX	X	X	XXXXX	X	XX	X	X	XXXXX	X
12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

XX	X	X	XXXXX	X	XX	X	X	XXXXX	X	XX	X	X	XXXXX	X
27	28	29	30	31	32	33	34	35	36	37	38	39	40	41

XX	X	X	XXXXX	X	XX	X	X	XXXXX	X	XX	X	X	XXXXX	X
42	43	44	45	46	47	48	49	50	51	52	53	54	55	56

```
XX   X   X   XXXXX  X   XX   X   X   XXXXX  X   XX   X   X   XXXXX  X
57   58  59  60       61  62   63  64  65       66  67   68  69  70       71

XX  XX  XX  XX  XX  XX  XX  XX  XX  X   X   XXX  XX  XX  X   X   @   XX  [CR]  [LF]
72  73  74  75  76  77  78  79  80  81  82  83   84  85  86  87  88  89
```

1	Header		1 character
2	Command		2 characters
3	Site name	Upper- and lowercase letters, numbers, periods (.) hyphens (-) and spaces ( )	20 characters
4	Probe status	(3) Status code	1 character
5	Probe error	(4) Status error code	1 character
6	Unused		4 characters
7	Parameter 1 code	(1) Parameter code	2 characters
8	Parameter 1 status	(5) Parameter status code	1 character
9	Parameter 1 error	(6) Parameter error code	1 character
10	Parameter 1 data	5 characters including decimal point, right-justified with blanks filled	5 characters
11	Parameter 1 unit	(2) Unit code	1 character
12	Parameter 2 code	(1) Parameter code	2 characters
13	Parameter 2 status	(5) Parameter status code	1 character
14	Parameter 2 error	(6) Parameter error code	1 character
15	Parameter 2 data	5 characters including decimal point, right-justified with blanks filled	5 characters
16	Parameter 2 unit	(2) Unit code	1 character
17	Parameter 3 code	(1) Parameter code	2 characters
18	Parameter 3 status	(5) Parameter status code	1 character
19	Parameter 3 error	(6) Parameter error code	1 character
20	Parameter 3 data	5 characters including decimal point, right-justified with blanks filled	5 characters
21	Parameter 3 unit	(2) Unit code	1 character
22	Parameter 4 code	(1) Parameter code	2 characters
23	Parameter 4 status	(5) Parameter status code	1 character
24	Parameter 4 error	(6) Parameter error code	1 character
25	Parameter 4 data	5 characters including decimal point, right-justified with blanks filled	5 characters
26	Parameter 4 unit	(2) Unit code	1 character
27	Parameter 5 code	(1) Parameter code	2 characters
28	Parameter 5 status	(5) Parameter status code	1 character
29	Parameter 5 error	(6) Parameter error code	1 character
30	Parameter 5 data	5 characters including decimal point, right-justified with blanks filled	5 characters
31	Parameter 5 unit	(2) Unit code	1 character
32	Parameter 6 code	(1) Parameter code	2 characters
33	Parameter 6 status	(5) Parameter status code	1 character
34	Parameter 6 error	(6) Parameter error code	1 character

35	Parameter 6 data	5 characters including decimal point, right-justified with blanks filled	5 characters
36	Parameter 6 unit	(2) Unit code	1 character
37	Parameter 7 code	(1) Parameter code	2 characters
38	Parameter 7 status	(5) Parameter status code	1 character
39	Parameter 7 error	(6) Parameter error code	1 character
40	Parameter 7 data	5 characters including decimal point, right-justified with blanks filled	5 characters
41	Parameter 7 unit	(2) Unit code	1 character
42	Parameter 8 code	(1) Parameter code	2 characters
43	Parameter 8 status	(5) Parameter status code	1 character
44	Parameter 8 error	(6) Parameter error code	1 character
45	Parameter 8 data	5 characters including decimal point, right-justified with blanks filled	5 characters
46	Parameter 8 unit	(2) Unit code	1 character
47	Parameter 9 code	(1) Parameter code	2 characters
48	Parameter 9 status	(5) Parameter status code	1 character
49	Parameter 9 error	(6) Parameter error code	1 character
50	Parameter 9 data	5 characters including decimal point, right-justified with blanks filled	5 characters
51	Parameter 9 unit	(2) Unit code	1 character
52	Parameter 10 code	(1) Parameter code	2 characters
53	Parameter 10 status	(5) Parameter status code	1 character
54	Parameter 10 error	(6) Parameter error code	1 character
55	Parameter 10 data	5 characters including decimal point, right-justified with blanks filled	5 characters
56	Parameter 10 unit	(2) Unit code	1 character
57	Parameter 11 code	(1) Parameter code	2 characters
58	Parameter 11 status	(5) Parameter status code	1 character
59	Parameter 11 error	(6) Parameter error code	1 character
60	Parameter 11 data	5 characters including decimal point, right-justified with blanks filled	5 characters
61	Parameter 11 unit	(2) Unit code	1 character
62	Parameter 12 code	(1) Parameter code	2 characters
63	Parameter 12 status	(5) Parameter status code	1 character
64	Parameter 12 error	(6) Parameter error code	1 character
65	Parameter 12 data	5 characters including decimal point, right-justified with blanks filled	5 characters
66	Parameter 12 unit	(2) Unit code (6) Parameter error code	1 character
67	Parameter 13 code	(1) Parameter code	2 characters
68	Parameter 13 status	(5) Parameter status code	1 character
69	Parameter 13 error	(6) Parameter error code	1 character
70	Parameter 13 data	5 characters including decimal point, right-justified with blanks filled	5 characters
71	Parameter 13 unit	(2) Unit code	1 character
72	Year	00 to 99	2 characters

73	Month	01 to 12	2 characters
74	Day	01 to 31	2 characters
75	Hour	00 to 23	2 characters
76	Minute	00 to 59	2 characters
77	Second	00 to 59	2 characters
78	Longitude (degrees)	00 to 90 or "--" (no GPS data)	2 characters
79	Longitude (minutes)	00 to 59 or "--" (no GPS data)	2 characters
80	Longitude (seconds)	00 to 59 or "--" (no GPS data)	2 characters
81	Unused	1 character	1 character
82	North latitude/South latitude	N: North; S: South	1 character
83	Latitude (degrees)	000 to 180 or "---" (no GPS data)	3 characters
84	Latitude (minutes)	00 to 59 or "--" (no GPS data)	2 characters
85	Latitude (seconds)	00 to 59 or "--" (no GPS data)	2 characters
86	Unused		1 character
87	East longitude/West longitude	E: East; W: West	1 character
88	Delimiter character		1 character
89	Frame check sequence (FCS)		2 characters

Memory data requests

Request command format

#	RM	X	X	AAAAAAAAAAAAAAAAAAAA	XX	XX	XX	@	XX	[CR]	[LF]
1	2	3	4	5	6	7	8	9	10		

1	Header		1 character
2	Command		2 characters
3	Data specification*1	0: Start search; 1: Next data item; 2: Previous data item; 3: Request same data again	1 character
4	Search method specification	0: All data; 1: Site search; 2: Date search	1 character
5	Search site*2	Upper- and lowercase letters, numbers, periods (.) hyphens (-) and spaces ( )	20 characters
6	Search year*3	00 to 99	2 characters
7	Search month*3	01 to 12	2 characters
8	Search day*3	01 to 31	2 characters
9	Delimiter character		1 character
10	Frame check sequence (FCS)		2 characters

*1: When sending the RM command, first send 0 [Start search], then 1 [Next data item], 2 [Previous data item] or 3 [Request same data again].

*2: [Search site] is only needed when [Site search] is specified as the search method. If another search method is specified, fill this field with spaces.

*3: [Search year], [Search month] and [Search day] are only needed when [Date search] is specified as the search method. If another search method is specified, fill this field with spaces.

● **Response format**

(when data exists)

```
#   RM  AAAAAAAAAAAAAAAAAAAA   XX  X   X   XXXXX  X
1   2   3                      4   5   6   7      8

XX  X   X   XXXXX  X   XX  X   X   XXXXX  X   XX  X   X   XXXXX  X
9   10  11  12     13  14  15  16  17     18  19  20  21  22     23

XX  X   X   XXXXX  X   XX  X   X   XXXXX  X   XX  X   X   XXXXX  X
24  25  26  27     28  29  30  31  32     33  34  35  36  37     38

XX  X   X   XXXXX  X   XX  X   X   XXXXX  X   XX  X   X   XXXXX  X
39  40  41  42     43  44  45  46  47     48  49  50  51  52     53

XX  X   X   XXXXX  X   XX  X   X   XXXXX  X   XX  X   X   XXXXX  X
54  55  56  57     58  59  60  61  62     63  64  65  66  67     68

XX  XX  XX  XX  XX  XX  XX  XX  XX  X   X   XXX  XX  XX  X   X   @   XX  [CR]  [LF]
69  70  71  72  73  74  75  76  77  78  79  80   81  82  83  84  85  86
```

1	Header		1 character
2	Command		2 characters
3	Site name	Upper- and lowercase letters, numbers, periods (.) hyphens (-) and spaces ( )	20 characters
4	Parameter 1 code	(1) Parameter code	2 characters
5	Parameter 1 selection	0: No selection; 1: Selection made	1 character
6	Parameter 1 error	(6) Parameter error code	1 character
7	Parameter 1 data	5 characters including decimal point, right-justified with blanks filled	5 characters
8	Parameter 1 unit	(2) Unit code	1 character
9	Parameter 2 code	(1) Parameter code	2 characters
10	Parameter 2 selection	0: No selection; 1: Selection made	1 character
11	Parameter 2 error	(6) Parameter error code	1 character
12	Parameter 2 data	5 characters including decimal point, right-justified with blanks filled	5 characters
13	Parameter 2 unit	(2) Unit code	1 character
14	Parameter 3 code	(1) Parameter code	2 characters
15	Parameter 3 selection	0: No selection; 1: Selection made	1 character
16	Parameter 3 error	(6) Parameter error code	1 character
17	Parameter 3 data	5 characters including decimal point, right-justified with blanks filled	5 characters
18	Parameter 3 unit	(2) Unit code	1 character
19	Parameter 4 code	(1) Parameter code	2 characters
20	Parameter 4 selection	0: No selection; 1: Selection made	1 character

21	Parameter 4 error	(6) Parameter error code	1 character
22	Parameter 4 data	5 characters including decimal point, right-justified with blanks filled	5 characters
23	Parameter 4 unit	(2) Unit code	1 character
24	Parameter 5 code	(1) Parameter code	2 characters
25	Parameter 5 selection	0: No selection; 1: Selection made	1 character
26	Parameter 5 error	(6) Parameter error code	1 character
27	Parameter 5 data	5 characters including decimal point, right-justified with blanks filled	5 characters
28	Parameter 5 unit	(2) Unit code	1 character
29	Parameter 6 code	(1) Parameter code	2 characters
30	Parameter 6 selection	0: No selection; 1: Selection made	1 character
31	Parameter 6 error	(6) Parameter error code	1 character
32	Parameter 6 data	5 characters including decimal point, right-justified with blanks filled	5 characters
33	Parameter 6 unit	(2) Unit code	1 character
34	Parameter 7 code	(1) Parameter code	2 characters
35	Parameter 7 selection	0: No selection; 1: Selection made	1 character
36	Parameter 7 error	(6) Parameter error code	1 character
37	Parameter 7 data	5 characters including decimal point, right-justified with blanks filled	5 characters
38	Parameter 7 unit	(2) Unit code	1 character
39	Parameter 8 code	(1) Parameter code	2 characters
40	Parameter 8 selection	0: No selection; 1: Selection made	1 character
41	Parameter 8 error	(6) Parameter error code	1 character
42	Parameter 8 data	5 characters including decimal point, right-justified with blanks filled	5 characters
43	Parameter 8 unit	(2) Unit code	1 character
44	Parameter 9 code	(1) Parameter code	2 characters
45	Parameter 9 selection	0: No selection; 1: Selection made	1 character
46	Parameter 9 error	(6) Parameter error code	1 character
47	Parameter 9 data	5 characters including decimal point, right-justified with blanks filled	5 characters
48	Parameter 9 unit	(2) Unit code	1 character
49	Parameter 10 code	(1) Parameter code	2 characters
50	Parameter 10 selection	0: No selection; 1: Selection made	1 character
51	Parameter 10 error	(6) Parameter error code	1 character
52	Parameter 10 data	5 characters including decimal point, right-justified with blanks filled	5 characters
53	Parameter 10 unit	(2) Unit code	1 character
54	Parameter 11 code	(1) Parameter code	2 characters
55	Parameter 11 selection	0: No selection; 1: Selection made	1 character
56	Parameter 11 error	(6) Parameter error code	1 character
57	Parameter 11 data	5 characters including decimal point, right-justified with blanks filled	5 characters
58	Parameter 11 unit	(2) Unit code	1 character
59	Parameter 12 code	(1) Parameter code	2 characters

60	Parameter 12 selection	0: No selection; 1: Selection made	1 character
61	Parameter 12 error	(6) Parameter error code	1 character
62	Parameter 12 data	5 characters including decimal point, right-justified with blanks filled	5 characters
63	Parameter 12 unit	(2) Unit code	1 character
64	Parameter 13 code	(1) Parameter code	2 characters
65	Parameter 13 selection	0: No selection; 1: Selection made	1 character
66	Parameter 13 error	(6) Parameter error code	1 character
67	Parameter 13 data	5 characters including decimal point, right-justified with blanks filled	5 characters
68	Parameter 13 unit	(2) Unit code	1 character
69	Year	00 to 99	2 characters
70	Month	01 to 12	2 characters
71	Day	01 to 31	2 characters
72	Hour	00 to 23	2 characters
73	Minute	00 to 59	2 characters
74	Second	00 to 5	2 characters
75	Longitude (degrees)	00 to 90 or "--" (no GPS data)	2 characters
76	Longitude (minutes)	00 to 59 or "--" (no GPS data)	2 characters
77	Longitude (seconds)	00 to 59 or "--" (no GPS data)	2 characters
78	Unused		1 character
79	North latitude/South latitude	N: North; S: South	1 character
80	Latitude (degrees)	000 to 180 or "---" (no GPS data)	3 characters
81	Latitude (minutes)	00 to 59 or "--" (no GPS data)	2 characters
82	Latitude (seconds)	00 to 59 or "--" (no GPS data)	2 characters
83	Unused		1 character
84	East longitude/West longitude	E: East; W: West	1 character
85	Delimiter character		1 character
86	Frame check sequence (FCS)		2 characters

When no data exists, or memory is at capacity)

#	RM	@	XX	[CR]	[LF]
1	2	3	4		

1	Header	1 character
2	Command	2 characters
3	Delimiter character\	1 character
4	Frame check sequence (FCS)	2 characters

Memory data count request

Request command format

#	RN	@	XX	[CR]	[LF]
1	2	3	4		

1	Header	1 character
2	Command	2 characters
3	Delimiter character\	1 character
4	Frame check sequence (FCS)	2 characters

Response format

#	RN	XXXXX	@	XX	[CR]	[LF]
1	2	3	4	5		

1	Header		1 character
2	Command		2 characters
3	Total data count	0 to 10000	5 characters
4	Delimiter character\		1 character
5	Frame check sequence (FCS)		2 characters

Command parse failure response

#	??	X	XX	X	@	XX	[CR]	[LF]
1	2	3	4	5	6	7		

1	Header	1 character
2	Command	2 characters
3	Command parse failure reason*4	1 character
4	Received command*5	2 characters
5	(3) Status code for probe status*5	1 character
6	Delimiter character	1 character
7	Frame check sequence (FCS)	2 characters

*4: List of command parse failure reasons

1: Frame length error
2: FCS mismatch
3: Undefined command
4: Data error
5: Data out of range
6: No "@" delimiter character
7: No "#" header character
8: No [Carriage return] + [Line feed] footer
9: Cannot accept command in this timing.

*5: Only set for command parse failure reason 9, [Cannot accept command in this timing]. Otherwise this field is filled with spaces.

4 Maintenance

Tip

HORIBA recommends regular manufacturer maintenance checks in order to ensure a long product life.

4.1 Routine care

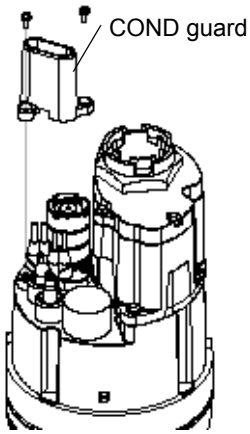
- **After measurement**

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power OFF.**

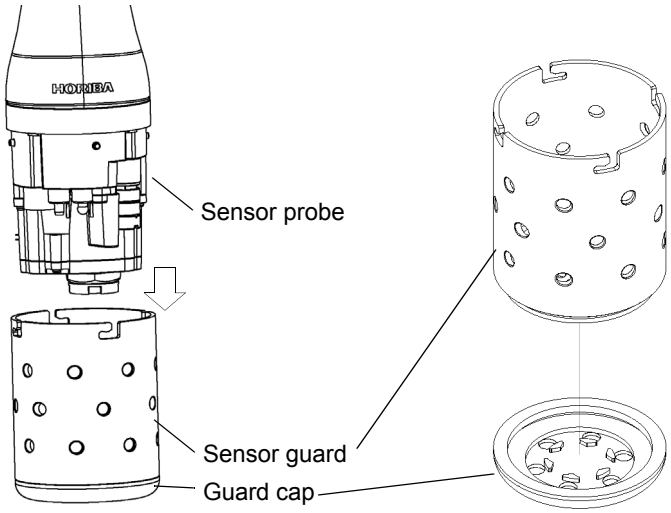
Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Remove the sensor guard, and clean the sensor with tap water.**
3. **Clean the turbidity sensor with the cleaning brush provided.**
4. **Remove the two screws securing the COND guard, and the COND guard itself, and use a test tube brush to gently remove any dirt from the electrical conductivity electrode.**



5. **Wipe off any dirt with a soft cloth. If parts are very dirty, clean them with neutral detergent, then rinse them. If parts are contaminated by oil, wipe it off with a soft cloth soaked in alcohol.**
6. **Put the COND guard back in place.**
7. **Remove the sensor guard's guard cap, wash off any dirt with tap water, then put the guard cap back in place.**



4.2 Every 2 months maintenance

● Dissolved oxygen (DO) sensor

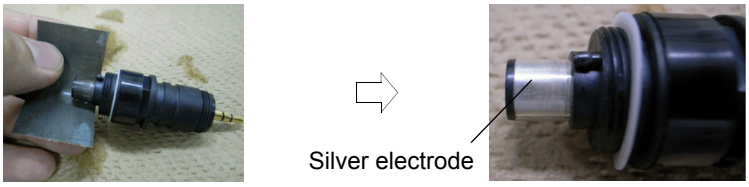
Note

- **The DO sensor's internal solution is potassium chloride (KCl). Although KCl is harmless, protective equipment such as gloves and goggles should be worn when working with it.**
- **Internal solution can be disposed of down a sink.**

- Replace the membrane cap.
- Polish the gold and silver electrodes when replacing the membrane cap.
  The gold electrode does not need to be polished if it is not dirty.

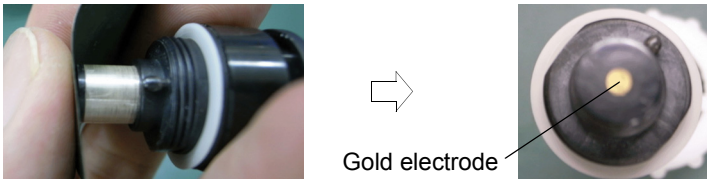
- **Silver electrode**

  Polish a silver electrode part with sandpaper (#500) and then wash metal electrode parts with water.



- **Gold electrode**

  Polish a gold electrode part with sandpaper (#8000) and then wash metal electrode parts with water.



Replace a membrane cap after clean metal electrodes parts.
Refer to “ 4.5 Replacing the membrane cap ” (page 87).

- **Reference electrode**

Note

- **The pH reference internal solution is potassium chloride (KCl). Although KCl is harmless, protective equipment such as gloves and goggles should be worn when working with it.**
- **Internal solution can be disposed of down a sink.**

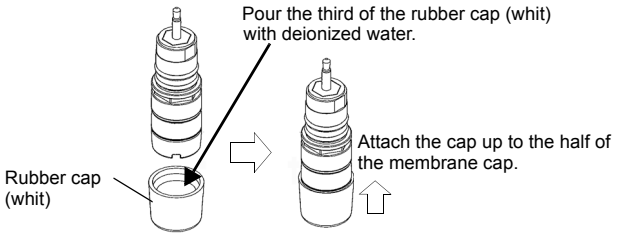
1. **Remove the rubber liquid junction plug from the reference electrode and dispose of the internal solution.**
2. **To prevent air entering, fill the reference electrode to the brim with its internal solution (No. 330).**
3. **Put the rubber liquid junction plug back in place.**

   If the rubber liquid junction plug is dirty, replace the liquid junctions (set of two; No. 9037005100). The reference electrode's internal solution will spill when replacing the liquid junctions. Rinse parts with tap water and dry them with a soft cloth.

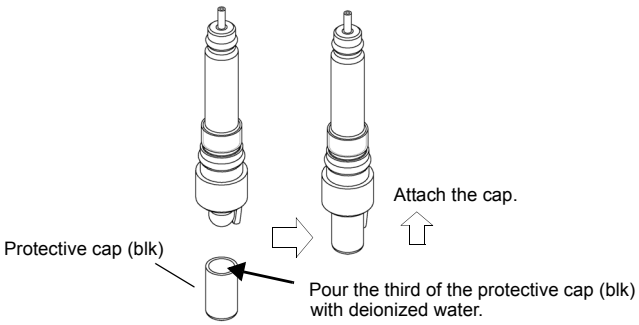
4.3 Storage

Short-term (under 2 months) storage

- Before storing the DO sensor, pour the third of the rubber cap (whit) provided with deionized water and cover the DO sensor with them.



- Before storing the pH sensor, pour the third of the protective cap (blk) provided with deionized water and cover the pH sensor with them.



Note

Before measuerment, remove the rubber cap (whit) and the protective cap (blk).

Long-term (2 months or more) storage

- Remove a membrane cap from DO sensor, and wash the gold electrode and silver electrode parts with water. Wipe off the moisture before storing DO sensor in the pack.
- Prevent internal solution seeping out of the reference chip by taping over the point of seepage with electrical tape.
- Before storing the system, remove the control unit's batteries to prevent battery leakage.

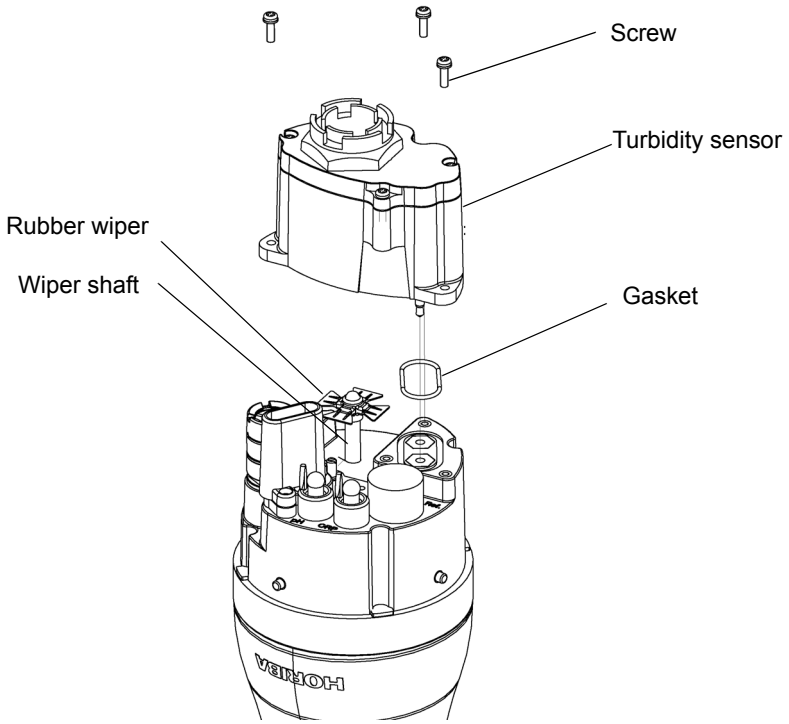
4.4 Replacing the turbidity sensor

1. **Press and hold down the control unit's POWER key for about 3 seconds to turn the power OFF.**

Note

The operation keys are designed to operate using the pad of a finger, sharp objects can tear the control unit cover damaging the operation keys.

2. **Remove the sensor guard, and clean the sensor probe with tap water.**
3. **Use dry air to blow away and dry off any moisture.**
4. **Remove the three screws holding the turbidity sensor by using No. 2 Phillips head screwdriver.**
5. **Pull out the turbidity sensor horizontally.**
6. **Remove the rubber wiper and gasket, and use a soft cloth to wipe off any dirt from the wiper shaft and turbidity sensor attachment. If parts are very dirty, use a soft cloth soaked in neutral detergent or alcohol.**
7. **Replace the rubber wiper and gasket with new ones. Coat the gasket with a thin layer of grease (No. 3014017718).**
8. **Attach the new turbidity sensor and fasten it in place with the three screws.**
9. **Perform four-point calibration before using the sensor.**



4.5 Replacing the membrane cap

Replacement procedure

1. **Prepare the DO sensor.**
   - Take a DO sensor out of pack (newly purchasing).
   - Remove a DO sensor from the sensor probe (after use).

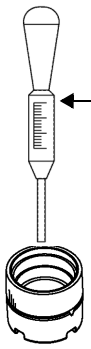
Newly purchasing

Undo a DO sensor from the sensor probe

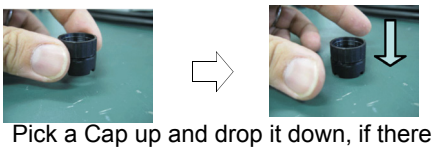
   - Twist a membrane cap from DO sensor.
   - Wash the gold electrode and silver electrode parts with water.

2. **Replace the silicone gasket with a new one.**

3. **Pour internal solution into a membrane cap with a dropper.**

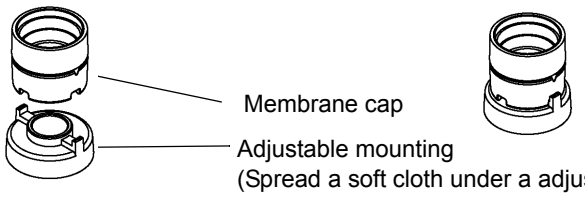


   - Check air bubbles in a membrane cap.

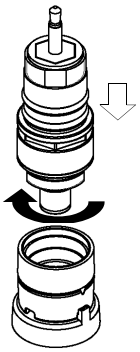


Pick a Cap up and drop it down, if there is air bubbles in internal solution of it.

4. **Set up a membrane cap on a adjustable mounting.**



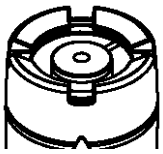
5. **Attach a membrane cap to DO sensor**



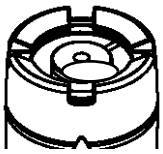
Twist a DO sensor
with holding a membrane cap tight.

6. **Check for membrane surface**

Check air bubbles in a membrane cap.



Good: Limited air bubbles



NG: Air bubbles of more than 5 mm in diameter

- NG → Replace a membrane cap again.
- Check that span calibration can be performed.

If the membrane cap is not attached correctly, sensitivity may be lost or response speed may decrease.

4.6 Troubleshooting

Note

If the sensor probe is removed while the control unit is indicating an error, errors cannot be canceled by using the ESC key. Either reconnect the sensor probe or restart the control unit.

4.6.1 Error displays

Error	Cause	Solution
Probe ADC error	Internal IC failure	Contact your nearest sales outlet to have the sensor probe repaired.
Probe EEPROM error/Factory	Internal IC failure	Turn the power OFF, then restart the system. If the error persists, initialize the system from the "System" menu. If the error still persists, contact your nearest sales outlet to have the sensor probe repaired.
Probe EEPROM error/User	Internal IC failure	Turn the power OFF, then restart the system. If the error persists, initialize the system from the "System" menu. If the error still persists, contact your nearest sales outlet to have the sensor probe repaired.
Turbidity sensor light source error	Turbidity sensor light source failure	Turn the power OFF, wipe off any water droplets on the probe, then remove the turbidity sensor. Check there are no water droplets around the turbidity sensor connector, then mount the sensor again. If the error persists, replace the turbidity sensor.
Turbidity sensor wiper motor error	The turbidity sensor wiper is not operating.	Press the ESC key. Check there are no obstacles near the wiper, then perform the measurement again. If the error persists, the motor will need to be replaced. Contact your nearest sales outlet to have the sensor probe repaired.
Probe capacitor error	Low battery voltage or internal IC failure	Turn the power OFF. Replace the display's batteries. If the error persists, contact your nearest sales outlet to have the sensor probe repaired.
Probe EEPROM error	Internal IC failure	Press the ESC key, then redo the operation. If the error persists, turn the power OFF, then restart the system (the current data will not be saved). If the error still persists, contact your nearest sales outlet to have the display repaired.
Probe board error	Probe board failure	Turn the power OFF. Contact your nearest sales outlet to have the sensor probe repaired.

Error	Cause	Solution
Zero-point calibration error	pH sensor 1. The pH standard solution is contaminated. 2. The pH-responsive membrane is dirty. 3. The concentration of the reference electrode's internal solution has changed. 4. The pH-responsive membrane is torn.	pH sensor 1. Replace the standard solution with new solution. 2. Clean the pH-responsive membrane. 3. Refil the reference electrode's internal solution. 4. Replace the sensor.
	COND sensor 1. There is moisture on the sensor. 2. The sensor is dirty. 3. The COND sensor is broken.	COND sensor 1. Blow-dry the moisture off the sensor. 2. Clean the sensor. 3. Contact your nearest sales outlet.
	TURB sensor 1. There are air bubbles on the cell. 2. The cell window is dirty. 3. The sensor is being affected by ambient light. 4. The solution is dirty. 5. The TURB sensor has failed.	TURB sensor 1. Shake the sensor probe vigorously. 2. Clean the cell window. 3. Calibrate using the calibration cup provided. 4. Replace the solution with new solution. 5. Replace the TURB sensor.
	DO sensor 1. There are air bubbles in the internal solution. 2. The DO sensor has failed.	DO sensor 1. Replace the diaphragm with a new one, and fill the DO sensor with new internal solution. 2. Replace the DO sensor.
	Water depth sensor 1. The water depth sensor is dirty. 2. The water depth sensor has failed.	Water depth sensor 1. Clean the water depth sensor. 2. Contact your nearest sales outlet.

Error	Cause	Solution
Span calibration error	pH sensor 1. The pH standard solution is contaminated. 2. The pH-responsive membrane is dirty. 3. The concentration of the reference electrode's internal solution has changed. 4. The pH-responsive membrane is torn.	pH sensor 1. Replace the standard solution with new solution. 2. Clean the pH-responsive membrane. 3. Refil the reference electrode's internal solution. 4. Replace the sensor.
	ORP sensor 1. The ORP standard solution is contaminated. 2. The ORP electrode is dirty. 3. The concentration of the reference electrode's internal solution has changed. 4. The ORP electrode has failed.	ORP sensor 1. Replace the standard solution with new solution. 2. Clean the ORP electrode. 3. Refil the reference electrode's internal solution. 4. Replace the ORP electrode.
	COND sensor 1. The calibration solution is not correct. 2. The sensor is dirty. 3. The COND sensor has failed.	COND sensor 1. Use the correct calibration solution for calibration. 2. Clean the sensor. 3. Contact your nearest sales outlet.
	TURB sensor 1. There are air bubbles on the cell. 2. The cell window is dirty. 3. The sensor is being affected by ambient light. 4. The solution is dirty. 5. The TURB sensor has failed.	TURB sensor 1. Shake the sensor probe vigorously. 2. Clean the cell window. 3. Calibrate using the calibration cup provided. 4. Replace the solution with new solution. 5. Replace the TURB sensor.
	DO sensor 1. The diaphragm is torn. 2. There are air bubbles in the internal solution. 3. The DO sensor has failed.	DO sensor 1. Replace the diaphragm with a new one, and fill the DO sensor with new internal solution. 2. Replace the diaphragm with a new one, and fill the DO sensor with new internal solution. 3. Replace the DO sensor.
	Temperature sensor The temperature sensor has failed.	Temperature sensor Contact your nearest sales outlet.
Calibration stability error	The calibration value of an individual parameter is not stable. 1. The sensor is dirty. 2. The sensor has not adjusted to the standard solution. 3. The temperature was unstable during calibration.	1. Clean the sensor. 2. Fill the transparent calibration cup with pH 4 standard solution, and wait for at least 20 minutes of conditioning before starting calibration. 3. Start calibration after the temperature has stabilized.
Turbidity calibration error	Error in turbidity measurement sequence	Turbidity calibration failed. Redo calibration after removing the displayed error.
Wet check	The cable connector is submerged.	Turn the power OFF and disconnect the cable connector. Wipe or blow-dry off all the water droplets on the probe. If the error persists, contact your nearest sales outlet to have the display and sensor probe repaired.
Power voltage error	The display's power board has failed.	This error could also be caused by poor cable contact. Turn the power OFF and disconnect the cable connector. Reconnect the connector and turn the power ON. If the error persists, contact your nearest sales outlet to have the display and sensor probe repaired.
Turbidity lamp power voltage error	The remaining battery level is low.	Turn the power OFF and replace the display's batteries with new ones.

Error	Cause	Solution
Display RTC error	The time display is incorrect.	Replace the coin battery.
Display FROM error	Internal IC failure	Contact your nearest sales outlet to have the control unit repaired.
Display EEPROM error	Internal IC failure	Contact your nearest sales outlet to have the control unit repaired.
Display save error	Insufficient memory space	Move data from the display, use the data operations screen to delete data, then redo the measurement.
Measurement sequence error	● When the measurement item is turbidity 1. The battery power is low. 2. The wiper is not operating normally. 3. The light source lamp is not lit. ● If items other than turbidity are also displayed 4. Board failure	1. Replace the batteries with new ones. 2. Check there are no obstacles near the wiper, then redo the measurement. If the error persists, the motor will need to be replaced. Contact your nearest sales outlet to have the sensor probe repaired. 3. Wipe off any water droplets on the probe, then remove the turbidity sensor. Check there are no water droplets around the turbidity sensor connector, then mount the sensor again. If the error persists, replace the turbidity sensor. 4. Contact your nearest sales outlet to have the sensor probe repaired.
Out of measurement range	The attempted measurement is outside the measurement range supported for that item.	The system must be used within its supported measurement ranges.
Last zero-point calibration invalid	pH sensor 1. The pH standard solution is contaminated. 2. The pH-responsive membrane is dirty. 3. The concentration of the reference electrode's internal solution has changed. 4. The pH-responsive membrane is torn.	pH sensor 1. Replace the standard solution with new solution. 2. Clean the pH-responsive membrane. 3. Refil the reference electrode's internal solution. 4. Replace the sensor.
	COND sensor 1. There is moisture on the sensor. 2. The sensor is dirty. 3. The COND sensor has failed.	COND sensor 1. Blow-dry the moisture off the sensor. 2. Clean the sensor. 3. Contact your nearest sales outlet.
	TURB sensor 1. There are air bubbles on the cell. 2. The cell window is dirty. 3. The sensor is being affected by ambient light. 4. The solution is dirty. 5. The TURB sensor has failed.	TURB sensor 1. Shake the sensor probe vigorously. 2. Clean the cell window. 3. Calibrate using the calibration cup provided. 4. Replace the solution with new solution. 5. Replace the TURB sensor.
	DO sensor 1. There are air bubbles in the internal solution. 2. The DO sensor has failed.	DO sensor 1. Replace the diaphragm with a new one, and fill the DO sensor with new internal solution. 2. Replace the DO sensor.
	Water depth sensor 1. The water depth sensor is dirty. 2. The water depth sensor has failed.	Water depth sensor 1. Clean the water depth sensor. 2. Contact your nearest sales outlet.
Out of measurement range	[See above.]	[See above.]
Last zero-point calibration invalid		

Error	Cause	Solution
Last span calibration invalid	pH sensor 1. The pH standard solution is contaminated. 2. The pH-responsive membrane is dirty. 3. The concentration of the reference electrode's internal solution has changed. 4. The pH-responsive membrane is torn.	pH sensor 1. Replace the standard solution with new solution. 2. Clean the pH-responsive membrane. 3. Refil the reference electrode's internal solution. 4. Replace the sensor.
	ORP sensor 1. The ORP standard solution is contaminated. 2. The ORP electrode is dirty. 3. The concentration of the reference electrode's internal solution has changed. 4. The ORP sensor glass is broken.	ORP sensor 1. Replace the standard solution with new solution. 2. Clean the ORP electrode. 3. Refil the reference electrode's internal solution. 4. Replace the sensor.
	COND sensor 1. The calibration solution is not correct. 2. The sensor is dirty. 3. The COND sensor has failed.	COND sensor 1. Use the correct calibration solution for calibration. 2. Clean the sensor. 3. Contact your nearest sales outlet.
	TURB sensor 1. There are air bubbles on the cell. 2. The cell window is dirty. 3. The sensor is being affected by ambient light. 4. The solution is dirty. 5. The TURB sensor has failed.	TURB sensor 1. Shake the sensor probe vigorously. 2. Clean the cell window. 3. Calibrate using the calibration cup provided. 4. Replace the solution with new solution. 5. Replace the TURB sensor.
	DO sensor 1. The diaphragm is torn. 2. There are air bubbles in the internal solution. 3. The DO sensor has failed.	DO sensor 1. Replace the diaphragm with a new one, and fill the DO sensor with new internal solution. 2. Replace the diaphragm with a new one, and fill the DO sensor with new internal solution. 3. Replace the DO sensor.
	Temperature sensor ● The temperature sensor has failed.	Temperature sensor ● Contact your nearest sales outlet.
Out of measurement range Last zero-point calibration invalid	[See above.]	[See above.]
Last span calibration invalid	The calibration value of an individual parameter is not stable. 1. The sensor is dirty. 2. The sensor has not adjusted to the standard solution. 3. The temperature was unstable during calibration.	1. Clean the sensors. 2. Fill the transparent calibration cup with pH 4 standard solution, and wait for at least 20 minutes of conditioning before starting calibration. 3. Start calibration after the temperature has stabilized.
Out of measurement range Last zero-point calibration invalid	[See above.]	[See above.]
Calibration value is factory default value.	Internal IC failure	Turn the power OFF, then restart the system. If the error persists, initialize the system from the "System" menu. If the error still persists, contact your nearest sales outlet to have the sensor probe repaired.

Error	Cause	Solution
Sample is unstable.	1. The concentration of the sample is unstable. 2. External light disturbance has affected the sensor. 3. Water has entered the turbidity sensor's connector.	1. Use a stirrer to agitate the sample during measurement. 2. Perform measurement away from direct sunlight. 3. Turn the power OFF, wipe off any water droplets on the probe, then remove the turbidity sensor. Check there are no water droplets around the turbidity sensor connector, then mount the sensor again. If the error persists, replace the turbidity sensor.

4.6.2 Error displays in sensor information

Error display	Cause	Solution
Measurement sequence error	Measurement sequence error	Turn the power OFF, then restart the system. If the error persists, have the probe repaired.
Out of measurement range	The measurement value is outside the measurement range.	Samples for measurement must be within the measurement range.
Last calibration invalid	The last calibration failed.	Redo calibration.
Calibration invalid	The calibration value is the factory default value.	Redo calibration.
Background unstable	The U-53 turbidity sensor is exposed to direct light.	Mount the guard cap and sensor guard and perform measurement away from direct sunlight.
	The turbidity value changed rapidly during measurement.	Measure a sample that has stable turbidity.

5 Specifications

Specification		Basic value	Model				
			U-51	U-52	U-52G	U-53	U-53G
Sensor probe	Measurement temperature range	−10°C to 55°C	✓	✓	✓	✓	✓
	Maximum sensor outer diameter	Approx. 96 mm					
	Sensor length	Approx. 340 mm					
	Cable length	2 m (standard) 10 m/30 m (options)					
	Mass	Approx. 1800 g					
	Auto calibration function	Uses pH 4 standard solution.					
	Measurement depth	30 m max.	✓	✓	✓	✓	✓
	Wet-part materials*3	PPS, glass, SUS316L, SUS304, FKM, PEEK, Q, titanium, FEP membrane, POM					
	Waterproofing standard	IP-68					
Control unit	Outer dimensions (W × D × H)	115 × 66 × 283 mm	✓	✓	—	✓	—
		115 × 66 × 335 mm	—	—	✓	—	✓
	Mass	Approx. 800 g	✓	✓	✓	✓	✓
	LCD	320 × 240 mm graphic LCD (monochrome) with backlight	✓	✓	✓	✓	✓
	Memory data items	10000	✓	✓	✓	✓	✓
	Communication interface	USB peripheral	✓	✓	✓	✓	✓
	Batteries	C-size dry cells (×4)	✓	✓	✓	✓	✓
	Waterproofing standard	IP-67	✓	✓	✓	✓	✓
	GPS unit	● Reception method (12 channel parallel) ● Measurement precision [With PDOP (high precision): 30 m or less (2 drms)]	—	—	✓	—	✓
	Estimated battery life*1	—	70 hours (no backlight)			500 measurements (no backlight)	
	Storage temperature range	−10°C to 60°C	✓	✓	✓	✓	✓
	Ambient temperature range	−5°C to 45°C					

Specification		Basic value	Model				
			U-51	U-52	U-52G	U-53	U-53G
pH measurement Two calibration	Measurement method	Glass electrode method	✓	✓	✓	✓	✓
	Range	pH 0 to 14					
	Resolution	0.01 pH					
	Precision*2	±0.1 pH					
Dissolved oxygen measurement ● Salinity conversion (0 to 70 PPT, automatic) ● Automatic temperature compensation	Measurement method	Polarographic method	✓	✓	✓	✓	✓
	Film thickness	25 μm					
	Range	0 mg/L to 50.0 mg/L					
	Resolution	0.01 mg/L					
	Precision*2	0 mg/L to 20 mg/L: ±0.2 mg/L 20 mg/L to 50 mg/L: ±0.5 mg/L					
Electrical conductivity measurement ● Auto range ● Automatic temperature conversion (25°C)	Measurement method	Four-AC-electrode method	✓	✓	✓	✓	✓
	Range	0 S/m to 10 S/m (0 mS/cm to 100 mS/cm)					
	Resolution	0.000 mS/cm to 0.999 mS/cm: 0.001 1.00 mS/cm to 9.99 mS/cm: 0.01 10.0 mS/cm to 99.9 mS/cm: 0.1 0.0 mS/m to 99.9 mS/m: 0.1 0.100 S/m to 0.999 S/m: 0.001 1.00 S/m to 9.99 S/m: 0.01					
	Precision*2	1% of full-scale (midpoint of two calibration points)					
Salinity measurement	Measurement method	Electrical conductivity conversion	✓	✓	✓	✓	✓
	Range	0 PPT to 70 PPT (parts per thousand)					
	Resolution	0.1 PPT					
	Precision	±3 PPT					
TDS (total dissolved solid) measurement ● Conversion coefficient setting	Measurement method	Electrical conductivity conversion	✓	✓	✓	✓	✓
	Range	0 g/L to 100 g/L					
	Resolution	0.1% of full-scale					
	Repeatability	±2 g/L					
	Precision	±5 g/L					
Seawater specific gravity measurement ● σt, σ0, σ15 display	Measurement method	Electrical conductivity conversion	✓	✓	✓	✓	✓
	Range	0 σt to 50 σt					
	Resolution	0.1 σt					
	Precision	±5 σt					

Specification		Basic value	Model				
			U-51	U-52	U-52G	U-53	U-53G
Temperature measurement	Measurement method	Platinum temperature sensor	✓	✓	✓	✓	✓
	Range	−10°C to 55°C					
	Resolution	0.01°C					
	Sensor	Platinum temperature sensor, JIS Class B (0.3 + 0.005 |t|)					
Turbidity measurement	Measurement method		–	LED forward 30° transmission/ scattering method		Tungsten lamp 90° transmission scattering method	
	Range			0 NTU to 800 NTU		0 NTU to 1000 NTU	
	Resolution			0.1 NTU		0.01 NTU	
	Precision*2			±5%of readout or ±1 NTU, whichever is larger		● ±0.5NTU (for 0 NTU to 10 NTU measurement range) ● 3% of readout or 1 NTU, whichever is larger (for 10 NTU to 1000 NTU measurement range)	
	Turbidity sensor wiper			–		✓	
Water depth measurement	Measurement method	Pressure method	–	–	✓	✓	✓
	Range	0 m to 30 m					
	Resolution	0.05 m					
	Precision*2	±0.3 m					
ORP (oxidation reduction potential) measurement	Measurement method	Platinum electrode method	✓	✓	✓	✓	✓
	Range	−2000 ～ +2000 mV					
	Resolution	1 mV					
	Precision*2	±15 mV					

*1: Battery life is estimated under following conditions.
- Continuous operation
- Using batteries: C-size alkaline dry cells
- Ambient temperature of the control unit: 20°C or more
- Backlight off

*2: The precision is defined by measuring the standard solution in the following cases.
- Turbidity and conductivity: after four point calibration
- pH and DO: after two point calibration
- Water depth and ORP: after one point calibration

*3: Metallic parts are made of stainless steel. Immersing in seawater may erode metallic parts.

6 Reference

6.1 Consumable parts

Sensor

Name	Model	No.	Description
pH sensor	#7112	3014057312	Standard type pH sensor
pH sensor ToupH	#7113	3200170923	Tough glass type pH sensor
ORP sensor	#7313	3200170920	
DO sensor	#7543	3200170924	
Reference electrode	#7210	3200043582	
R bush unit	—	3200043587	Reference electrode liquid junction
TURB cell U-52	#7800	3200172803	For U-52/U-52G
TURB cell U-53	#7801	3200172800	For U-53/U-53G
Membrane cap	—	3200170194	For DO sensor

Standard solution and inner solution

Name	Model	No.	Description
pH 4 (For automatic calibration) 500 mL	#100-4	3200043638	Standard solution for auto calibration. Also used for manual pH span calibration.
pH 4 (For automatic calibration) 4 L	#140-4	3200174430	
pH 7 500 mL	#100-7	3200043637	Standard solution for pH zero-point calibration.
pH 9 500 mL	#100-9	3200043636	Standard solution for pH manual span calibration.
Powder for ORP standard solution 10 packs	#160-51	3200043618	For ORP calibration.
Powder for ORP standard solution 10 packs	#160-22	3200043617	
Inner solution for DO sensor, 50 mL	#306	3200170938	Internal solution for DO sensor.
Internal solution for pH, 250 mL	#330	3200043641	Supplementary internal solution for pH reference electrode.

Others

Name	Model	No.	Description
Silicone grease	—	3014017718	Silicone grease for coating sensor O-ring.
Sponge brush unit	—	3200169531	Brush for cleaning sensor probe.
O-ring set for reference electrode	—	3200169376	O-rings for reference electrode.
O-ring set for DO sensor	—	3200169426	O-rings for DO sensor.
Rubber cap set for sensor guard	—	3200169428	Rubber caps used between sensor guard and sensor probe.
O-ring set for pH and ORP sensor	—	3200169520	O-rings for pH and ORP sensors.
Wiper unit	—	3200169789	Rubber wiper for U-53/U-53G turbidity sensors.
Protective cap (blk) for pH sensor	—	3200175019	Cap attached to tip of pH sensor for sensor probe storage.
Rubber cap (whit) for DO sensor	—	3200175020	Cap attached to tip of DO sensor for sensor probe storage.

6.2 Options sold separately

Name	Model	No.	Description
Bag	U-5030	3200174772	Storage bag for sensor probes and flow cell. Can be carried in one hand.
Flow cell assy	—	3200156570	Used when collecting measurement samples by pump.
Probe guard	—	3200167002	Used for taking measurements in locations where there is a current or where there is a thick layer of sludge.
Communication cable	—	3200174823	A PC connection cable. Comes with data collection software.

6.3 pH measurement

6.3.1 Principle of pH measurement

U-50 series use the glass electrode method for pH measurements. The glass electrode method measures a potential difference between the glass film for pH and the reference electrode. For more information, refer to “JIS Z 8802 pH measurement method”.

6.3.2 Temperature compensation

The electromotive force generated by the glass electrode changes depending on the temperature of the solution.

Temperature compensation is used to compensate for the change in electromotive force caused by temperature.

This function does not compensate the change in pH caused by the temperature of the solution. When pH is to be measured, the temperature of the solution must be recorded along with that pH value, even if a pH meter has automatic temperature compensation function. If the solution temperature is not recorded, the results of the pH measurement may be meaningless.

6.3.3 Standard solutions

When measuring pH, the pH meter must be calibrated using standard solution. There are five kinds of standard solutions specified in “JIS Z 8802 pH measurement”. For normal measurement, two of standard solutions with pH of 4, 7, and 9 are sufficient to accurately calibrate the meter.

For standard solutions, refer to “JIS Z 8802 pH measurement”.

pH 4 standard solution: (Phthalate) 0.05 mol/L potassium hydrogen phthalate aqueous solution

pH 7 standard solutio: (Neutral phosphate) 0.025 mol/L potassium dihydrogenphosphate, 0.025 mol/L disodium hydrogenphosphate aqueous solution

pH 9 standard solution: (Borate) 0.01 mol/L sodium tetraborate aqueous solution

Table 2 pH values of pH standard solutions at various temperatures settings

Temp. (℃)	pH 4 standard solution Phthalate	pH 7 standard solution Neutral phosphate	pH 9 standard solution Borate
0	4.01	6.98	9.46
5	4.01	6.95	9.39
10	4.00	6.92	9.33
15	4.00	6.90	9.27
20	4.00	6.88	9.22
25	4.01	6.86	9.18
30	4.01	6.85	9.14
35	4.02	6.84	9.10
40	4.03	6.84	9.07
45	4.04	6.84	9.04

6.4 DO measurement

6.4.1 Principle of DO measurement

Dissolved oxygen (DO) refers to the amount of oxygen that is contained in water.

The concentration of dissolved oxygen is generally given as mg/L or as a percentage value (the dissolved oxygen saturation ratio).

Dissolved oxygen is essential for maintaining the self-purifying ability of rivers and seas and also for fish to live. The concentration of dissolved oxygen acts as an indicator of water quality. It is often measured when processing waste water and managing water quality. Fig. 1 provides an overview of the principles behind dissolved oxygen sensor measurement.

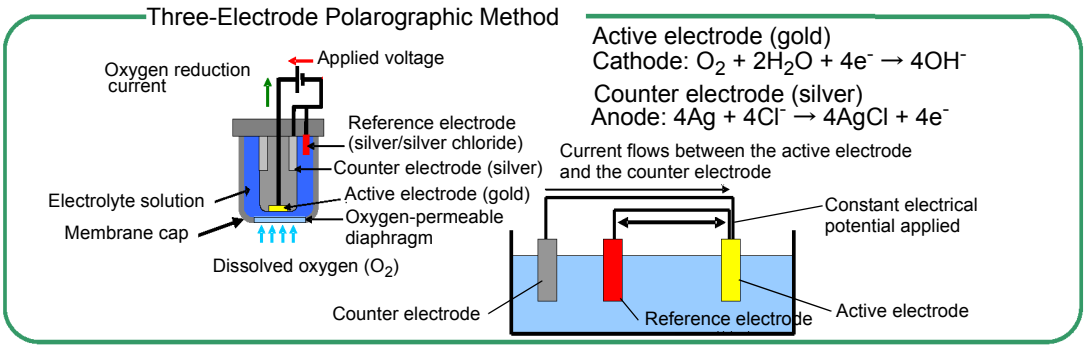


Fig. 1 Overview of principles behind dissolved oxygen sensor

The polarographic oxygen sensor is an enclosed sensor wherein voltage is applied to a cathode made of a precious metal (such as gold or platinum) and an anode also made of a precious metal (such as silver) via an external circuit, and a cap with an oxygen permeable diaphragm (membrane) is filled with electrolyte solution. As indicated in Fig. 1, the concentration of dissolved oxygen can be measured by measuring the current proportional to the amount of reduced oxygen when oxygen that has dispersed through the oxygen permeable diaphragm produces a reductive reaction on the surface of the active electrode (gold). The method of measuring dissolved oxygen based on the above principle is called the Membrane Electrode Method. Compared to the Chemical Analysis Method, which requires complicated pre-processing to alleviate the effect of reduced materials and oxidizing materials, this method allows dissolved oxygen to be measured very easily. It is also easy to remove undesired buildup from the silver electrode by polishing and cleaning if an insulator forms on it due to oxidation, making the method reusable.

6.4.2 Salinity calibration

When the solution and air come into contact and form an equilibrium (i.e. saturation), the relationship between the concentration of dissolved oxygen in the solution, C, [mol/L], and the partial pressure of oxygen in the air, Ps, [MPa/(mg/L)], can be represented by the following formula:

$$C = Ps/H$$

Where H [MPa/(mg/L)] is the Henry constant, a value that changes according to the composition of the solution. As H typically becomes larger as the salinity of the water increases, C becomes smaller.

The DO sensor detects the partial pressure of oxygen (Ps) in the above formula. Accordingly, if the DO sensor is immersed in deionized water saturated with air, or in an aqueous solution containing salt, the output current does not change, resulting in an erroneous measurement. For example, when salt is added to a sample, the amount of oxygen that can be dissolved in the solution decreases, but because the partial pressure of oxygen does not change, the value displayed by the control unit stays the same regardless of salt content. This concept is indicated in graph form below. (Fig. 2)

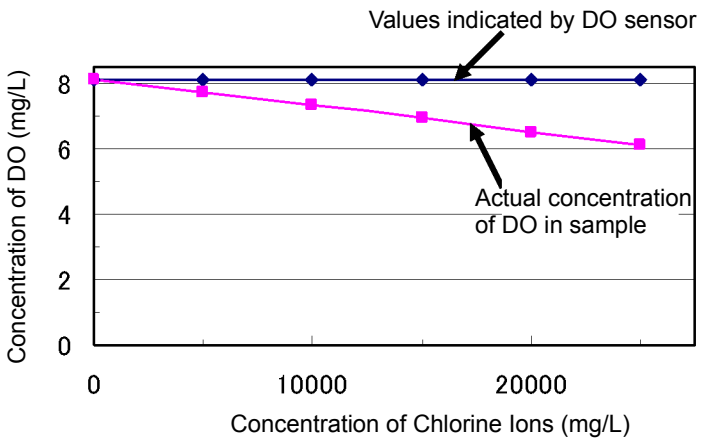


Fig. 2 Relationship between chlorine ion concentration and dissolved oxygen concentration

In samples with a high salt concentration, the solubility of oxygen is lower, but as the partial pressure of oxygen does not change, the value actually indicated on the control unit is higher than the actual value. In order to obtain a measurement of the concentration of dissolved oxygen in an aqueous solution that contains salt, it is therefore necessary to first perform salinity compensation. Conventionally, dissolved oxygen sensors have performed salinity compensation by inputting the salinity of the sample. This is fine as long as the salinity is already known. However, in most cases salinity is unknown, so even if dissolved oxygen sensors contained a salinity compensation function, it was of no practical use.

The U-50 Series can calculate and measure salinity in samples from electrical conductivity values, and can thus be used to automatically compensate for salinity.

6.5 Conductivity (COND) measurement

6.5.1 Four-AC-electrode method

Conductivity is an index of the flow of electrical current in a substance.

Salts dissolved in water are separated into cations and anions. Such solution is called electrolytic solution.

Electrolytic solution has the property of allowing the flow of current according to Ohm's law. This property is referred

to as ionic conductivity, since current flow is caused by ion movement in electrolytic solution.

Metals, on the other hand, allow the flow of current by means of electrons. This property is called electronic conductivity,

which is distinguished from ionic conductivity.

A cube with 1 m on each side, as shown in Fig. 3, is used to demonstrate an electrolytic solution. Two electrode plates are placed on opposite sides, and the cube is filled with solution. If the resistance between these two electrode plates is represented by r(Ω), the conductivity of the solution L($S \cdot m^{-1}$) is represented as L=1/r. S stands for Siemens, a unit of measurement of conductance.

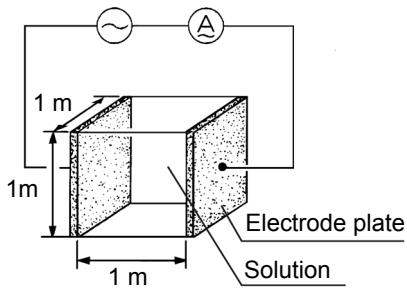


Fig. 3 Definition of conductivity

The most general method for measuring conductivity is based on the above principle, and is called the 2-electrode method.

In the 2-electrode method the influence of polarization cannot be ignored for solutions with high conductivity and conductivity cannot be measure accurately. In addition, contamination on the surface of the electrode increases apparent resistance, resulting in inaccurate measurement of conductivity.

The U-50 series has adopted the 4-electrode method to overcome these disadvantages of the the 2-electrode method.

As shown in Fig. 4, the U-50 series uses two voltage-detecting electrodes and two voltage-applying electrodes, for a total of four electrodes. The voltage-detecting electrodes are for detecting AC voltage, and the voltage-applying electrodes are for applying AC voltage.

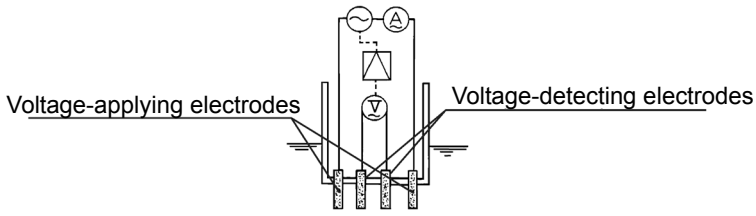


Fig. 4 Principle of the 4-electrode method

Let us assume that the current, I(A), flows in a sample of conductivity L – under automatic control of the voltage-applying electrodes – so that the voltage at the voltage-detecting-electrodes, E(V), remains constant at all times.
Then, the resistance of the sample, R(Ω), across the voltage-detecting electrodes is represented as R=E/I. The resistance, R, of the sample is inversely proportional to its conductivity, L. Accordingly, a measurement of current, Is,
of a standard solution of known conductivity, Ls, enables calculation of conductivity of a sample according to the formula L = Ls (I/Is) from the ratio L : Ls = I : Is.
Even in the 4-electrode method, polarization occurs, since AC current flows in the voltage-applying electrodes. The voltage-detecting electrodes are, however, free from the effects of polarization, since they are separated from the voltage-applying electrodes, and furthermore, current flow is negligible. Therefore, the 4-electrode method is an excellent method to enable measurement of conductivity covering a very high range.

6.5.2 SI units

New measurement units, called SI units, have been in use from 1996. Accordingly, the U-50 series also uses SI units. The following conversion table is provided for people who use the conventional kind of conductivity meter.
Note that along with the change in unit systems, the measurement values and cell counts have also changed.

	Former units	→	SI unit
Measurement value	0.1 mS/cm	→	0.01 S/m
	1 mS/cm	→	0.1 S/m
	100 mS/cm	→	10 S/m

6.5.3 Temperature coefficient

In general, the conductivity of a solution varies largely with its temperature.
The conductivity of a solution depends on the ionic conductivity, described earlier. As the temperature rises, conductivity becomes higher since the movement of the ions becomes more active.
The temperature coefficient shows the change in % of conductivity per °C, with a certain temperature taken as the reference temperature. This is expressed in units of %/°C. The temperature coefficient assumes the premise that the conductivity of a sample changes linearly according to temperature.
Strictly speaking, with actual samples, however, conductivity changes along a curve. Furthermore, the cuve varies with the type of sample. In the ranges of smaller temperature changes, however, samples are said to have the temperature coefficient of 2%/°C (at reference temperature 25°C); this holds for most samples, except in certain special cases.
(The temperature coefficients for various types of solutions are listed on the next page.)
The U-50 series uses an automatic temperature conversion function to calculate conductivity at 25°C at a temperature
coefficient of 2 %/°C based on the measured value of the temperature. Results are displayed on the readout.
The U-50 series's temperature conversion function is based on the following formula.
$L_{25} = L_t / \{ 1 + K (t - 25) \}$
L_{25} : Conductivity of solution converted to 25°C
t : Temperature of solution at time of measurement (°C)
L_t : Conductivity of solution at t (°C)
K : Temperature coefficient (%/°C)

Conductivity and temperature coefficient for various solutions

Conductivity and related temperature coefficients of representative substances (at 25°C) are shown in the table below.

Substance	Temp. (ºC)	Conc. (wt%)	Cond. (S/m)	Temp.coef. (%/°C)	Substance	Temp. (ºC)	Conc. (wt%)	Cond. (S/m)	Temp.coef. (%/°C)
NaOH	15	5	19.69	2.01	NaCl	18	5	6.72	2.17
		10	31.24	2.17			10	12.11	2.14
		15	34.63	2.49			15	16.42	2.12
		20	32.70	2.99			20	19.57	2.16
		30	20.22	4.50			25	21.35	2.27
		40	11.64	6.48	Na_2SO_4	18	5	4.09	2.36
KOH	15	25.2	54.03	2.09			10	6.87	2.49
		29.4	54.34	2.21			15	8.86	2.56
		33.6	52.21	2.36	Na_2CO_3	18	5	4.56	2.52
		42	42.12	2.83			10	7.05	2.71
NH_3	15	0.1	0.0251	2.46			15	8.36	2.94
		1.6	0.0867	2.38	KCl	18	5	6.90	2.01
		4.01	0.1095	2.50			10	13.59	1.88
		8.03	0.1038	2.62			15	20.20	1.79
		16.15	0.0632	3.01			20	26.77	1.68
HF	18	1.5	1.98	7.20			21	28.10	1.66
		4.8	5.93	6.66	KBr	15	5	4.65	2.06
		24.5	28.32	5.83			10	9.28	1.94
HCl	18	5	39.48	1.58			20	19.07	1.77
		10	63.02	1.56	KCN	15	3.25	5.07	2.07
		20	76.15	1.54			6.5	10.26	1.93
		30	66.20	1.52			—	—	—
H_2S0_4	18	5	20.85	1.21	NH_4Cl	18	5	9.18	1.98
		10	39.15	1.28			10	17.76	1.86
		20	65.27	1.45			15	25.86	1.71
		40	68.00	1.78			20	33.65	1.61
		50	54.05	1.93			25	40.25	1.54
		60	37.26	2.13	NH_4NO_3	15	5	5.90	2.03
		80	11.05	3.49			10	11.17	1.94
		100.14	1.87	0.30			30	28.41	1.68
		—	—	—			50	36.22	1.56
HNO_3	18	6.2	31.23	1.47	$CuSO_4$	18	2.5	10.90	2.13
		12.4	54.18	1.42			5	18.90	2.16
		31	78.19	1.39			10	32.00	2.18
		49.6	63.41	1.57			15	42.10	2.31
		62	49.64	1.57	CH_3COOH	18	10	15.26	1.69
H_3PO_4	15	10	5.66	1.04			15	16.19	1.74
		20	11.29	1.14			20	16.05	1.79
		40	20.70	1.50			30	14.01	1.86
		45	20.87	1.61			40	10.81	1.96
		50	20.73	1.74			60	4.56	2.06

6.6 Salinity (SAL) conversion

The U-50 series is designed to calculate salinity as well as the other parameters.

Note that the “salinity” here is the salinity of sea water. There is a constant relation between conductivity and salinity at certain temperatures.

Therefore, if data on the conductivity and temperature are available, the corresponding salinity can be known. In other words, the salinity measurement of the U-50 series is based on the principle of calculating the salt content, making use of the measured values of conductivity and temperature.

Note therefore, that measured results of all substances whose conductivity is detected are displayed as salinity. For example, the measured result is displayed as NaCl concentration, even if in fact the sample component is, hydrochloric acid (HCl).

6.7 TDS conversion

TDS is short for Total Dissolved Solids and means the total dissolved solid amount.

The conductivity of a solution is affected by the amount of salinity, minerals, and dissolved gases. That is, conductivity is an index that shows the total amount of all substances in the solution. Of these substances, TDS indicates only the amount of dissolved solids.

TDS can be used for a comparison of the state of substances composed of a single component such as NaCl. However, the use of TDS for the comparison of solutions of different types causes serious errors.

Conductivity and TDS are expressed by the following formulas.

Conductivity in SI units (S/m) ..... TDS(g/L) = L (S/m) $\times$ K $\times$ 10

TDS(g/L) = L (mS/m) $\times$ K $\div$ 100

Conductivity in the old units (mS/cm) ..... TDS(g/L) = L (mS/cm)$\times$ K

K = TDS coefficient

Initial settings use the values listed in the table (Page 80) that generally uses TDS coefficients.

For accurate TDS comparisons, find the TDS coefficient from measured conductivity values. Then set the value thus obtained and make measurements.

6.8 σt conversion

- **Specific gravity of seawater**

The density and specific gravity of seawater are equal numerically and generally are not distinguished strictly. Since seawater density ρ is between 1.000 and 1.031, 1 is subtracted from ρ and σ is obtained by multiplying the value by 1000.

The resultant value is used as the specific gravity of seawater.

$\sigma = (\rho - 1) \times 1000$

The density of seawater ρ is expressed by function of temperature, hydraulic pressure, and salinity. The density of seawater under the atmospheric pressure is expressed as σ_t. The density of seawater under the atmospheric pressure is determined by temperature and salinity.

The U-50 Series models make salinity measurement through temperature measurements and conductivity conversion and find σ_t through calculations.

In Japan σ_{15} at 15°C is called a standard specific gravity and widely used while in foreign countries σ_0 at 0°C is employed. σ_{15} and σ_0 are determined by the function of salinity.

In ocean surveys, in particular, these values σ_t, σ_{15}, and σ_0 are more widely used than conductivity and salinity and, in the U-50 Series models, newly added as measurement components.

6.9 Turbidity (TURB) measurement

6.9.1 Principle of turbidity measurement

U-52 and U-53 sensors measure turbidity using the Transmitting and Scattering Method shown in Fig. 5. U-52 sensors use a pulse light LED (infra-red emitting diode) as a light source, and detect scattered light from a 30° angle off center. U-53 sensors use a tungsten lamp as a light source and detect scattered light from a 90° angle. Both models display turbidity as a ratio of scattered light to transmitted light to reduce the affect of the color of the sample. The U-53 method conforms to EPA Method 180.1, and employs wipers to reduce the affect of air bubbles.

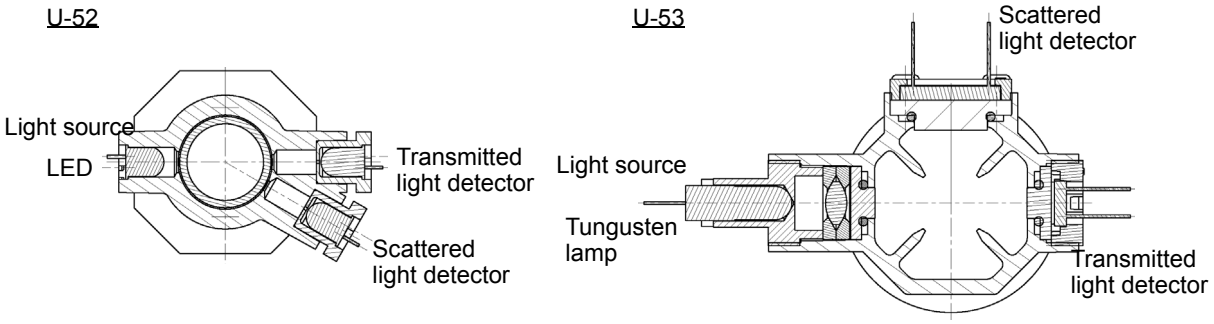


Fig. 5 Turbidity cell

6.9.2 Standard solution

U-50 series can perform calibration using formazin (NTU) or kaolin standard solutions as a turbidity standard solution. However, units for the solution used for calibration should be displayed in measurements. Do not use more than 400 mg/L of kaolin standard solution because it increases precipitation speed, resulting in measurement error.

6.10 Depth (DEPTH) measurement

6.10.1 Principle of depth measurement

For the W-22XD and W-23XD models, depth measurement can be made through use of a pressure gauge. The principle of the depth measurement uses the relation between depth and pressure.

Although the measurement with the depth sensor is affected by atmospheric pressure, the depth sensor, however, makes zero-point adjustments through the automatic calibration before measurements.

6.10.2 Influence of temperature and calibration

The depth sensor depends greatly on temperature. For a wide difference between the temperature at which the sensor has been automatically calibrated and the temperature of the measurement sample, the sensor can make depth measurements with a higher accuracy by the following method:

1. **Immerse the depth sensor of the sensor probe in the sample.**
2. **Keep the sensor immersed in the sample for about 30 minutes until the temperatures of the sensor and the sample are the same.**
3. **Then make the zero calibration of the sensor manually.**

6.11 Oxidation reduction potential (ORP) measurement

6.11.1 Principle of ORP measurement

ORP is an abbreviation for oxidation-reduction potential. ORP is the energy level (potential) determined according to the state of equilibrium between the oxidants (M^{Z+}) and reductants $M^{(Z-N)+}$ that coexist within a solution.

$$M^{Z+} + ne^- \Leftrightarrow M^{(Z-N)+} \qquad \cdots (1)$$

If only the solution, forming the ORP measuring system shown in Fig. 6. The difference of potential between two electrodes is generally expressed by the following equation.

$$E = E_0 - \frac{RT}{nF} \ln \frac{a_M{}^{(z-n)+}}{a_M{}^{z+}} \qquad \cdots (2)$$

E: Electric potential E_0 : Constant R: Gas constant T : Absolute temperature
n: Electron count F : Faraday constant a : Activity

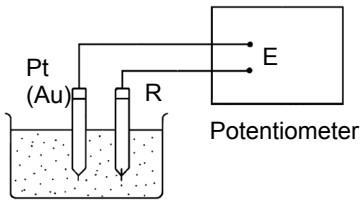


Fig. 6 Measuring mV

For example, for a solution in which trivalent iron ions coexist with bivalent iron ions, equations 1 and 2 would be as follows.

$$Fe^{3+} + e^- \Leftrightarrow Fe^{2+} \qquad \cdots (1)$$

$$E = E_0 - \frac{RT}{F} \ln \frac{a_{Fe}{}^{2+}}{a_{Fe}{}^{3+}} \qquad \cdots (2)$$

When only one type of state of equilibrium uniquely by equation (Fe^{3+}) and the reductant (Fe^{2+}) (using the equation $a_{Fe}{}^{2+}/ a_{Fe}{}^{3+}$). Actually, however many kinds of states of equilibrium exist simultaneously between various kinds of ions, in most solutions. This means that under actual circumstances, ORP cannot be expressed using the simple equation shown above and that the physical and chemical significance with respect to the solution is not very clear.
In this respect, the value of ORP must be understood to be only one indicator of the property of a solution. The measurement of ORP is widely used, however, as an important index in the analysis of solutions (potentiometric titration) and in the waste water treatment.

6.11.2 Standard electrode (reference electrode) types and ORP

The ORP is obtained comparing with corresponding reference electrode employed.
If different kinds of reference electrodes are used for measurement, the ORP value of the same solution may appear to be different. HORIBA's reference electrode uses Ag/AgCl with 3.33 mol/L KCl as inner solution. According to general technical literature, normal hydrogen electrodes (N.H.E.) are often used as the standard electrode.
The relationship between N.H.E. and the ORP that is measured using an Ag/AgCl with 3.33 mol/L KCl electrode is expressed by the following equation.
$E_{N.H.E.} = E + 206 - 0.7(t - 25)$ mV t = 0 - 60°C
$E_{N.H.E.}$: Measured ORP value using N.H.E. as the reference electrode

E: Measured ORP value using Ag/AgCl with 3.33 mol/L KCl as the reference electrode
Potential sign
Standard ORP is expressed in the following way, in literature related to electrochemistry and analytical chemistry.

A $Li^{+} + e^{-} \rightarrow Li$
$E_0 = -3.024$ V VS N.H.E.

However, in some literature, the "+" and "-" signs are reversed.

B $Li \rightarrow Li^{+} + e^{-}$
$E_0 = +3.024$ V VS N.H.E.

In expressions like B, above, the reaction is just reversed and there is no essential difference. But this kind of expression does invite confusion. The majority of the world, today, is consistent in its use of the signs as they are used in A, above.
For this reason, HORIBA, too, uses signs concerning ORP that are consistent with A, above.

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Tetra Tech Internal Standard Operating Procedures (SOP)

Field SOP - 1

Dissolved Oxygen

METHOD #: SM 4500-O G Membrane Electrode Method (APHA Standard Methods online)

TITLE: Dissolved Oxygen (Membrane Electrode)

ANALYTE: Dissolved Oxygen

INSTRUMENTATION: Dissolved Oxygen sensor - Horiba U-52

LOCATION: Determined on-site in the field

1.0 Scope and Application

1.1 This method is applicable to drinking, surface, and saline waters, groundwater, and domestic and industrial wastes.

2.0 Summary of Method

2.1 The DO of a sample is determined by measurement using a membrane electrode probe. The Horiba U-52 uses a polarographic oxygen sensor which consists of a cathode made of a precious metal (such as gold or platinum) and an anode also made of a precious metal (such as silver) bathed in an electrolyte solution and capped with an oxygen permeable diaphragm (membrane). The permeable plastic membrane serves as a diffusion barrier against impurities in the test solution that can cause electrode poisoning or other interferences. After passing through the permeable membrane, the oxygen is reduced by an applied potential voltage that is referenced to the anode. Reduction of oxygen to hydroxide ion (OH-) occurs at the cathode surface. An electrical current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode. Under steady-state conditions the current is directly proportional to the DO concentration.

2.2 Because the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary maintain fresh solution near the membrane interface, either by using a flow-through cell or by stirring the test solution.

3.0 Sample Handling and Preservation

3.1 Samples must be unpreserved and analyzed immediately (i.e., within 15 minutes of sample collection) in the field at the time of sampling.

3.2 Flow-through cells are to be used for all groundwater monitoring well samples collected using low-flow purging and sampling procedures.

3.3 Surface water samples are measured by placing the probe directly into the water body. Other aqueous samples are measured by placing the probe directly into the sample in a clean plastic or glass container. If not using a flow through cell for sampling, sample containers should be carefully filled with as minimal disturbance and aeration as possible. The sample container should be overflowing with at least 1-2 volumes of sample prior to sample analysis and filled from the bottom with tubing, if possible.

4.0 Interferences

4.1 Dissolved oxygen can be defined as the volume of oxygen contained in a volume of water. The solubility of oxygen in water is dependent on the water temperature, salinity, and pressure. As the temperature of the water decreases, the solubility of oxygen increases. As salinity increases, the solubility of oxygen decreases. And finally, as the pressure decreases (altitude increases), the solubility of oxygen decreases.

4.2 Dissolved organic materials are not known to interfere with the output from dissolved oxygen probes.

4.3 As noted above, dissolved inorganic salts are a factor in the performance of dissolved oxygen probes.

4.3.1 Probes with membranes respond to a partial pressure of oxygen which in turn is a function of dissolved inorganic salts. Conversion factors for seawater and brackish waters may be calculated from dissolved oxygen saturation versus salinity data. Conversion factors for specific inorganic salts may be developed experimentally. Broad variations in the kinds and concentrations of salts in samples can make the use of a membrane probe difficult.

4.3.2 The Horiba U-52 can calculate and measure salinity in samples from electrical conductivity values and can provide automatic compensation for salinity.

4.4 Reactive compounds can interfere with the output or the performance of dissolved oxygen probes.

4.4.1 Reactive gasses which pass through the membrane probes may interfere. For example, chlorine will depolarize the cathode and cause a high probe-output. Long-term exposures to chlorine will coat the anode with the chloride of the anode metal and eventually desensitize the probe.

4.4.2 Alkaline samples in which free chlorine does not exist will not interfere.

4.4.3 Hydrogen sulfide will interfere with membrane probes if the applied potential is greater than the half-wave potential of the sulfide ion. If the applied potential is less than the half-wave potential, an interfering reaction will not occur, but coating of the anode with the sulfide of the anode metal can take place. Prolonged use of membrane electrodes in waters containing such gases as hydrogen sulfide (H2S) tends to lower cell sensitivity. Eliminate this interference by frequently changing and calibrating the membrane electrode.

4.5 As noted above, dissolved oxygen probes are temperature sensitive. The Horiba U-52 provides automatic temperature compensation.

4.6 As noted above, differences in the atmospheric pressure of the measurement location influence the dissolved oxygen measurement. The Horiba U-52 is capable of compensating for changes in atmospheric pressure.

5.0 Apparatus

5.1 Horiba U-52. Tetra Tech GEO does not own a Horiba U-52 meter; therefore, the U-52 meter and flow-through cell must be rented from Pine Environmental Services, Inc. (Pine). Pine is a NJ Certified Laboratory that owns, maintains, and rents environmental field equipment, including the Horiba U-52. When ordering from Pine, a "NJ Lab Certified Meter" must be requested. Pine will then provide a calibrated Horiba U-52 along with Pre-Field Calibration documentation and Certificates of Analysis (COA) for the standards and compounds used during DO sensor calibration.

5.2 Upon receipt of the rental Horiba U-52 and before use, review the Pre-Field Calibration documentation and the COAs to make sure they are complete and apply to the meter and standards used during DO sensor calibration (i.e., meter serial number and standard lot numbers). Check the standards documentation to make sure they are not expired. If there are issues with the meters, standards, calibration documentation or COAs, contact Pine to resolve the issue and order a replacement meter or corrected documentation if necessary.

5.3 The Horiba U-52 may be rented from another environmental field equipment provider only if the selected rental company can provide the same pre-field calibrated equipment, documentation, standards, and COAs as Pine.

6.0 Reagents

6.1 Since the Horiba U-52 DO sensor is calibrated by Pine prior to receipt of the instrument by Tetra Tech GEO, no reagents are required.

7.0 Calibration

7.1 Weekly calibration of the Horiba U-52 DO sensor is conducted by Pine prior to delivering the instrument to Tetra Tech GEO (i.e., prior to use). Pine calibrates the DO sensor weekly using the Winkler titration and supplies Pre-Field Calibration documentation and COAs for the titrant used during calibration.

7.1.1 The Horiba U-52 meter must not be used for more than one week after the Winkler titration was performed. If the Horiba U-52 meter is required for DO measurements for more than one week, then the initial meter must be returned to Pine and another calibrated Horiba U-52 meter must be obtained.

7.2 The Horiba U-52 DO sensor must also be calibrated daily 1) in a sample with zero DO and 2) against air or air-saturated water prior to each use. Refer to the "manual" calibration procedures provided in the Horiba U-50 Series instruction manual (pages 56-59) for the two-point (i.e., zero and span) and the one-point (i.e., span only) calibration methods and use the procedures below:

7.2.1 Wait at least 20 minutes after turning the system power ON before calibrating the DO sensor.

7.2.2 Prepare the zero DO solution. Pour DI water into the 500 mL bottle containing Sodium Sulfite powder that is provided by Pine with the Horiba U-52. Immediately stir the mixture to get as much of the powder dissolved as possible (not all of the powder will dissolve). Do not shake the bottle, because it could aerate the water. Attach the bottle cap and let the solution stand for at least 5 to 10 minutes prior to use (recommended 20 minutes).

7.2.3 Perform the zero DO calibration.

7.2.3.1 Insert the Horiba U-52 probe into the black outer calibration cup and pour enough zero DO solution into the cup to completely submerge the DO sensor. Allow the unit to stabilize in the solution for at least 5 minutes (actual stabilization time may be 10-15 minutes).

7.2.3.2 If the DO value is ≤0.3 mg/L, record the result in the field logbook or on the daily calibration log sheet, along with the date and time of calibration and the initials of the analyst performing the calibration. Skip Section 7.2.4 and complete the 100% DO saturation calibration using the procedures in Section 7.2.5.

7.2.3.3 If the DO value is >0.3 mg/L, then proceed to Section 7.2.4 and perform a 2-point %DO saturation calibration (zero and 100% DO saturation), <u>starting with the probe still in the zero DO solution</u>.

7.2.4 Perform a 2-point %DO saturation calibration. Follow the instructions on page 25 in the Horiba U-50 Series instruction manual to select DO readings in %DO saturation, if not already selected and visible on the measurement screen.

7.2.4.1 First, calibrate the zero %DO point. Press the control unit's CAL key to set the calibration mode. Press the down arrow key to move the cursor to "Manual Calibration", then press the ENTER key. In the parameter selection screen, move the cursor to DO%, then press ENTER. Select two-point calibration and press ENTER.

7.2.4.2 Measure the temperature in the calibration chamber and observe the readings until the instrument stabilizes.

7.2.4.3 Press the up and down arrow keys to set the DO value to zero %DO saturation. Check that the "Measurement Value" has stabilized, then press the ENTER key to start calibration.

7.2.4.4 When the message "Cal complete. Press ENT to span cal" appears, press the ENTER key to start the span calibration procedure.

7.2.4.5 Next, calibrate the 100% DO saturation point. Pour out the zero DO solution and then place the DO sensor in the water-saturated air of the wet calibration cup.

7.2.4.6 Measure the temperature in the calibration chamber and observe the readings until the instrument stabilizes.

7.2.4.7 Press the up and down arrow keys to set the DO value to 100 %DO saturation. Check that the "Measurement Value" has stabilized, then press the ENTER key to start calibration.

7.2.4.8 Calibration is finished when the message "Cal complete. ENT to manual cal menu" appears. Press the ENTER key to return to the calibration parameter selection screen.

7.2.4.9 Record the calibration data in the field logbook or on the daily calibration log sheet, along with the date and time of calibration and the initials of the analyst performing the calibration.

7.2.5 Perform the 100% DO calibration in air.

7.2.5.1 The DO sensor is calibrated against air that is saturated with water at a known temperature and ambient atmospheric pressure. Follow the instructions on page 25 in the Horiba U-50 Series instruction manual to select DO readings in %DO saturation, if not already selected and visible on the measurement screen.

7.2.5.2 If the calibration cup is dry, then wet the inside of the calibration chamber with water, pour out the excess water (leave a few drops) and insert the sensor into the chamber (this ensures 100% humidity).

7.2.5.3 Allow adequate time for the DO sensor and the air inside the calibration chamber to equilibrate.

7.2.5.4 Press the control unit's CAL key to set the calibration mode. Press the down arrow key to move the cursor to "Manual Calibration", then press the ENTER key. In the parameter selection screen, move the cursor to DO%, then press ENTER. Select one point calibration and press ENTER.

7.2.5.5 Measure the temperature in the calibration chamber and observe the readings until the instrument stabilizes.

7.2.5.6 Press the up and down arrow keys to set the DO value to 100% DO saturation. Check that the "Measurement Value" has stabilized, then press the ENTER key to start calibration.

7.2.5.7 When the message "Cal complete. Press ENT to manual cal menu" appears, press the ENTER key to return to the calibration parameter selection screen.

7.2.5.8 Record the calibration data in the field logbook or on the daily calibration log sheet, along with the date and time of calibration and the initials of the analyst performing the calibration.

8.0 Procedure

8.1 Turn the Horiba U-52 on by pressing the POWER button for about 3 seconds. The "MEASUREMENT" screen appears after about 10 seconds.

8.2 Verify that the Horiba U-52 DO sensor was calibrated less than one week ago as outlined in Section 7 above.

8.3 Check that "SINGLE MEASUREMENT" has been selected in the measurement screen.

8.4 Place the sample solution in a clean glass beaker or the flow-through cell provided with the U-52 using a sufficient volume to cover the sensing elements of

the electrodes and, if applicable, to give adequate clearance for stirring.

8.4.1 If measurements are collected on samples in a flow-through cell, no additional movement of the sample (i.e., stirring the sample) during measurement is necessary. Gently shake the sensor probe in the sample initially to remove any air bubbles from the sensors. Allow the sample to flow though the cell at a rate of approximately 0.2 to 0.5 liters per minute.

8.4.2 If surface water field measurements are being made, the electrodes may be immersed directly in the sample stream to an adequate depth and moved in a manner to insure sufficient sample movement across the electrode sensing element as indicated by drift free readings.

8.5 The DO value will appear on the screen. When the measurement values are stable, press the MEAS key to acquire the 5-second average. Record this DO value and the measurement temperature in the field logbook or on the well purge data sheet.

8.6 Record the following in the field logbook or on the well purge data sheet:

- type of analysis performed;
- instrument model;
- serial number;
- assigned sample ID;
- date;
- time of analysis;
- results to the nearest 0.1 mg/L:
- name or initials of person(s) collecting the sample and name or initials of person(s) performing the analysis; and,
- NJDEP Department Sanctioned Analytical Method (DSAM) used (i.e., SM 4500-O G).

9.0 Calculation

9.1 Dissolved oxygen meters read in milligrams of dissolved oxygen per liter of sample (mg/L DO). Record the DO value to the nearest 0.1 mg/L and temperature to the nearest degree °C.

10.0 Quality Control

10.1 If samples are collected without using a flow-through cell (i.e., a non-low-flow measurement of DO), then a duplicate sample will be collected and analyzed. Duplicate DO samples will be analyzed at a frequency of one per day.

10.2 If DO readings show distinct, unexplainable changes in DO levels, or if the probe has been in waters with high sulfides, the DO sensor may need recalibration. Contact a Pine technician for assistance.

11.0 Precision and Accuracy

11.1 The Horiba U-52 manufacturer's specification claims ±0.2 mg/L precision for DO concentrations from 0 mg/L to 20 mg/L and a resolution of 0.01 mg/L.

Bibliography

1. Standard Methods for the Examination of Water and Wastewater, SM 4500-O G online (Approved by Standard Methods Committee, 2001).

2. HORIBA Multi Water Quality Checker U-50 Series Instruction Manual, April, 2009.

3. EPA Method 360.1, Approved for NPDES (Issued 1971), online.

4. Field Measurement of Dissolved Oxygen, USEPA Region 4 Science and Ecosystem Support Division, Athens, Georgia, February 12, 2010.

5. Tetra Tech NUS, Inc., SOP # SA-1.1 Groundwater Sample Acquisition And Onsite Water Quality Testing, Revision 7, April 7, 2008

Field SOP – 2

pH

METHOD #: SM 4500-H^+ B. Electrometric Method (APHA Standard Methods online)

TITLE: pH (Electrometric)

ANALYTE: pH

INSTRUMENTATION: pH sensor - Horiba U-52

LOCATION: Determined on-site in the field

1.0 Scope and Application

1.1 This method is applicable to drinking, surface, and saline waters, groundwater, and domestic and industrial wastes.

2.0 Summary of Method

2.1 The pH of a sample is determined electrometrically using either a glass electrode in combination with a reference potential, or a combination electrode.

3.0 Sample Handling and Preservation

3.1 Samples must be unpreserved and analyzed immediately (i.e., within 15 minutes of sample collection) in the field at the time of sampling.

3.2 Flow-through cells are to be used for all groundwater monitoring well samples collected using low-flow purging and sampling procedures.

3.3 Surface water samples are measured by placing the probe directly into the water body. Other aqueous samples are measured by placing the probe directly into the sample in a clean plastic or glass container.

4.0 Interferences

4.1 Measurements of pH are affected by temperature via mechanical effects that change the properties in the electrodes. Errors in pH measurement are controlled by using instruments having temperature compensation or by calibrating the meter at the temperature of the samples. The Horiba U-52 provides automatic temperature compensation.

4.2 Temperature effects on the electrometric measurement of pH arise from two sources. The first is caused by the change in electrode output at various temperatures. This interference can be controlled with instruments having temperature compensation or by calibrating the electrode-instrument system at the temperature of the samples. The Horiba U-52 provides automatic temperature compensation. The second source is the change of pH inherent in the sample at various temperatures. This error is sample dependent and cannot be controlled; it should therefore be noted by reporting both the pH and temperature at the time of analysis.

4.3 Coatings of oily material or particulate matter can impair electrode response. These coatings can usually be removed by gentle wiping or detergent washing, followed by distilled water rinsing. Remove the sensor guard, and clean the sensor with tap water. Wipe off any dirt with a soft cloth. If parts are very dirty, clean them with neutral detergent, then rinse them. If parts are contaminated by oil, wipe it off with a soft cloth soaked in alcohol.

5.0 Apparatus

5.1 Horiba U-52. Tetra Tech GEO does not own a Horiba U-52 meter; therefore, the U-52 meter and flow-through cell must be rented from Pine Environmental Services, Inc. (Pine). Pine is a NJ Certified Laboratory that owns, maintains, and rents environmental field equipment, including the Horiba U-52. When ordering from Pine, a "NJ Lab Certified Meter" must be requested. Pine will then provide a calibrated Horiba U-52 along with Pre-Field Calibration documentation, pH standard buffer solutions (pH 4, 7, and 10 standards) for use during Daily/Field calibrations, and Certificates of Analysis (COA) for the pH standards.

5.2 Upon receipt of the rental Horiba U-52 and before use, review the Pre-Field Calibration documentation and the COAs to make sure they are complete and apply to the meter and standards received (i.e., meter serial number and standard lot numbers). Check the standards to make sure they are not expired. If there are issues with the meters, standards, calibration documentation or COAs, contact Pine to resolve the issue and order a replacement meter, replacement standards, or corrected documentation if necessary.

5.3 The Horiba U-52 may be rented from another environmental field equipment provider only if the selected rental company can provide the same pre-field calibrated equipment, documentation, pH standards, and COAs as Pine.

6.0 Reagents

6.1 Purchased standard buffer solutions of pH values that bracket the expected sample pH range. Only fresh, unexpired buffers are used for calibration and all buffered aliquots must be disposed of after use. Use buffers with nominal values of 4.0, 7.0 and 10.0 pH units for most situations. If the sample pH is outside the range of 4.0 to 10.0, then use two buffers that bracket the expected range with the pH 7 buffer being one of the two buffers.

6.2 Buffers must be labeled with the date received, date opened and expiration date. Discard any buffer that is past its expiration date.

6.3 Buffers must be disposed of after each use.

7.0 Calibration

7.1 The Horiba U-52 must be calibrated daily during use at a minimum of two points that bracket the expected pH of the samples and are at least three pH units apart. For most situations, calibrate using the pH 4 (zero point) and pH 10 (span) buffer solutions. Follow the "manual" calibration procedures provided in the Horiba U-50 Series instruction manual (pages 43-45).

7.2 Buffer calibration values must be within ±0.05 units of the expected value and recorded to 2 decimal places. If the calibration values are not within this range the meter must be recalibrated. Record these values and the measurement temperatures in the field logbook or on the daily calibration log sheet, along with the date and time of calibration and the initials of the analyst performing the calibration.

7.3 A calibration check standard must be analyzed immediately after the pH meter is calibrated. This calibration check must be performed with a third buffer within the calibration range that is three pH units apart from the calibration buffer values (i.e., if calibrated with pH 4 and pH 10 buffers, then perform the calibration check with a pH 7 buffer). If the calibration check standard values are not within ±0.10 pH units of the expected value, then meter must be recalibrated. Record these values and the measurement temperatures in the field logbook or on the daily calibration log sheet, along with the date and time of the calibration check and the initials of the analyst performing the calibration check.

7.4 When the pH meter is in use longer than three hours, re-verify the pH meter calibration once every three hours by measuring a new aliquot of the third buffer solution. The 3-hour check standard values must be within ±0.20 units of the expected value. Record these values and the measurement temperatures in the field logbook or on the daily calibration log sheet, along with the date and time of the 3-hour check and the initials of the analyst performing the 3-hour check.

7.4.1 If low-flow groundwater sampling is being conducted and it takes longer than 3 hours to purge a particular well, then the 3-hour check standard must be completed immediately after purging and sampling of the well is completed.

7.5 If the 3-hour check standard is more than ± 0.2 pH units from the expected value, the pH meter should be recalibrated or replaced and a notation recorded in the field logbook or on the calibration sheet. If the 3-hour check standard was measured following sample collection from a well that required more than 3 hours to complete purging and sampling, then a notation should also be recorded on the associated well purge data sheet.

8.0 Procedure

8.1 Turn the Horiba U-52 on by pressing the POWER button for about 3 seconds. The "MEASUREMENT" screen appears after about 10 seconds.

8.2 Calibrate the meter and pH electrode as outlined in Section 7 above.

8.3 Check that "SINGLE MEASUREMENT" has been selected in the measurement screen.

8.4 Place the sample or buffer solution in a clean glass beaker or the flow-through cell provided with the U-52 using a sufficient volume to cover the sensing elements of the electrodes and, if applicable, to give adequate clearance for stirring.

8.4.1 If measurements are collected on samples in a flow-through cell, no additional movement of the sample (i.e., stirring the sample) during measurement is necessary. Gently shake the sensor probe in the sample initially to remove any air bubbles from the sensors. Allow the sample to flow though the cell at a rate of approximately 0.2 to 0.5 liters per minute.

8.4.2 If surface water field measurements are being made, the electrodes may be immersed directly in the sample stream to an adequate depth and moved in a manner to insure sufficient sample movement across the electrode sensing element as indicated by drift free (< 0.1 pH) readings.

8.5 The pH value will appear on the screen. When the measurement values are stable, press the MEAS key to acquire the 5-second average. Record this pH value and the measurement temperature in the field logbook or on the well purge data sheet.

8.6 Record the following in the field logbook or on the well purge data sheet:

- type of analysis performed;
- instrument model;
- serial number;
- assigned sample ID;
- date;
- time of analysis;
- results to ± 0.1 pH units;
- name or initials of person(s) collecting the sample and name or initials of person(s) performing the analysis; and,
- NJDEP Department Sanctioned Analytical Method (DSAM) used (i.e., SM 4500-H+B).

9.0 Calculation

9.1 The Horiba U-52 meter reads directly in pH units. Report pH to the nearest 0.1 unit and temperature to the nearest degree °C.

10.0 Quality Control

10.1 A calibration check standard should be performed daily following initial calibration (follow procedures in Section 7.3 above).

10.2 A 3-hour check standard should be measured every three hours when the pH meter is in use longer than three hours (follow procedures in Sections 7.4 and 7.5 above).

10.3 If samples are collected without using a flow-through cell (i.e., a non-low-flow measurement of pH), then a duplicate sample will be collected and analyzed. Duplicate pH samples will be analyzed at a frequency of one per day.

11.0 Precision and Accuracy

11.1 Forty-four analysts in twenty laboratories analyzed six synthetic water samples containing exact increments of hydrogen-hydroxyl ions, with the following results:

pH Units	Standard Deviation pH Units	Accuracy as Bias %	Accuracy as Bias pH Unit
3.5	0.10	-0.29	-0.01
3.5	0.11	-0.00	
7.1	0.20	+1.01	+0.07
7.2	0.18	-0.03	-0.002
8.0	0.13	-0.12	-0.01
8.0	0.12	+0.16	+0.01

(FWPCA Method Study 1, Mineral and Physical Analyses)

11.2 In a single laboratory (EMSL), using surface water samples at an average pH of 7.7, the standard deviation was ± 0.1.

Bibliography

1. Standard Methods for the Examination of Water and Wastewater, SM 4500-H+B online (Approved by Standard Methods Committee, 2000).

2. Annual Book of ASTM Standards, Part 31, "Water", Standard D1293-65, p 178 (1976).

3. Peden, M. E. and Skowron, L. M., Ionic Stability of Precipitation Samples, Atmospheric Environment, Vol. 12, pp. 2343-2349, 1978.

4. HORIBA Multi Water Quality Checker U-50 Series Instruction Manual, April, 2009.

Field SOP – 3

Specific Conductance

SOP Title:	Specific Conductance (Wheatstone Bridge)
Parameter:	Specific Conductance - Aqueous
Category:	WPP02 – Inorganic Parameters, Nutrients and Demands
Revision No.:	Revision 0
Revision Date:	19 December 2011
NJDEP DSAM:	EPA 120.1
Applicable Code(s):	WPP02.45500
Page Nos.:	1 of 6

Approved By:
Steve Feldmann – QA Officer
Signature:

METHOD #: EPA 120.1 Method

TITLE: Conductance (Specific Conductance, µmhos at 25°C)

ANALYTE: Conductance

INSTRUMENTATION: Conductivity sensor - Horiba U-52

LOCATION: Determined on-site in the field

1.0 Scope and Application

1.1 This method is applicable to drinking, surface, and saline water, groundwater, and domestic and industrial wastes.

2.0 Summary of Method

2.1 The specific conductance of a sample is measured by use of a self-contained conductivity meter, Wheatstone bridge-type, or equivalent.

3.0 Sample Handling and Preservation

3.1 Samples must be unpreserved and analyzed immediately (i.e., within 15 minutes of sample collection) in the field at the time of sampling.

3.2 Flow-through cells are to be used for all groundwater monitoring well samples collected using low-flow purging and sampling procedures.

3.3 Surface water samples are measured by placing the probe directly into the water body. Other aqueous samples are measured by placing the probe directly into the sample in a clean plastic or glass container.

4.0 Interferences

4.1 Temperature variations and corrections represent the largest source of potential error. In general, the conductivity of an aqueous solution varies largely with its temperature. The conductivity of a solution depends on the ionic conductivity (i.e., the current flow caused by the movement of dissolved cations and anions in solution). As the temperature rises, conductivity becomes higher since the

movement of the ions becomes more active. The temperature coefficient shows the change in % of conductivity per °C, with a certain temperature taken as the reference temperature. This is expressed in units of %/°C. The temperature coefficient assumes the premise that the conductivity of a sample changes linearly according to temperature. Strictly speaking, with actual samples, however, conductivity changes along a curve. Furthermore, the curve varies with the type of sample. In the ranges of smaller temperature changes, however, samples are said to have the temperature coefficient of 2%/°C (at reference temperature 25°C); this holds for most samples, except in certain special cases. The Horiba U-52 uses an automatic temperature conversion function to calculate conductivity at 25°C at a temperature coefficient of 2%/°C based on the measured value of the temperature. Results are displayed on the readout.

4.2 Coatings of oily material or particulate matter can impair electrode response. These coatings can usually be removed by gentle wiping or detergent washing, followed by distilled water rinsing. Remove the sensor guard, and clean the sensor with tap water. Wipe off any dirt with a soft cloth. If parts are very dirty, clean them with neutral detergent, then rinse them. If parts are contaminated by oil, wipe it off with a soft cloth soaked in alcohol.

5.0 Apparatus

5.1 Horiba U-52. Tetra Tech GEO does not own a Horiba U-52 meter; therefore, the U-52 meter and flow-through cell must be rented from Pine Environmental Services, Inc. (Pine). Pine is a NJ Certified Laboratory that owns, maintains, and rents environmental field equipment, including the Horiba U-52. When ordering from Pine, a "NJ Lab Certified Meter" must be requested. Pine will then provide a calibrated Horiba U-52 along with Pre-Field Calibration documentation, a potassium chloride (KCl) standard solution (usually 1,413 µmhos/cm solution) for use during daily specific conductivity checks, and Certificates of Analysis (COA) for the standard solutions used during calibration and for daily checks.

5.2 Upon receipt of the rental Horiba U-52 and before use, review the Pre-Field Calibration documentation (including an initial 5-point calibration curve) and the lot-specific COAs to make sure they are complete and apply to the meter and standards received (i.e., meter serial number and standard lot numbers). Check the standards to make sure they are not expired. If there are issues with the meters, standards, calibration documentation or COAs, contact Pine to resolve the issue and order a replacement meter, replacement standards, or corrected

documentation if necessary.

5.3 The Horiba U-52 may be rented from another environmental field equipment provider only if the selected rental company can provide the same pre-field calibrated equipment, documentation, standards, and COAs as Pine.

6.0 Reagents

6.1 Purchased or laboratory prepared KCl standard solutions. Only fresh, unexpired standard solutions are to be used and all standard solution aliquots must be disposed of after use. Standard solutions provided by Pine should include a check standard (usually 1,413 µmhos/cm solution).

6.2 Standard solutions must be labeled with the date received, date opened and expiration date. Discard any standard solution that is past its expiration date.

6.3 Standard solutions must be disposed of after each use.

7.0 Calibration

7.1 An initial 5-point calibration of the Horiba U-52 must be performed by Pine prior to analysis. Analytical records documenting this calibration must be provided by Pine with the instrument when it is rented.

7.2 A KCl specific conductivity check standard must be analyzed daily or whenever specific conductivity samples are measured. The check standard should be analyzed at the beginning of the field day and prior to manual calibration of the Horiba U-52 pH electrode. <u>In order to be acceptable, the value obtained must be within ±1% of the expected value of the specific conductivity check standard.</u> Record the check standard measurement value in the field logbook or on the daily calibration log sheet, along with the date and time of the check standard analysis and the initials of the analyst performing the check standard analysis.

8.0 Procedure

8.1 Turn the Horiba U-52 on by pressing the POWER button for about 3 seconds. The "MEASUREMENT" screen appears after about 10 seconds.

8.2 Analyze the specific conductivity check standard as outlined in Section 7.

8.3 Check that "SINGLE MEASUREMENT" has been selected in the measurement screen.

8.4 Place the sample or check standard solution in a clean glass beaker or the flow-through cell provided with the U-52 using a sufficient volume to cover the sensing elements of the electrodes and, if applicable, to give adequate clearance for stirring.

8.4.1 If measurements are collected on samples in a flow-through cell, no additional movement of the sample (i.e., stirring the sample) during measurement is necessary. Gently shake the sensor probe in the sample initially to remove any air bubbles from the sensors. Allow the sample to flow though the cell at a rate of approximately 0.2 to 0.5 liters per minute.

8.4.2 If surface water field measurements are being made, the electrodes may be immersed directly in the sample stream to an adequate depth and moved in a manner to insure sufficient sample movement across the electrode sensing element as indicated by drift free readings.

8.5 The specific conductivity value will appear on the screen. When the measurement values are stable, press the MEAS key to acquire the 5-second average. Record this specific conductivity value and the measurement temperature in the field logbook or on the well purge data sheet.

8.6 Record the following in the field logbook or on the well purge data sheet:

- type of analysis performed;
- instrument model;
- serial number;
- assigned sample ID;
- date;
- time of analysis;
- results in either µmhos/cm or µS/cm;
- name or initials of person(s) collecting the sample and name or initials of person(s) performing the analysis; and,
- NJDEP Department Sanctioned Analytical Method (DSAM) used (i.e., EPA 120.1).

9.0 Calculation

9.1 The Horiba U-52 provides automatic temperature compensation and reads specific conductivity directly.

9.2 Specific conductivity measurements must be recorded in either µmhos/cm or µS/cm (these are equivalent units). The Horiba U-52 meter, however, reads specific conductivity directly in mS/cm or S/m. Adjust the meter to read specific conductivity values in mS/cm and record the measured values. Convert the recorded measurements to µS/cm (i.e., multiply the specific conductivity value in mS/cm by 1000).

10.0 Quality Control

10.1 A specific conductivity check standard should be performed daily (follow procedures in Section 7.3 above).

11.0 Precision and Accuracy

11.1 Forty-one analysts in 17 laboratories analyzed six synthetic water samples containing increments of inorganic salts, with the following results:

Increment as specific conductivity	Precision as Standard Deviation	Accuracy as Bias %	Accuracy as Bias µmhos/cm
100	7.55	-2.02	-2.0
106	8.14	-0.76	-0.8
808	66.1	-3.63	-29.3
848	79.6	-4.54	-38.5
1640	106	-5.36	-87.9
1710	119	-5.08	-86.9

(FWPCA Method Study 1, Mineral and Physical Analyses)

11.2 In a single laboratory (EMSL), using surface water samples with an average conductivity of 536 µmhos/cm at 25°C, the standard deviation was ± 6.

Bibliography

1. EPA Method 120.1, Approved for NPDES (Editorial Revision 1982).
2. HORIBA Multi Water Quality Checker U-50 Series Instruction Manual, April, 2009.

Field SOP – 4

Taylor Waterproof Digital Thermometer

Specifications

Measurement Range:
-40 to 450°F/-40 to 230°C

Accuracy:
+/- 1°F (.06°C) from 0 to 230°F (-18 to 110°C)
+/- 3.6°F (2°C) above 230°F (110°C) and below 0°F (-18°C)

Repeatability:
1°F (.55°C) from 0 to 200°F (-18 to 93°C)

Battery:
One (1) LR44, 1.5 volt alkaline (included)

Resolution:
0.1°F & °C full range

Temperature Display:
°C or °F selectable

Auto Shut off:
After 10 minutes if no change in temperature has occurred.

Stepdown Probe: 1.5mm diameter

Response Time :
6 seconds, with 2-second updates.

One Year Limited Warranty

This product is warranted against defects in materials or workmanship for one (1) year for the original purchaser from date of original purchase. It does not cover damages or wear resulting from accident, misuse, abuse, commercial use, or unauthorized adjustment and/or repair.

Should this product require service (or replacement at our option) while under warranty, do not return to retailer. Please pack the item carefully and return it prepaid, along with store receipt showing date of purchase and a note explaining reason for return to:

Taylor Precision Products
2220 Entrada Del Sol
Las Cruces, New Mexico 88001 USA
www.taylorusa.com

There are no express warranties except as listed above. This warranty gives you specific legal rights, and you may have other rights which vary from state to state.

Made to our exact specifications in China.

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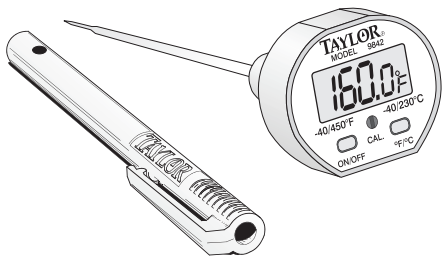
CP9842FDA 11.07

TAYLOR® **9842FDA**

Waterproof Digital Thermometer

Leading the Way in Accuracy®



Instruction Manual

Spécifications

Plage de mesure:
-40 à 450°F/-40 à 230°C

Exactitude:
+/- .06°C (1°F) de 0 à 230°F (-18 à 110°C)
+/- 2°C (3.6°F) au-dessus de 110°C (230°F) et de moins de -18°C (0°F)

Répétabilité:
.55°C (1°F) de -18 à 93°C (0 à 200°F)

Pile:
Un (1) pile 1,5 v LR44 de alcaline (incluse)

Résolution:
0,1 °F ou °C

Affichage de température:
°C ou °F sélectionnable

Arrêt automatique:
Après 10 minutes, s'il n'y a pas de changement de température

Sonde abaissement: 1,50 mm de diamètre

Temps de réaction:
6 secondes avec des mises à jour de 2 secondes

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Thermomètre numérique étanche

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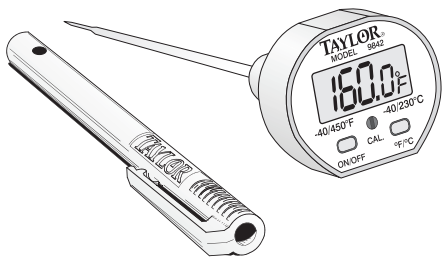

Manuel d'instructions

Especificaciones

Rango de medición:
-40 a 450°F/-40 a 230°C

Precisión:
+/- 1°F (.06°C) entre 0 a 230°F (-18 to 110°C)
+/- 3.6°F (2°C) sobre de 230°F (110°C) y abajo de 0°F (-18°C)

Repetibilidad:
1°F (.55°C) entre 0 a 200°F (-18 a 93°C)

Batería:
Una (1) batería LR44, 1.5V de alcalino (incluida)

Resolución:
0,1 °F o °C

Pantalla de temperatura:
°C o °F seleccionar

Apagado automático:
Después de 10 minutos si no hay cambio en la temperatura

Sonda reductora: diámetro de 1,5 mm

Tiempo de respuesta:
6 segundos, con actualizaciones de 2 segundos

Garantía limitada por un año

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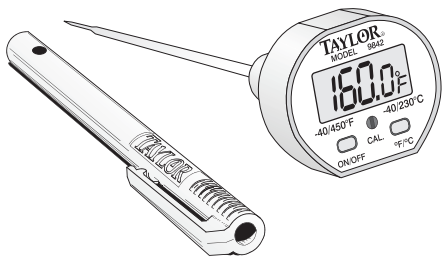
TAYLOR® **9842FDA**

Termómetro digital prueba de agua

Leading the Way in Accuracy®



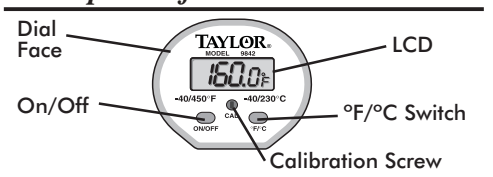
Manual de instrucciones

Thank you for purchasing a Taylor® Waterproof Digital thermometer. This state-of-the art measurement instrument is engineered and designed to meet the highest quality standards…to assure you uncompromising accuracy and consistently dependable, convenient performance. In order to optimize its function, please read this instruction manual carefully before use…and keep it handy for future reference.

General Operation

1. Sterilize the metal probe by inserting it into an appropriate solution such as boiling water for several minutes.
2. Turn unit on with "**On/Off**" button located on the dial face. Select Fahrenheit or Celsius using the button marked "**°F/°C**". **Note: To save battery life, this unit has an AUTO-OFF feature that turns the instrument off after 10 minutes if no change in temperature has occurred.**
3. When ready to test the temperature, insert stem at least 1" for the most accurate reading. The LCD will stabilize when reading is complete (*approximately 10 seconds*).
4. To avoid burns near heat, use the pocket sleeve as a handle by inserting the stem through the small hole at the top of the pocket sleeve.
5. Be sure to sanitize the stem before *inserting it into another product (See Antimicrobial Feature*).

Description of Parts



Battery Replacement

The thermometer operates on 1 LR44 (1.5v) battery (installed). Change the battery when display becomes dim. To replace battery:

1. Open battery door by sliding a screwdriver under the lip of the rubber battery door.
2. Tap the unit against your hand with the battery opening down to make the battery slide out.
3. Insert battery with positive side up (square end of battery)
4. Push rubber door in firmly so that the battery is all the way in position. **Note: If battery door is not closed properly, water can get into the battery compartment causing the unit to malfunction.**
5. It is recommended to only remove the battery door when necessary to replace the battery as this will help maintain water tight integrity.

Antimicrobial Feature

Taylor's Safe-T-Guard™ sleeve and housing incorporates a non-toxic chemical compound that inhibits the growth of harmful pathogens, which minimizes cross contamination. It is important to thoroughly clean and disinfect your thermometer after each use.

CAUTION

Not for use as an oven thermometer. Do not leave in oven. LCD case temperature exposure limits are 10° to 140°F. Do not expose stem tip to temperatures 50°F above or below measurement range (*see Specifications*).

Calibration

Digital thermometers that have a bead type thermistor sensor such as the model 9842 seldom require recalibration or testing. The reason for this is the long-term stability of the thermistor sensor. Nevertheless, if it is desirable to calibrate to a specific temperature, turn the calibration screw on the dial to the left to decrease the temperature reading or to the right to increase the reading. The following procedure is recommended if recalibrating at 32°F (0°C).

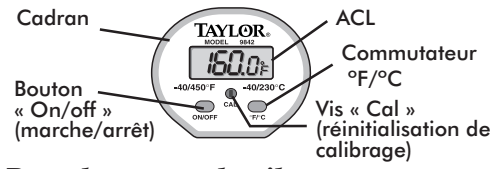
1. Fill a container with crushed or chipped ice.
2. Add water slowly until it overflows.
3. Add more ice until it is packed tightly to the bottom of the container, allowing excess to overflow.
4. Insert the stem of the thermometer at least 2″ into the container and allow it to stabilize for 5 minutes. Note: It is important that the tip of the thermometer not touch the bottom of the container.
5. If the temperature reading is 32°F, the thermometer is accurately calibrated. If necessary to adjust the thermometer, do so by small amounts and allow it to stabilize before making any additional adjustments.

Merci de votre achat d'un thermomètre numérique étanche Taylor®. Cet instrument de mesure à la fine pointe de la technologie est fabriqué et conçu pour répondre aux normes de qualité les plus élevées pour vous assurer des années d'exactitude sans compromis et une performance pratique, fiable constante. Pour optimiser cette fonction, veuillez lire attentivement ce manuel d'instructions avant d'utiliser votre produit … et gardez-le à portée de la main à titre de référence.

Fonctionnement général

1. Stérilisez la sonde métallique en l'insérant dans une solution appropriée, comme de l'eau bouillante, pendant plusieurs minutes.
2. Mettez l'appareil en marche avec le bouton «**On/off**» (marche/arrêt) sur le cadran. Choisissez Fahrenheit ou Celsius en utilisant le bouton marqué « **°F/°C** ». **Remarque: Pour conserver la pile, cet appareil comprend une fonction « AUTO-OFF » (arrêt automatique) qui éteint l'instrument après 10 minutes sans changement de température.**
3. Lorsque vous êtes prêt à tester la température, insérez la tige d'au moins 1 po (2,5 cm) pour le relevé le plus exact. L'ACL se stabilisera à la fin du relevé (*environ 10 secondes*).
4. Pour éviter les brûlures près de la chaleur, utilisez le manchon de poche comme poignée en insérant la tige à travers le petit trou sur le dessus du manchon de poche.
5. Assurez-vous de désinfecter la tige avant de l'insérer dans tout autre produit (*reportez-vous à la fonction Antimicrobienne*).

Description des pièces



Remplacement de pile

Le thermomètre fonctionne avec 1 pile LR44 (1,5 V) (installée). Changez la pile lorsque l'affichage faiblit. Pour remplacer la pile:

1. Ouvrez la porte de pile en glissant un tournevis sous la lèvre de la porte de pile de caoutchouc.
2. Frappez l'unité contre votre main avec l'ouverture de la pile vers le bas pour que la pile sorte.
3. Insérez la pile avec le côté positif vers le haut (extrémité carrée de la pile)
4. Poussez la porte de caoutchouc fermement pour que la pile soit bien en position. Remarque: Si la porte de piles n'est pas fermée correctement, l'eau pourrait pénétrer dans le compartiment et l'appareil fonctionnerait mal.
5. Il est recommandé de retirer la porte de pile seulement au besoin pour replacer la pile car ceci aidera à maintenir l'intégrité de l'étanchéité.

Fonction antimicrobienne

Le manchon et boîtier Safe-T-Guard™ de Taylor incorpore un composé chimique non-toxique qui prévient la croissance de pathogènes dangereux ce qui réduit la contamination croisée. Il est important de bien nettoyer et désinfecter votre thermomètre après chaque utilisation.

MISE EN GARDE

Ne doit pas être utilisé comme thermomètre de four. Ne laissez pas dans le four. Les limites d'exposition de température du boîtier à ACL sont de - 12 à 60 °C (10 à 140 °F). N'exposez pas le bout de la tige à des températures de plus ou de moins de 10 °C (50 °F) de la plage de mesure (lire spécifications).

Calibrage

Les thermomètres numériques qui ont une sonde à thermistance de type à bille comme le modèle 9842 n'exige pas souvent de recalibrage ou de test. La raison est la stabilité à long terme de la thermistance. Néanmoins, il est préférable de calibrer à une température précise, tournez la vis de calibrage sur le cadran vers la gauche pour réduire le relevé de température ou vers la droite pour augmenter le relevé. La procédure suivante est recommandée pour un recalibrage à 0 °C (32 °F).

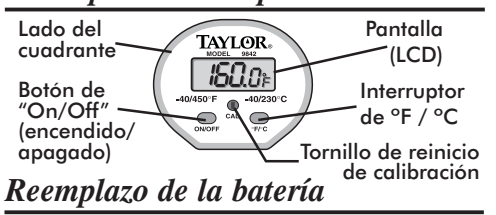
1. Remplissez un contenant avec de la glace concassée ou en copeaux.
2. Ajoutez lentement de l'eau jusqu'à ce que cela déborde.
3. Ajoutez plus de glace jusqu'à ce que le tout soit bien tassé au bas du contenant, laissant le surplus déborder.
4. Insérez la tige du thermomètre à au moins 5,08 cm (2 po) dans le contenant et laissez stabiliser pendant 5 minutes. **Remarque : Il est important que le bout du thermomètre ne touche pas le fond du contenant.**
5. Si le relevé de température est de 0°C (32 °F), le thermomètre est calibré avec exactitude. S'il faut ajuster le thermomètre, faites-le en petites quantités et laissez le tout stabiliser avant tout autre ajustement.

Gracias por comprar un Termómetro digital a prueba de agua Taylor®. Este instrumento de medición de vanguardia está construido y diseñado para cumplir con los más altos estándares de calidad... para asegurarle una exactitud constante y un funcionamiento sistemáticamente confiable y práctico. A fin de optimizar el funcionamiento de la unidad, antes de utilizarla lea este manual de instrucciones cuidadosamente… y téngalo a mano para referencia futura.

Funcionamiento general

1. Esterilice la sonda de metal introduciéndola en una solución adecuada, tal como agua hirviendo, durante varios minutos.
2. Encienda la unidad con el botón "**On/Off**" ubicado en el lado del cuadrante. Seleccione Fahrenheit o Celsius usando el botón marcado "**°F/°C**". Nota: para ahorrar vida útil de la batería, esta unidad cuenta con una característica de apagado automático que apaga el instrumento después de 10 minutos si no hay ningún cambio de temperatura.
3. Cuando esté listo para tomar la temperatura, introduzca el vástago al menos 1″ (2,5 cm) para obtener la lectura más precisa. La pantalla LCD se estabilizará cuando la lectura esté completa (*aproximadamente 10 segundos*).
4. Para evitar quemaduras cerca del calor, utilice la funda como un asa introduciendo el vástago a través del orificio pequeño que está en la parte superior de la funda.
5. Asegúrese de desinfectar el vástago antes de introducirlo en otro producto (*Ver Característica antimicrobiana*).

Descripción de las partes



Reemplazo de la batería

El termómetro funciona con una batería LR44 (1,5v) (instalada). Cambie la batería cuando la pantalla se vuelva borrosa. Para reemplazar la batería:

1. Abra el compartimiento de la batería deslizando un destornillador bajo el borde de la puerta de goma del compartimiento de la batería.
2. Golpee la unidad contra la palma de su mano con la abertura para la batería hacia abajo para hacer salir la batería.
3. Introduzca la batería con el lado positivo hacia arriba (extremo cuadrado de la batería)
4. Presione la puerta de goma con firmeza para que la batería quede bien colocada. Nota: si la puerta del compartimiento no está correctamente cerrada, puede entrar agua en el mismo haciendo que la unidad funcione mal.
5. Se recomienda quitar la puerta del compartimiento de la batería únicamente cuando sea necesario para volver a colocar la batería ya que esto ayudará a mantener una integridad hermética.

Característica antimicrobiana

La funda y la carcasa Safe-T-Guard™ de Taylor incorporan un compuesto químico no tóxico que inhibe el crecimiento de agentes patógenos nocivos, lo cual minimiza la contaminación cruzada. Es importante limpiar y desinfectar totalmente su termómetro después de cada uso.

ATENCIÓN

No es para usar como termómetro para horno. No deje dentro del horno. Los límites de exposición de temperatura de la caja de la pantalla LCD son 10° a 140°F. No exponga la punta del vástago a temperaturas superiores a 50°F (10°C) o inferiores al rango de medición (vea especificaciones).

Calibración

Los termómetros digitales que tienen un sensor termistor como el modelo 9842 muy pocas veces requieren una recalibración o pruebas. El motivo de esto es la estabilidad a largo plazo del sensor termistor. Sin embargo, si desea calibrar a una temperatura específica, gire hacia la izquierda el tornillo de calibración que se encuentra en el cuadrante para disminuir la lectura de temperatura o hacia la derecha para aumentar la lectura. Se recomienda el siguiente procedimiento si va a recalibrar a 32°F (0°C).

1. Llene un recipiente de hielo picado o en cubitos.
2. Agregue agua lentamente hasta que se desborde.
3. Agregue más hielo hasta que el recipiente quede totalmente lleno hasta el fondo, permitiendo que el exceso se desborde.
4. Introduzca el vástago del termómetro al menos 2″ dentro del recipiente y permita que se estabilice durante 5 minutos. **Nota: Es importante que la punta del termómetro no toque el fondo del recipiente.**
5. Si la lectura de temperatura es de 32°F (0°C), el termómetro está calibrado correctamente. Si es necesario ajustar el termómetro, hágalo de a poco y permita que se estabilice antes de hacer ajustes adicionales.

Field SOP – 5

Temperature

METHOD #: SM 2550-B Temperature (APHA Standard Methods online)

TITLE: Temperature (Thermometric)

ANALYTE: Temperature

INSTRUMENTATION: Temperature sensor - Horiba U-52

LOCATION: Determined on-site in the field

1.0 Scope and Application

1.1 This method is applicable to drinking, surface, and saline waters, groundwater, and domestic and industrial wastes.

2.0 Summary of Method

2.1 Temperature measurements are made with a Horiba U-52, which measures temperature via a platinum temperature sensor.

3.0 Sample Handling and Preservation

3.1 Samples must be unpreserved and analyzed immediately in the field at the time of sampling (i.e., within 15 minutes of sample collection).

3.2 Flow-through cells are to be used for all groundwater monitoring well samples collected using low-flow purging and sampling procedures.

3.3 Surface water samples are measured by placing the probe directly into the water body. Other aqueous samples are measured by placing the probe directly into the sample in a clean plastic or glass container.

4.0 Interferences

4.1 No interferences are related to this method.

5.0 Apparatus

5.1 Horiba U-52. Tetra Tech GEO does not own a Horiba U-52 meter; therefore, the U-52 meter and flow-through cell must be rented from Pine Environmental Services, Inc. (Pine). Pine is a NJ Certified Laboratory that owns, maintains, and rents environmental field equipment, including the Horiba U-52. When ordering from Pine, a "NJ Lab Certified Meter" must be requested. Pine will then provide a calibrated Horiba U-52 along with Pre-Field Calibration documentation.

5.2 Upon receipt of the rental Horiba U-52 and before use, review the Pre-Field Calibration documentation for temperature to make sure that it is complete and applies to the meter received (i.e., the meter serial number). If there are issues with the meter or calibration documentation, contact Pine to resolve the issue and order a replacement meter or corrected documentation if necessary.

5.3 The Horiba U-52 may be rented from another environmental field equipment provider only if the selected rental company can provide the same pre-field calibrated equipment, calibration documentation, standards, and COAs as Pine.

6.0 Reagents

6.1 None required.

7.0 Calibration Verification

7.1 Pine verifies the Horiba U-52 temperature sensor quarterly by comparing the temperature readings within the range of use to the readings on a National Institute of Standards and Technology (NIST) certified thermometer, as required in N.J.A.C. 7:18-3.3.

7.2 The Pre-Field Calibration documentation for temperature provided by Pine must include the serial number of the NIST thermometer used, unique identification for the calibrated Horiba U-52 meter and any correction factor determined.

8.0 Procedure

8.1 Turn the Horiba U-52 on by pressing the POWER button for about 3 seconds. The "MEASUREMENT" screen appears after about 10 seconds.

8.2 Check that "SINGLE MEASUREMENT" has been selected in the measurement screen.

8.3 Place the sample or buffer solution in a clean glass beaker or the flow-through cell provided with the U-52 using a sufficient volume to cover the sensing elements of the electrodes and, if applicable, to give adequate clearance for stirring.

8.3.1 If measurements are collected on samples in a flow-through cell, no additional movement of the sample (i.e., stirring the sample) during measurement is necessary. Gently shake the sensor probe in the sample initially to remove any air bubbles from the sensors. Allow the sample to flow though the cell at a rate of approximately 0.2 to 0.5 liters per minute.

8.3.2 If surface water field measurements are being made, the electrodes may be immersed directly in the sample stream to an adequate depth and moved in a manner to insure sufficient sample movement across the electrode sensing element as indicated by drift free readings.

8.4 The temperature value will appear on the screen. When the measurement values are stable, press the MEAS key to acquire the 5-second average. Record the temperature value in the field logbook or on the well purge data sheet.

8.5 Record the following in the field logbook or on the well purge data sheet:

- type of analysis performed;
- instrument model;
- serial number;
- assigned sample ID;
- date;
- time of analysis;
- results to ± 0.1°C;
- name or initials of person(s) collecting the sample and name or initials of person(s) performing the analysis; and,
- NJDEP Department Sanctioned Analytical Method (DSAM) used (i.e., SM 2550-B).

9.0 Calculation

9.1 The Horiba U-52 meter reads temperature directly in degrees °C. Correction factors must be recorded and applied to the temperature measurements, if applicable.

10.0 Quality Control

10.1 The Horiba U-52 temperature sensor must be verified against a NIST thermometer within the range of use on a quarterly basis.

11.0 Precision and Accuracy

11.1 Precision and accuracy for this method have not been determined.

Bibliography

1. Standard Methods for the Examination of Water and Wastewater, SM 2550-B online (Approved by Standard Methods Committee, 2000).

2. HORIBA Multi Water Quality Checker U-50 Series Instruction Manual, April, 2009.

Field SOP – 6

Turbidity

TETRA TECH GEO	**SOP Title:**	Turbidity (Nephelometric)
	Parameter:	Turbidity - Aqueous
	Category:	WPP02 – Inorganic Parameters, Nutrients and Demands
Approved By: Steve Feldmann – QA Officer	**Revision No.:**	Revision 0
	Revision Date:	19 December 2011
Signature:	**NJDEP DSAM:**	EPA 180.1
	Applicable Code(s):	WPP02.50000
	Page Nos.:	1 of 5

METHOD #: EPA 180.1 Method

TITLE: Determination of Turbidity by Nephelometry

ANALYTE: Turbidity

INSTRUMENTATION: Turbidity Meter – LaMotte 2020e

LOCATION: Determined on-site in the field

1.0 Scope and Application

1.1 This method is applicable to drinking, surface, and saline water, groundwater, and domestic and industrial wastes.

2.0 Summary of Method

2.1 The method is based upon a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension. The higher the intensity of scattered light, the higher the turbidity. Readings, in Nephelometric Turbidity Units (NTUs), are made in a nephelometer.

3.0 Sample Handling and Preservation

3.1 Samples should be collected in clear, colorless plastic or glass bottles. All bottles must be thoroughly cleaned and rinsed with turbidity free water. Volume collected should be sufficient to insure a representative sample, allow for replicate analysis (if required), and minimize waste disposal. No chemical preservation is required.

3.2 Samples must be unpreserved and analyzed immediately (i.e., within 15 minutes of sample collection) in the field at the time of sampling.

4.0 Interferences

4.1 The presence of floating debris and coarse sediments which settle out rapidly will give low readings. Finely divided air bubbles can cause high readings.

4.2 The presence of true color, that is the color of water which is due to dissolved substances that absorb light, will cause turbidities to be low, although this effect is generally not significant with drinking waters.

4.3 Light-absorbing materials such as activated carbon in significant concentrations can cause low readings.

5.0 Apparatus

5.1 LaMotte 2020e. Tetra Tech GEO does not own a LaMotte 2020e meter; therefore, the LaMotte 2020e meter must be rented from Pine Environmental Services, Inc. (Pine). Pine is a NJ Certified Laboratory that owns, maintains, and rents environmental field equipment, including the LaMotte 2020e. When ordering from Pine, a "NJ Lab Certified Meter" must be requested. Pine will then provide a calibrated LaMotte 2020e along with Pre-Field Calibration documentation, standard solutions (0 NTU, 1 NTU, and 10 NTU solutions) for use during Daily/Field calibrations and daily standard checks, and Certificates of Analysis (COA) for the turbidity standards.

5.2 Upon receipt of the rental LaMotte 2020e and before use, review the Pre-Field Calibration documentation and the lot-specific COAs to make sure they are complete and apply to the meter and standards received (i.e., meter serial number and standard lot numbers). Check the standards to make sure they are not expired. If there are issues with the meters, standards, calibration documentation or COAs, contact Pine to resolve the issue and order a replacement meter, replacement standards, or corrected documentation if necessary.

5.3 The LaMotte 2020e may be rented from another environmental field equipment provider only if the selected rental company can provide the same pre-field calibrated equipment, documentation, standards, and COAs as Pine.

5.4 The sample tubes to be used with the LaMotte 2020e must be clean and free from lint, fingerprints, dried spills and significant scratches, especially the central zone between the bottom and the sample line. Scratches, fingerprints and water droplets on the tube can cause stray light interference leading to inaccurate results when measuring turbidity. Scratches and abrasions will affect the accuracy of the readings. Tubes that have been scratched in the light zone through excessive use should be discarded and replaced with new ones.

5.5 Tubes should always be washed on the inside and outside with mild detergent prior to use to remove dirt or fingerprints. After a tube has been filled and capped, it should be held by the cap and the outside surface should be wiped with a clean, lint-free absorbent cloth until it is dry and smudge-free. Handling the tube only by the cap will avoid problems from fingerprints.

6.0 Reagents

6.1 Purchased or laboratory prepared turbidity standard solutions. Only fresh, unexpired standard solutions are to be used. Use standard solutions with nominal values of 0, 1, and 10 NTUs for calibration. The 1 NTU and 10 NTU standard solutions can be used for daily standard checks.

6.2 Standard solutions must be labeled with the date received, date opened and expiration date. Discard any standard solution that is past its expiration date.

6.3 Standard solutions must be disposed of after each use.

7.0 Calibration

7.1 The LaMotte 2020e must be calibrated daily prior to measuring samples. Follow the calibration procedures provided in the LaMotte 2020e instruction manual (pages 38-43). Calibrate using the 0 NTU (blank), 1 NTU, and 10 NTU standard solutions. Record the calibration data in the field logbook or on the daily calibration log sheet, along with the date and time of calibration and the initials of the analyst performing the calibration.

7.2 A daily turbidity standard check must be analyzed each day of use. <u>The percent recovery of the daily standard check must be within ±10% of the expected value.</u> If the calibration values are not within this range, then the meter must be recalibrated. Record the check standard measurement value in the field logbook or on the daily calibration log sheet, along with the date and time of the check standard analysis and the initials of the analyst performing the check standard analysis.

8.0 Procedure

8.1 Turn the LaMotte 2020e on by pressing the ON button.

8.2 Calibrate the turbidity meter as outlined in Section 7 above.

8.3 Follow the sample analysis procedures provided in the LaMotte 2020e instruction manual (pages 32-35). As noted in the manual on page 35, the meter will remember the last scanned blank reading. It is not necessary to scan a blank each time the test is performed. To use the previous blank reading, instead of scanning a new one, scroll to Scan Sample and proceed.

8.4 Record the following in the field logbook or on the well purge data sheet:

- type of analysis performed;
- instrument model;
- serial number;
- assigned sample ID;
- date;
- time of analysis;
- results in NTUs;
- name or initials of person(s) collecting the sample and name or initials of person(s) performing the analysis; and,
- NJDEP Department Sanctioned Analytical Method (DSAM) used (i.e., EPA 180.1).

9.0 Calculation

9.1 The LaMotte 2020e meter reads directly in NTUs.

10.0 Quality Control

10.1 A turbidity check standard should be performed daily (follow procedures in Section 7.2 above).

11.0 Precision and Accuracy

11.1 In a single laboratory (EMSL-Cincinnati), using surface water samples at levels of 26, 41, 75, and 180 NTU, the standard deviations were ±0.60, ±0.94, ±1.2, and ±4.7 units, respectively.

11.2 The inter-laboratory precision and accuracy data in Table 1 were developed using a reagent water matrix. Values are in NTU.

TABLE 1. INTERLABORATORY PRECISION AND ACCURACY DATA

Number of Values Reported	True Value (T)	Mean (X)	Residual for X	Standard Deviation (S)	Residual for S
373	0.45	0.4864	0.0027	0.1071	-0.0078
374	0.6	0.6026	-0.0244	0.1048	-0.0211
289	0.65	0.6931	0.0183	0.1301	0.0005
482	0.91	0.9244	0.0013	0.2512	0.1024
484	0.91	0.9919	0.0688	0.1486	-0.0002
489	1	0.9405	-0.0686	0.1318	-0.0236
640	1.36	1.3456	-0.0074	0.1894	0.0075
487	3.4	3.2616	-0.0401	0.3219	-0.0103
288	4.8	4.5684	-0.0706	0.3776	-0.0577
714	5.6	5.6984	0.2952	0.4411	-0.0531
641	5.95	5.6026	-0.135	0.4122	-0.1078

Regressions: $X = 0.955T + 0.54$, $S = 0.074T + 0.082$

Bibliography

1. EPA Method 180.1, Determination of Turbidity by Nephelometry, Revision 2.0, August 1993.

2. LaMotte 2020e/i Turbidity Meter, Version 1.3, Code 1979-MN, 6.21.05

Field SOP – 7

Low-Flow Groundwater Sampling

Procedure for Collection of Low-Flow, Minimal-Drawdown Groundwater Samples

I. Introduction

This standard operating procedure (SOP) describes methods used to sample groundwater with low flow, minimal drawdown techniques. If a dense or light non-aqueous phase (free product) liquid (DNAPL or LNAPL) is encountered, the thickness of the layer will be recorded in the field notebook. Groundwater will not be collected from wells that have DNAPL or LNAPL present.

II. Equipment and Supplies

The following equipment will be used to perform low flow, minimal drawdown, groundwater sampling.

1. Depth-to-water measuring device - An electronic water-level indicator or steel tape and chalk, with marked intervals of 0.01 foot. Interface probe for determination of liquid products (NAPL) presence, if needed.
2. Steel tape and weight - Used for measuring total depth of well. Lead weight should not be used.
3. Sampling pump - Submersible or bladder pumps with adjustable rate controls are preferred. Pumps are to be constructed of inert materials, such as stainless steel and Teflon®. Pump types that are acceptable include gear and helical driven, centrifugal (low-flow type), and air-activated piston. An adjustable rate, peristaltic pump can be used when the depth to water is 20 feet or less.
4. Tubing - Teflon® or Teflon®-lined polyethylene tubing is preferred when sampling for organic compounds. Polyethylene tubing can be used when sampling inorganics.
5. Power source - If a combustion type (gasoline or diesel-driven) generator is used, it must be placed downwind of the sampling area.
6. Flow measurement supplies - flow meter, graduated cylinder, and a stop watch.
7. Multi-parameter meter with flow-through cell - This can be one instrument or more contained in a flow-through cell. The water quality indicator parameters that are monitored are pH, ORP/Eh, (ORP) dissolved oxygen (DO), turbidity, specific conductance, and temperature. Calibration fluids for all instruments should be NIST-traceable and there should be enough for daily calibration throughout the sampling event.
8. Decontamination supplies - Including a reliable and documented source of distilled water. Pressure sprayers, buckets or decontamination tubes for pumps, brushes and non-phosphate soap will also be needed.
9. Sample bottles, sample preservation supplies, sample tags or labels, and chain-of-custody forms.
10. Well construction, field, and water quality data from the previous sampling event.
11. Well keys and map of well locations.
12. Field notebook, ground-water sampling logs, and calculator.
13. Polyethylene sheeting placed on ground around the well head.
14. Personal protective equipment as specified in the site Accident Prevention Plan.
15. Air monitoring equipment as specified in the Site Health and Safety Plan.
16. Miscellaneous Supplies – Decontaminated sampling equipment, 6-mil plastic sheeting, measuring tape, field books, writing instrument, and digital camera.
17. Containers with re-sealable lids.

III. Guidelines

Note that investigative derived waste (IDW) generated during well installation, well purging, and sampling will be placed in re-sealable containers and managed.

Generally, the following considerations should be taken into account during groundwater sampling activities.

1. If DNAPL or LNAPL is encountered, a water/oil interface probe will be lowered into the well to measure the thickness of the layer; measurements will be recorded in the field notebook. DNAPL or LNAPL will not be sampled in the low flow, minimal drawdown technique. Groundwater will not be collected from wells that have DNAPL or LNAPL present.

2. All equipment entering the well or included in the sampling chain should be cleaned using appropriate decontamination procedures and should be staged on 0.5-mil polyethylene plastic.

3. A new, clean pair of disposable nitrile gloves will be worn during sampling and changed between sampling locations.

4. All sample containers will be placed in separate plastic bags immediately after collection and decontamination of the outside of the container.

5. All used field equipment to be decontaminated will be placed in plastic bags. All field waste (i.e., PPE, plastic sheeting, towels, etc.) will be placed in a plastic bag for subsequent disposal.

6. If possible, one member of the field team will be solely responsible for entering all field activity information into the field logbook (if applicable), while another member(s) will be solely responsible for collecting samples.

7. Sample collection activities will precede progressively from the suspected least contaminated area to the suspected most contaminated area.

8. Field personnel will use equipment constructed of Teflon or stainless steel that has been properly decontaminated.

9. Plastic sheeting should be placed around the well to prevent sampling equipment from coming into contact with the ground.

10. Tighten the cap on all sample containers after sampling.

11. Prior to the commencement of sampling activities, each on-site well will be assessed to determine its condition and suitability for sampling. Data to be collected includes the general condition of the well, construction details, depth to water, total depth, and any other relevant information or recommendations regarding the wells. The procedure for collecting these measurements will generally follow the steps outlined in Section IV below, with observations either recorded in a field book or well assessment form.

IV. Procedure

1. Check and record the condition of the monitoring well for damage or evidence of tampering. Lay out polyethylene sheeting around the well to minimize the likelihood of contamination of sampling/purging equipment from the soil. Place monitoring, purging, and sampling equipment on the sheeting.

2. Unlock well head. Record location, time, date, and appropriate information in a field logbook or on the ground-water sampling log.

3. Remove inner casing cap.

4. Monitor the headspace of the monitoring well at the rim of the casing for explosive gas with a multi-gas meter and record in the logbook. If the existing monitoring well has a history of positive readings of the headspace, then the sampling must be conducted in accordance with the Health and Safety Plan.

5. Measure the depth to water (water level must be measured to nearest 0.01 feet) relative to a reference measuring point on the well casing with an electronic water level indicator (Refer to Attachment A - Solinst® Water Level Meter: Op Instructions) and record in log-book or groundwater sampling log. If no reference point is found, measure relative to the top of the inner casing, then mark that reference point and note that location in the field logbook. Record information on depth to ground water in the field logbook or groundwater sampling log. Measure the depth to water a second time to confirm initial measurement; measurement should agree within 0.01 feet or re-measure.

6. Check the available well information or field information for the total depth of the monitoring well. Use the information from the depth of water in step six and the total depth of the monitoring well to calculate the volume of the water in the monitoring well or the volume of one casing. Record information in field logbook or groundwater sampling log.

7. Place the pump and support equipment at the wellhead and slowly lower the pump and tubing down into the monitoring well until the location of the pump intake is set at a pre- determined location within the screen interval. The placement of the pump intake should be positioned with a calibrated sampling pump hose, sounded with a weighted tape, or using a pre-measured hose. Refer to the available monitoring well information to determine the depth and length of the screen interval. Measure the depth of the pump intake while lowering the pump into location. Record pump location in field logbook or groundwater sampling log.

8. Measure the water level (water level must be measured to nearest 0.01 feet) and record information on the ground-water sampling log, leave water level indicator probe in the monitoring well.

9. Connect the discharge line from the pump to a flow-through cell. The discharge line from the flow-through cell should be directed to a container to contain the purge water during the purging and sampling of the monitoring well.

10. Start pumping the well at a low flow rate (0.1 to 0.5 liter per minute) and slowly increase the speed. Check water level. Maintain a steady flow rate while maintaining a drawdown of less than 0.33 feet. If drawdown is greater than 0.33 feet, lower the flow rate. 0.33 feet is a goal to help guide with

the flow rate adjustment. It should be noted that this goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval, and may require adjustment based on site-specific conditions and personal experience.

11. Measure the discharge rate of the pump with a graduated cylinder and a stop watch. Also, measure the water level and record both flow rate and water level on the groundwater sampling log. Continue purging, monitor and record water level and pump rate every three to five minutes during purging. Pumping rates should be kept at minimal flow to ensure minimal drawdown in the monitoring well.

12. During the purging, a minimum of one tubing volume (including the volume of water in the pump and flow cell) must be purged prior to recording the water quality indicator parameters. Then monitor and record the water quality indicator parameters every five minutes. Parameters should be recorded in a field notebook. The water quality indicator field parameters are turbidity, dissolved oxygen, specific electrical conductance, pH, redox potential, and temperature. Oxidation-reduction potential may not always be an appropriate stabilization parameter, and will depend on site-specific conditions. However, readings should be recorded because of its value as a double check for oxidizing conditions. The stabilization criterion is based on three successive readings of the water quality field parameters; the following are the criteria which must be used:

Parameter	Stabilization Criteria
pH	+/- 0.1 pH units
Specific Electrical Conductance (SEC)	+/- 3% S/cm
Oxidation-Reduction Potential (ORP)	+/- 10 millivolts
Turbidity	+/- 10% NTUs (when turbidity is greater than 10 NTUs)
Dissolved Oxygen	+/- 0.3 milligrams per liter

Once the criteria have been successfully met indicating that the water quality indicator parameters have stabilized, then sample collection can take place. Note that if a stabilized drawdown in the well cannot be maintained at 0.33 feet, stop pumping and allow for recovery. Under no circumstances should the well be pumped dry.

13. Organize sampling containers with the lids off. Fill the sample containers from the output end of the tubing by first filling all of the containers a quarter full, then half full, then three-quarters full, and then full. Be careful not to overflow the containers since they are pre-preserved.

14. Ensure that the tops on the sample containers are tightly closed, and wipe down the outside of the sample containers to remove any excess water.

15. Retrieve and equipment from inside the well and replace the well cap.

16. Close and lock the well.

17. Decontaminate equipment prior to moving to the next location. Teflon tubing is to be discarded after use.

V. Quality Control and Reporting

Field instruments will be maintained and calibrated per the requirements in QAPP Worksheet 22 and data will be verified per the requirements in QAPP Worksheet 34. Quality control samples will be collected in accordance with QAPP Worksheet 20.

VI. References

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1996, Low Stress (low flow) Purging and Sampling Prodedure for the Collection of Ground water Samples From Monitoring Wells, SOP#: GW 0001, July 30, 1996.

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Field SOP – 8

Sample Management

Procedure to Conduct Sample Management

I. Introduction

This standard operating procedure (SOP) provides reference information on sample management procedures.

II. Definitions

Trip Blanks – Trip blanks are used to check for sample contamination originating during sample transport and shipping as well as from site conditions. Trip blanks are necessary when aqueous environmental samples are collected for volatile organic analysis. Trip blanks will be submitted to the laboratory for analysis at a rate of 1 per daily shipment.

Field Blanks –Field blanks are used to check the efficacy of sampling equipment decontamination procedures. Field blanks are collected for each type of non-dedicated sampling equipment. Field blanks will be submitted to the laboratory for analysis at a rate of 1 per day (while sampling is occurring).

Field Duplicate – Field duplicates are two separate samples collected from the same sampling location. Field duplicates are used to evaluate field sampling precision and are collected at a frequency of 1 per 20 environmental field samples for each analyte group.

Matrix Spike/Matrix Spike Duplicates (MS/MSD) – MS/MSD analysis is the process where standard mixes are added to field samples prior to extraction. The sample is then split into duplicates and analyzed. The analysis is used to evaluate the matrix effect of the sample upon the analytical methodology. MS/MSD samples will be submitted to the laboratory for analysis at a rate of 1 per 20 environmental field samples for each analyte group.

III. Guidelines

The use of sample management procedures during sample collection is intended to ensure that all samples obtained during the site investigation are accounted for when the project is completed. The sample management officer (SMO) is responsible for the implementation of sample management, and also for assuring that the proper QA/QC samples are collected.

IV. Laboratory Coordination

Weekly contact should be maintained with subcontract laboratories to keep them informed of the status of the sampling program. As a courtesy, copies of the COC will be provided electronically to the laboratory along with tracking number. Arrangements will be made with the subcontract laboratory to provide

suitable, clean sample containers appropriate for each test. Laboratories will provide Material Safety Data Sheets for all preservatives used in sample containers.

V. Sample Documentation, Packaging, and Shipping Procedures

The field leader will be responsible for accurate documentation of samples collected in the field. Documentation will be entered into the field logbook as samples are collected. The information recorded should include but not be limited to the following:

- Sample number (Sample ID)
- Location
- Method of sample collection
- Sample date
- Time of collection
- Preservative(s) used
- Number of bottles collected
- Collection of quality control samples

The Sample Management Officer (SMO) will be responsible for the documentation, packaging, and shipping of the samples. These procedures are outlined in the sections below. The Site Quality Control Officer bears the ultimate responsibility of tracking and managing all field and quality control samples.

Documentation and Chain of Custody

Before placing a sample in a cooler, the sample label should be covered with clear tape. The sample labels should contain the following information:

- Sample ID
- Matrix type
- Requested analyses

Once all of the samples have been collected, they should be grouped for shipment by the receiving laboratory. Aqueous and solids samples must be shipped in separate coolers, under separate COCs. COCs will be prepared and attached to the inside of each cooler. (Sample date and time will be recorded on the COC or provided to the Site Quality Control Officer.)

Packaging and Shipping Samples

Below are guidelines for packaging and shipping samples.

1. Make sure the caps on the sample bottles are tightly sealed. Wipe down the outside of all of the sample bottles. Note that some samples bottles are pre-preserved with acid. Refer to Material Safety Data Sheets as necessary.

2. Ensure that sample label is firmly attached to bottle. Cover label with clear tape. Tape must be wrapped around the entire bottle (otherwise the stickers will come off due to the humidity).

3. Apply one custody seal around the circumference of the container or over the cap and onto the sides of the container. The custody seal must applied to sample containers in such a manner as to reveal if the container was opened during transit. Note that for 40 mL vials, the custody seal goes on the outside of the bag.

4. Place containers in individual zip-lock bags. Eliminate extra air space from the bag before sealing. Cover sample containers with bubble wrap (one layer). Note that for 40 mL vials, all vials associated with the one sample go in one bag.

5. Place the bagged container into a bubble-wrap bag and seal with tape.

6. Prepare the shipping cooler so that no leakage can occur during shipping. Securely seal all valves using duct tape on both the inside and the outside of the cooler, and line with plastic or a larger garbage bag.

7. Surround the sample bottles with bags of ice. Prior to placement in the cooler, remove the ice from the original bag and re-pack into double zip lock bags. Use enough ice to ensure that the proper temperature (2-6 degrees Celsius) is maintained during transport. Place a temperature blank (filled with tap water and labeled as “temperature blank”) into the cooler. When arranging bottles in the cooler, do not stack sample bottles on top of each other (i.e., only one layer of bottles can be placed in the cooler).

8. Ensure that Trip Blanks for VOC shipments are included in shipment, if required.

9. Once the samples are packed, close, and securely tie or tape the plastic or garbage bag.

10. Fill in the relinquished by and received by sections of the COC prior to shipment.

11. Seal the original COC form in a Ziploc bag and tape to the inside of the cooler.

12. Place a disclaimer sticker on the inside of the cooler near the COC. Stickers should state “Environmental Samples, Non-Hazardous”. Information should be written in English.

13. Close the cooler and seal with strapping tape, which must be taped around the cooler three times. If visibly dirty, wipe down the outside. Apply two signed and dated custody seals to the cooler diagonally across from each other where the cooler lid meets the cooler. Apply the custody seals in such a manner as to reveal if the cooler was opened during transit. Cover the custody seals with clear tape.

14. If applicable, place a shipping waybill on the outside of each cooler.

15. Attach the following stickers to the outside of the cooler (1) “Environmental Samples, Non-Hazardous” label, and (2) “This way up” label. Cover stickers with clear tape.

16. Notify the laboratory of the shipment.

Field SOP – 9

Secondary Containment

TO: All Kinder Morgan Contractors

FROM: Carteret, EHS Department

DATE: 8 October 2014

SUBJECT: Secondary Containment Requirements

All contractors at the facility are required to provide secondary containment measures to minimize the risk of spills or releases upon Close Of Business next Friday (10/17/14).

1. Secondary containment measures include double walled tanks, containment berms, containment trays, containment pallets, drum overpacks, flammable cabinets, drip pans for hose connections and vehicle fueling, etc.

2. Use grounded drip pans for flammables or combustibles.

3. Provide secondary containment for containers such as tanks, totes, drums, pails, bags, generators, compressors, light towers, portable pumps, etc.

4. Containers include those that are used, stored, or handled for different purposes such as fueling construction vehicles, painting, sandblasting tanks and piping, etc.

5. During rain events, ensure containers are covered (e.g. with a tarp or other material) to prevent rainwater from accumulating in the secondary containment.

Questions regarding this issue can be directed to the undersigned at 732-541-5161 ext. 75248. Thank you for your cooperation.

Sincerely,

KINDER MORGAN LIQUIDS TERMINALS, LLC

Merary J. Rolon
Environmental, Health & Safety, Sr. Specialist

Attachment 4

Field Modification Form (template)

FIELD MODIFICATION FORM FOR
KINDER MORGAN STATEN ISLAND SITE
LOUIS BERGER

Date:

Document:

Activity:

Requested Modification:

Rationale:

Attachments:

Technical Manager: _____

Quality Assurance Officer: _____

Quality Control Officer: _____

Attachment 5

Non-Conformance Quality Control Report (template)

KINDER MORGAN STATEN ISLAND SITE

NON-CONFORMANCE/QUALITY CONTROL REPORT

Date: _____

Organization Name: _____

Initiator's Name & Title: _____

Problem Description:

_____

_____

_____

_____

_____

_____

_____

Reported To: _____

Corrective Action:

_____

_____

_____

_____

_____

_____

_____

Reviewed and Implemented by: _____

Louis Berger

412 MOUNT KEMBLE AVENUE | MORRISTOWN, NJ | 07962