Multi-Parameter
Water Quality **TROLL**®

Multi-Parameter **TROLL** *9500*

OPERATOR'S MANUAL

January 2009

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USA		*(US & Canada)*

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1 INTRODUCTION

GENERAL DESCRIPTION OF THE MP TROLL 9500

Your new Multi-Parameter TROLL 9500 water quality probe uses the latest sensor and electronics technology to provide a robust, durable, and user-friendly instrument.

The MP TROLL 9500 logs data from up to 7 water-level and water-quality sensors, as well as built-in temperature and barometric pressure sensors. Many custom options and versions are available, so your instrument may not look exactly like those we have chosen to illustrate in this manual.

The MP TROLL 9500 provides the convenience of a laboratory-quality measurement instrument for field use, providing true in-situ monitoring of water level and water quality.

HOW TO USE THIS MANUAL

This operator's manual is designed as both a start-up guide and a permanent reference for the features, uses, and applications of the Multi-Parameter TROLL 9500.

Section 1: Introduction to this Operator's Manual and to In-Situ Inc.; contacting us for warranty and repair issues

Section 2: Description of components and features of the Multi-Parameter TROLL 9500

Section 3: Getting Started: setting up the software, connecting for the first time, Quick-Calibrating the sensors, and a summary overview of the setup to start collecting data

Section 4: Control Software: Win-Situ® 4 and Pocket-Situ 4

Section 5: Profiling

Section 6: How to set up tests and start logging data; extracting data to your PC; viewing and graphing data

Section 7: Monitoring Pressure (Water Level): Info on the two basic types of pressure sensors; setting up the pressure channel to obtain the most accurate readings for your altitude and latitude; how to display data as you wish to see it

Section 8: Temperature

Section 9: Barometric Pressure

Section 10: An overview of monitoring water quality with the MP TROLL 9500: Sensor installation and calibration, software options, calibration reports

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The manual includes a Glossary and a comprehensive Index

CONVENTIONS

Throughout this operator's manual you will see the following symbols.

The check mark highlights a tip about a convenient feature of the MP TROLL 9500

The exclamation point calls your attention to a requirement or important action that should not be overlooked

Typical usage questions and answers that we hope will help you gain a better understanding of your new Multi-Parameter TROLL 9500 and simplify its setup and operation

UNPACKING AND INSPECTION

Your MP TROLL 9500 was carefully inspected before shipping. Check the instrument for any physical damage sustained during shipment. Notify In-Situ and file a claim with the carrier if there is any such damage; do not attempt to operate the instrument.

Please save packing materials for future storage and shipping of your MP TROLL 9500. The shipping boxes have been performance-tested and provide protection for the instrument and its accessories.

Accessories may be shipped separately and should also be inspected for physical damage and the fulfillment of your order.

SERIAL NUMBER

The serial number is located on the large label on the Multi-Parameter TROLL 9500 body, and also on a small label inside the battery compartment. The serial number is programmed into the instrument and displayed when the instrument is connected to a PC running Win-Situ 4 or Pocket-Situ 4. We recommend that owners keep a separate record of this number. Should your Multi-Parameter TROLL 9500 be lost or stolen, the serial number is often necessary for tracing and recovery, as well as any insurance claims. If necessary, In-Situ maintains complete records of original owner's names and serial numbers.

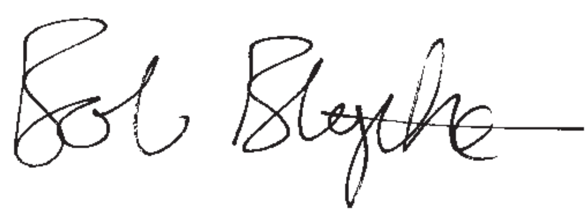
Serial numbers of the water-quality sensors are stored in sensor memory and displayed in the software when sensors are installed.

TO OUR CUSTOMERS . . .

Thank you for your purchase of an In-Situ product. We are glad you chose us and our products to help you with your environmental monitoring needs. In-Situ Inc. has been designing and manufacturing world-class environmental monitoring instrumentation for over 25 years in the Rocky Mountains of the United States. As it was in the beginning, our expectation is that this product will provide you with many trouble-free years of use. To that end, we pride ourselves on delivering the best customer service and support possible—24 hours a day, 7 days a week. We believe that this level of commitment to you, our customer, is imperative in helping you ensure clean, safe groundwater and surface water resources across the globe. We also understand the need for accurate, reliable assessments and we continue to make significant investments in Research and Development to ensure that we deliver the latest product and technological innovations to support your needs.

Whether you are gathering information about your body of water for a few moments, or over a period of years, you can rely upon us to provide you with a quality product and outstanding customer support at a fair price and have that product delivered to you when and where you need it.

We want your experience with In-Situ Inc. to be pleasant and professional, whether you are renting from us, or purchasing from us. We would be pleased to hear from you and learn more about your needs, and your experiences with our products. Again, we thank you for choosing In-Situ Inc. and we look forward to serving your needs now, and in the future.



Bob Blythe, President and CEO
In-Situ Inc.
bblythe@in-situ.com

WHAT WE PROVIDE

WARRANTY PROVISIONS

In-Situ Inc. warrants the Multi-Parameter TROLL 9500 for one year, RDO sensors for three years, and other sensors for 90 days from date of purchase by the end user against defects in materials and workmanship under normal operating conditions. To exercise this warranty contact Technical Support at the phone or e-mail address listed below for a return material authorization (RMA) and instructions. Complete warranty provisions are posted on our website at www.In-Situ.com.

Maintenance & calibration plans as well as extended warranties are available. Contact your In-Situ representative for complete information.

FIRMWARE & SOFTWARE UPGRADES

From time to time In-Situ may make available enhanced versions of firmware and software to its customers over the Internet.

Visit our website at www.in-situ.com to download the latest firmware and software.

HOW TO CONTACT US

Technical Support:	800 446 7488
	Toll-free 24 hours a day in the U.S. and Canada
Address:	In-Situ Inc. 221 East Lincoln Ave. Fort Collins, CO 80524 USA
Phone:	970 498 1500
Fax:	970 498 1598
Internet:	www.in-situ.com
e-mail:	support@in-situ.com

To Obtain Repair Service (U.S.)

If you suspect that your Multi-Parameter TROLL 9500 is malfunctioning and repair is required, you can help assure efficient servicing by following these guidelines:

1. Call or e-mail In-Situ Technical Support (support@in-situ.com). Have the product model and serial number handy.
2. Be prepared to describe the problem, including how the instrument was being used and the conditions noted at the time of the malfunction.
3. If Tech Support determines that service is needed, they will ask that your company pre-approve a specified dollar amount for repair charges. When the pre-approval is received, Tech Support will assign an RMA (Return Material Authorization) number.

   TIP: *Please keep your RMA number for future reference.*

4. Clean the Multi-Parameter TROLL 9500 and cable. Decontaminate thoroughly if it has been used in a toxic or hazardous environment. See the cleaning guidelines and form on the following page.

   If an instrument returned for servicing shows evidence of having been used in a toxic or hazardous environment, Customer Service personnel will require written proof of decontamination before they can service the unit.

5. Carefully pack your Multi-Parameter TROLL 9500 in its original shipping box, if possible. Include a statement certifying that the instrument and cable have been decontaminated, and any supporting information.
6. Mark the RMA number clearly on the outside of the box with a marker or label.
7. Send the package, shipping prepaid, to

   In-Situ Inc.
   ATTN: Repairs
   221 East Lincoln Ave.
   Fort Collins, CO 80524
   USA

The warranty does not cover damage during transit. We recommend the customer insure all shipments. Warranty repairs will be shipped back prepaid.

Outside the U.S.

Contact your international In-Situ distributor for repair and service information.

CERTIFICATION

The MP TROLL 9500 complies with all applicable directives per the CE and FCC and was tested to the EN 61326 / FCC specifications

CLEANING GUIDELINES

Please help us protect the health and safety of our employees by cleaning and decontaminating equipment that has been subjected to any potential biological or health hazards, and labeling such equipment. Unfortunately, *we cannot service your equipment without such notification*. Please complete and sign the form below (or a similar statement certifying that the equipment has been cleaned and decontaminated) and send it along to us with each downhole instrument.

- We recommend a good cleaning solution, such as Alconox®, a glassware cleaning product available from In-Situ (Catalog No. 0029810) and laboratory supply houses.
- Clean all cabling. Remove all foreign matter.
- Clean cable connector(s) with a clean, dry cloth. Do not submerge.
- Clean the probe body—including the nosecone, restrictor, cable head, and protective caps. Remove all foreign matter.
- Remove and clean all removable sensors. Rinse with deionized or distilled water after cleaning.

If an instrument is returned to our Service Center for repair or recalibration without a statement that it has been cleaned and decontaminated, or in the opinion of our Service Representatives presents a potential health or biological hazard, we reserve the right to withhold service until proper certification has been obtained.

Alconox is a registered trademark of Alconox Inc.

Decontamination & Cleaning Statement

Company Name____Phone ________________________

Address ____

City __________________________________ State ________________ Zip _______________________

Instrument Type___________________________________Serial Number___________________________

Contaminant(s) (if known) ____

____

Decontamination procedure(s) used ____

____

Cleaning verified by____ Title___________________________

Date________________________________

In-Situ Inc.

2 COMPONENTS & FEATURES

SYSTEM DESCRIPTION

The Multi-Parameter TROLL 9500 is a compact, modular system with a range of components to customize the instrument to various applications and operational modes. Components include the instrument body with a host of options, sensors, cables, external power accessories, and consumable items.

STANDARD FEATURES

- 47 mm (1.85 in) diameter
- corrosion-resistant PVC housing with titanium set screws
- 316L stainless steel flow restrictor/sensor buard
- Viton® seals
- Fast data sampling
- Continuous real-time readings (profiling)
- User-replaceable off-the-shelf D-cell alkaline batteries, or In-Situ–supplied 3.6V lithium D-cell batteries
- Fully submersible
- RS485 communications
- Low-power microprocessor
- Permanently installed, factory-calibrated temperature sensor
- Permanently installed, factory-calibrated barometric pressure sensor, for use on vented cable
- Temperature-compensated real-time clock
- Easy-to-use Win-Situ® 4 control software for setup, downloading, text and graphical data display
- Optically isolated communication signals
- Cable available in standard and custom lengths of vented or non-vented polyurethane, Halogen-free polyurethane, or Tefzel®
- External power capable

OPTIONAL FEATURES

- Profiler and Professional feature sets, both available in ***XP*** with extended parameter capability
- Smart Sensors for water quality measurements—removable, replaceable, field-calibrated
  - Basic Sensors include Dissolved Oxygen (polarographic), pH, combination pH/ORP, Low Conductivity, High Conductivity
  - The Extended Sensor set includes Ammonium, Chloride, Nitrate, Turbidity, RDO® Optical Dissolved Oxygen
- Pocket-Situ full-featured control software for field use on a PDA—take continuous real-time readings, calibrate, program, and download logged data from multiple MP TROLLs
- RuggedReader® handheld PDA
- Temperature-compensated vented or non-vented pressure sensor, available in several ranges, permanently installed and factory-calibrated
- Permanently installed, factory-calibrated turbidity sensor
- Integral data logging capability—up to 4 megabytes flash data-storage memory (about a million individual readings)
- Fast data downloads
- Up to 16-test capacity; linear, event, and linear average measurement schedules
- SDI-12 or RS485 interface—or both
- Flow-Sense low-flow sampling software for automated sampling and report creation
- Optional accessories include low-flow flowcell, user-serviceable turbidity wiper, battery-powered magnetic stirrer for use in stagnant water
- Instrument networking and telemetry

MP TROLL 9500

CABLES

Several basic cable types are used in the MP TROLL 9500 system:

- RuggedCable™, TPU-jacketed (Thermoplastic PolyUrethane)
    - vented or non-vented
    - Halogen-Free vented or non-vented (LSZH-rated, low smoke zero halide)

Vented cable is recommended for applications where accurate barometric pressure measurement is required—for example when calibrating dissolved oxygen, or for measuring DO in percent saturation.

- Vented Tefzel®* cable
- Stainless steel suspension wire for use when cable venting is not required (e.g., with an absolute pressure sensor)
- Communication cables for programming the device/downloading the logged data

RuggedCable™

Cable includes conductors for power and communication signals, a strength member, and a Kellems® grip to anchor the MP TROLL 9500 securely. Available in standard and custom lengths.

Uphole and downhole ends are identical bayonet-type Twist-Lock connectors that mate with the TROLL 9500 body, TROLL Com communication cable, desiccants, and other accessories.

Vented cable is designed for use with vented pressure/level sensors (gauged measurements). The cable vent tube insures that atmospheric pressure is the reference pressure applied to the pressure sensor diaphragm. Vented cable also enables proper functioning of the internal barometric pressure sensor, and improves dissolved oxygen readings.

Non-vented cable may be used with non-vented pressure/level sensors (absolute measurements), or instruments without a pressure sensor.

** FEP = fluorinated ethylene propylene, the generic equivalent of DuPont Teflon®.*

CABLE DESICCANTS

Small Desiccant

Clear cap of indicating silica gel desiccant seals the uphole end of the RuggedCable during use; protects the cable vent tube and device electronics from condensation. The desiccant is blue when active. It will absorb moisture from the top down and for best results should be replaced before the entire volume has turned pink. Replacements are available from In-Situ Inc. or your distributor.

Large Desiccant

The high-volume desiccant pack may last up to 20 times longer than the small desiccant in humid environments. It attaches to the RuggedCable in the same way. Refill kits are available from In-Situ Inc. or your distributor.

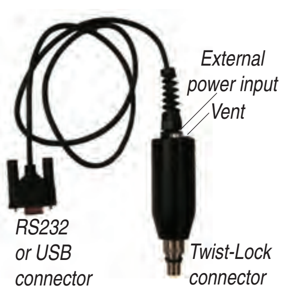
Accessory	Catalog No.
Small desiccant (3)	0052230
Large desiccant, plastic connector	0053550
Large desiccant, titanium connector	0051810
Large desiccant refill kit	0029140

COMMUNICATION CABLES

Comm cables interface between the TROLL 9500 and a desktop/laptop PC or handheld PDA for profiling, calibrating, programming, and downloading. Both types include 0.9 m (3 ft) polyurethane cable, external power input jack, and vent with replaceable membrane.

TROLL Com (Cable Connect)

Connects a TROLL 9500's RuggedCable to a serial or USB port; Weatherproof, withstands a temporary immersion (IP67).



TROLL Com (Direct Connect)

Connects a TROLL 9500 directly to a serial or USB port. A good choice for permanent connection to a PC, or for programming a non-vented TROLL 9500 that will be deployed without RuggedCable. Not designed for field use.

Accessory	Catalog No.
RS232 TROLL Com, Cable Connect	0056140
RS232 TROLL Com, Direct Connect	0056150
USB TROLL Com, Cable Connect	0052500
USB TROLL Com, Direct Connect	0052510

POWER COMPONENTS

The MP TROLL 9500 operates in 2 power modes

- internal power
- external AC line power

INTERNAL POWER

The MP TROLL 9500 uses:

- two standard 1.5V alkaline D cells, OR
- two 3.6V lithium D cells—recommended for use with an RDO optical dissolved oxygen sensor, and with a turbidity wiper

Use only Saft LSH-20 3.6V lithium D cells. Use of any other lithium battery will void the product warranty.

EXTERNAL POWER

A single MP TROLL 9500 can run exclusively on power supplied from a 9-12 VDC line power supply connected to a 90-264 VAC input. When line power is enabled, the TROLL shuts down the battery regulator, thus preserving the internal batteries. All TROLL Com models include an external power input jack.

Accessory	Catalog No.
AC Adapter 9V	0031880
Replacement batteries, alkaline (1)	0042020
Lithium battery (2) kit	0048230

***TIP:** Battery life is dependent upon temperature, cable length, and how often the device is recording measurements.*

WATER QUALITY ACCESSORIES

Basic Sensors	Catalog No.
pH	0059510
pH/ORP	0059520
Low Conductivity	0033210
High Conductivity	0033220
Polarographic Dissolved Oxygen	0032870

Extended Sensors	Catalog No.
Nitrate	0032050
Ammonium	0032060
Chloride	0032070
RDO Optical Dissolved Oxygen sensor for use with pressure and/or turbidity sensor, sub-4”	0085070
RDO Optical Dissolved Oxygen sensor without pressure and/or turbidity sensor, sub-2”	0084310

Calibration Kits (four liters unless otherwise noted)

Turbidity Wiper	0044510
Battery-Powered Magnetic Stirrer	0042210

Calibration Kit	Catalog No.
Quick-Cal: 4 x 250 mL (for calibrating Basic Sensors)	0033250
Dissolved Oxygen: 1 liter DI water, 500 mL Na_2SO_3	0032110
RDO bubbler cal kit for 0085070 sensor	0048580
RDO bubbler cal kit for 0084310 sensor	0080830
Polarographic DO bubbler cal kit	0095150
Conductivity: 147 µS, 1413 µS, 12890 µS, DI water	0032090
Low Conductivity: 2 each 147 µS, 1413 µS	0032630
High Conductivity: 2 each 12890 µS, 58670 µS	0032640
pH: 1 each pH 4, pH 7, pH 10, DI water	0032080
ORP: 1 liter Zobell’s Solution	0032100
pH/ORP: 1 each pH 4, pH 7, pH 10, Zobell’s Solution	0032120
Nitrate: 1 each 14, 140, 1400 ppm, DI water	0032130
Low Nitrate: 2 each 14, 140 ppm	0032650
High Nitrate: 2 each 140, 1400 ppm	0032660
Ammonium: 1 each 14 ppm, 140 ppm, 1400 ppm, DI water	0032140
Low Ammonium: 2 each 14, 140 ppm	0032670
High Ammonium: 2 each 140, 1400 ppm	0032680
Chloride: 1 each 35.5, 355, 3545 ppm, DI water	0032150
Low Chloride: 2 each 35.5, 355 ppm	0032690
High Chloride: 2 each 355, 3545 ppm	0032700

Individual Calibration Solutions (one liter unless otherwise noted)

Calibration Solution	Catalog No.
Na_2SO_3 (Sodium Sulfite) for DO Cal, 500 mL	0017670
Conductivity, 147 µS	0032560
Conductivity, 1413 µS	0020680
Conductivity, 12890 µS	0020690
Conductivity, 58670 µS	0032580
pH 4	0006370
pH 7	0006380
pH 10	0006390
ZoBell’s Solution (ORP)	0032210
Nitrate, 14 ppm as N	0032520
Nitrate, 140 ppm as N	0032230
Nitrate, 1400 ppm as N	0032240
Ammonium, 14 ppm as N	0032510
Ammonium, 140 ppm as N	0032260
Ammonium, 1400 ppm as N	0032270
Chloride, 35.5 ppm	0032500
Chloride, 355 ppm	0032290
Chloride, 3545 ppm	0032300
Turbidity, 10 NTU polymer suspension, 500 mL	0033070
Turbidity, 100 NTU polymer suspension, 500 mL	0033100
Turbidity, 1000 NTU polymer suspension, 500 mL	0033120
Turbidity, 1800 NTU polymer suspension, 500 mL	0033140

Maintenance/Service/Replacement Parts	Catalog No.
Sensor insertion tool	0042310
Sensor removal tool	0042110
Cal cup, PVC	0041440
Replacement wiper head	0044520
Wiper pad replacement kit	0044530
Lithium battery kit (2 “D” cells, 3.6V ea.)	0048230

MP TROLL 9500 Maintenance kit (o-rings, lubricant, dust caps, sensor port plugs)	0095100
MP TROLL 9500 Maintenance kit (o-rings, lubricant, dust caps, sensor port plugs) for use with 0085070 RDO sensors	0095100
DO sensor service kit, 1-mil membranes	0033200
DO sensor service kit, 2-mil membranes	0033440
RDO Sensor Cap replacement kit	0084230
RDO Maintenance kit (sensors purchased before 09/08)	0048250
RDO Foil replacement kit (sensors purch. before 09/08)	0048500
pH & pH/ORP Reference Filling Solution (60 mL)	0056900
pH & pH/ORP Reference Junction kit	0059620
pH & pH/ORP Sensor Storage Solution (500 mL)	0065370

INSTALLATION ACCESSORIES

- Twist-Lock Hanger: stainless steel hanger to suspend a non-vented TROLL 9500, Level TROLL, or Baro TROLL while taking data; no venting, no communication capabilities
- Cable Extender: connects two lengths of RuggedCable
- Wellcaps, locking and vented
- Well Docks: top-of-well support for 2”, 4”, or 6” well
- SDI-12 adapter: power and signal management for SDI-12 communication

Accessory	Catalog No.
Twist-Lock Hanger	0051480
Cable Extender	0051490
Locking Wellcap, 2”	0020360
Locking Wellcap, 2” vented	0020370
Locking Wellcap, 4”	0020380
Locking Wellcap, 4” vented	0020390
Top-of-well installation ring	WELLDOCK2”, 4”, 6”
SDI-12 adapter	0095200, 0095210
Flow Cell (sub-2 in)	0044710
Flow Cell (sub-4 in)	0057600

CONTROL SOFTWARE

Win-Situ® 4 enables communication between the MP TROLL 9500 and a desktop or laptop PC.

Win-Situ provides instrument control for calibration, profiling, direct readings, data logging, data extraction, data viewing (text and graphical interface), choice of units and other custom display options, battery/memory usage tracking, interface to networks and telemetry.

System requirements: Microsoft® Windows® 2000, Windows XP, or Windows Vista™; Internet Explorer (IE) 5.0 or later, and a CD-ROM drive.

Pocket-Situ 4 provides Win-Situ’s features and functions on a field-portable platform. Requirements: In-Situ RuggedReader® or other supported PDA running Microsoft Pocket PC (Windows Mobile®) 2003 or later, with a serial communications port for connection to the TROLL 9500, and at least 16 megabyte capacity for data storage (SD card, CF card, or the device’s built-in non-volatile memory).

For installation and file exchange, Pocket-Situ requires the following installed on an office desktop or laptop computer:

- Microsoft® ActiveSync®
- Win-Situ 4
- Optional: Win-Situ Sync (or Pocket-Sync 4, earlier version of Win-Situ Sync)

Twist-Lock Hanger

Cable Extender

Locking Wellcap

Well Dock

SDI-12 Adapter

PRODUCT SPECIFICATIONS

Wetted Materials*	PVC, titanium, Viton®, acetal, 316L SS
Operating Temperature*	-5°C to 50°C (23°F to 122°F)
Storage Temperature*	-40°C to 80°C (-40°F to 176°F)
Pressure Rating*	350 psi (246 m, 807 ft)
Dimensions	47 mm (1.85 in) dia, x 57.7 cm (22.7 in) long
with RDO adapter	88.4 mm (3.48 in) dia, 57.7 cm (22.7 in) long
Weight (without cable)	1.4 Kg (3.1 lbs)

Power

Battery type	2 standard alkaline D-cells (1.5 V), or 2 lithium D cells (approx. 3.6 V)
External power input	9-12 VDC (optional)

Data Sampling

Memory type/size (memory -equipped models)	4 megabytes flash data storage, about 1,000,000 individual readings
Fastest linear logging rate	5 seconds (10 seconds with RDO)
Profiling speed	2 seconds
Communications	RS485
Computer interface	RS232

Software

Win-Situ® 4	Desktop/laptop PC with Microsoft® Windows® 2000 SP2 or later (Windows XP, Windows Vista™), Internet Explorer 5.0 or later, serial com port, CD-ROM drive, 16-64 Mb RAM
Pocket-Situ 4	In-Situ RuggedReader® or other supported handheld PDA running Microsoft Pocket PC (Windows Mobile®) 2003 or later

Cable

Jacket options	Polyurethane, halogen-free (HF) polyurethane, Tefzel®
Conductors	6 conductors, 24 AWG, polypropylene insulation
Diameter	6.7 mm (0.265 in)
Connector	Titanium, 18.5 mm (0.73 in) O.D.
Break strength	127 kg (280 lb)
Minimum bend radius	2X cable diameter (13.5 mm, 0.54 in)
Weight	Vented, regular & HF: 14 kg/300 m (32.3 lb/1000 ft) Non-vented, regular & HF: 16 kg/300 m (35.6 lb/1000 ft) Vented Tefzel®: 23kg/300m (52 lb/1000 ft)

** Base unit = MP TROLL 9500 & factory-installed sensors*

Factory-Installed Sensors

Pressure/level	
Type	Media-isolated piezoresistive silicon strain gauge
Range	15 psig (0-11 m, 0-35 ft) 30 psia/psig (0-21 m, 0-69 ft) 100 psia/psig (0-70 m, 0-231 ft) 300 psia/psig (0-210 m, 0-692 ft)
Accuracy	better than ± 0.1% FS
Resolution	1 mm
Temperature	
Type	Platinum resistance thermometer
Range	-5°C to 50°C (23°F to 122°F)
Accuracy	± 0.1°C
Resolution	0.01°C
Barometric pressure	
Type	Piezoresistive silicon pressure sensor
Range	0-16.5 psia (854 mm Hg, 33.6 in Hg)
Accuracy	± 0.3% FS (2.54 mm Hg, 0.1 in Hg)
Resolution	0.1 mm Hg, 0.01 in Hg
Turbidity	
Type	Nephelometer, 90° light scattering, 870 nm LED, solid-state
Range	0-2000 NTU
Accuracy	± 5% or 2 NTU (whichever is greater)
Resolution	0.1 NTU
Turbidity Wiper	
Pressure Rating	350 psi (246 m, 807 ft)
Operating Temp.	0°C to 50°C

Basic Sensors

Conductivity	
Type	4-cell conductivity, AC drive
Operating Range	
Low Range sensor	5 µS/cm to 20,000 µS/cm
High Range sensor	150 µS/cm to 112,000 µS/cm
Accuracy	
Low Range sensor	± 0.5% or 2 µS/cm (whichever is greater) when calibrated in region of interest.
High Range sensor	± 0.5% + 2 µS/cm between 150 µS/cm and 112,000 µS/cm when calibrated in region of interest. From 70 to 150 µS/cm & 112,000 to 200,000 µS/cm ± 2% + 4 µS/cm typical
Resolution	Range-dependent
Pressure Rating	350 psi (246 m, 807 ft)
Operating Temp.	-5°C to 50°C (23°F to 122°F)

pH

Type	Glass sensing bulb, single-junction electrode, replaceable ceramic junction, refillable reference electrolyte
Range	0 to 12 pH units
Pressure Rating	350 psi 246 m, 807 ft
Operating Temp.	0°C to 50°C (32°F to 122°F)
Accuracy	± 0.1 pH unit
Resolution	0.01 pH unit

pH/ORP

Type	Glass sensing bulb, platinum wire, single-junction electrode, replaceable ceramic junction, refillable reference electrolyte
Range	± 1400 mV, 0 to 12 pH
Pressure Rating	350 psi 246 m, 807 ft
Operating Temp.	0°C to 50°C (32°F to 122°F)
Accuracy	± 4 mV, ± 0.1 pH unit
Resolution	1 mV, 0.01 pH unit

Dissolved Oxygen (polarographic)

Type	Clark polarographic
Range	0 to 20 mg/L, 0 to 200% saturation
Pressure Rating	350 psi (246 m, 807 ft); submersion & retrieval at up to 4 ft per second
Operating Temp.	-5°C to 50°C (23°F to 122°F)
Accuracy	± 0.2 mg/L
Resolution	0.01 mg/L

Extended Sensors

Dissolved Oxygen (optical, RDO)

Type	Optical, fluorescence quenching
Range	0 to 20 mg/L, 0 to 450% saturation
Pressure Rating	300 psi
Operating Temp.	0°C to 40°C (32°F to 104°F)
Accuracy	± 0.1 mg/L @ 0-8 mg/L ± 0.2 mg/L @ 8-20 mg/L
Resolution	0.01 mg/L

Ammonium (NH_4^+)

Type	PVC membrane sensing element, double junction Ag/AgCl reference half-cell, reference electrolyte gel
Range	0.14 to 14,000 ppm N (0.1 to 18,000 ppm NH_4^+)
Pressure Rating	20 psi (14 m, 46 ft)
Operating Temp.	-5°C to 40°C (23°F to 104°F)
Accuracy	± 10%
Resolution	0.01 ppm

Chloride (Cl^-)

Type	Solid-state sensing electrode, double junction Ag/AgCl reference half-cell, reference electrolyte gel
Range	0.35 to 35,500 ppm Cl (2 to 35,000 ppm Cl^-)
Pressure Rating	100 psi (70 m, 231 ft)
Operating Temp.	-5°C to 50°C (23°F to 122°F)
Accuracy	± 15%
Resolution	0.01 ppm

Nitrate (NO_3^-)

Type	PVC membrane sensing element, double junction Ag/AgCl reference half-cell, reference electrolyte gel
Range	0.14 to 14,000 ppm N (0.4 to 62,000 ppm NO_3^-)
Pressure Rating	20 psi (14 m, 46 ft)
Operating Temp.	-5°C to 40°C (23°F to 104°F)
Accuracy	± 10%
Resolution	0.01 ppm

Typical Battery Life @ 20°C

Battery type Installed sensors	Sample Interval 15 min.
2 alkaline D-cells	
Pressure, temperature, baro, turbidity	127 days
Pressure, temperature, baro, turbidity, pH/ORP, conductivity, RDO, DO	85 days
Pressure, temperature, baro, turbidity, pH/ORP, conductivity, RDO	90 days
2 lithium D-cells	
Pressure, temperature, baro, pH/ORP, conductivity, RDO, turbidity, no wiper	270 days

3 GETTING STARTED

This section provides a quick overview of the initial steps necessary to get the Multi-Parameter TROLL 9500 ready to take measurements.

You will need—

- Power
- Sensors
- Software
- Cable

  TROLL Com communication cable for deployment
- Calibration Kit—one for each sensor to be calibrated, or the QuickCal Kit for the Basic Sensor set (pH, ORP, polarographic D.O., Conductivity)

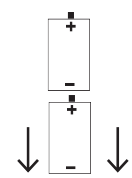
PROVIDE POWER

TIP: *When the unit ships with a Polarographic Dissolved Oxygen sensor installed, alkaline batteries are pre-installed in the device to power the D.O. sensor and keep it conditioned.*

Install batteries in the Multi-Parameter TROLL 9500 as follows:

1. Unscrew and remove the battery compartment cover. Slide it up over the cable (if attached).

2. Insert two D-size batteries negative side first, positive side up.



3. Replace the battery compartment cover and tighten to compress the o-ring seals.

Screw the cover down firmly to compress the o-rings and create a waterproof seal. When properly assembled, the o-rings will not be vsible.

TIP: *The MP TROLL 9500 uses standard off-the-shelf 1.5V alkaline D-cells.*

Alternatively, you may use Saft LSH-20 3.6V lithium D cells. Use of any other lithium battery will void the product warranty.

INSTALL SENSORS

Basic water-quality sensors—pH or pH/ORP, polarographic D.O., Conductivity—may arrive installed in the instrument's sensor ports. Proceed to **Install Software** if there are no additional sensors to be installed.

Install sensors in the Extended Sensor Set and any sensors shipped separately as follows:

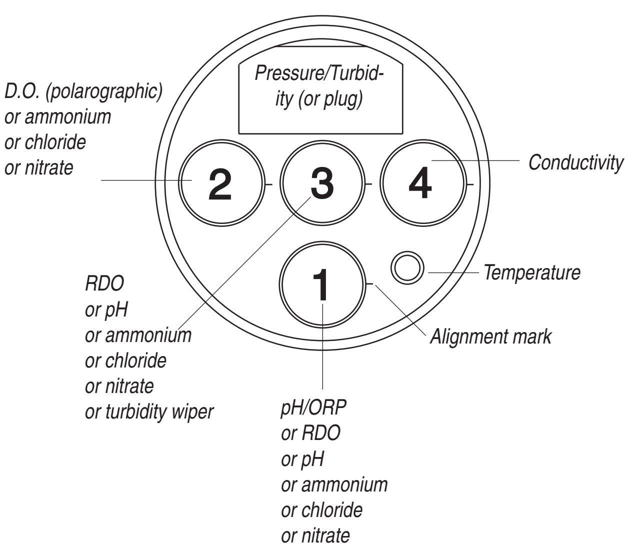
TIP: *The RDO® Optical Dissolved Oxygen sensor has special installation requirements. Please refer to the RDO Quick Start guide, or see Section 13 of this operator's manual for complete information.*

1. Remove the restrictor or Cal Cup from the front end of the MP TROLL 9500.

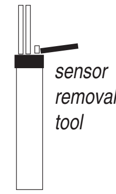
This allows access to the sensor block depicted in the drawing below.

There are four sensor ports, 1 – 4, plus a permanently installed pressure and/or turbidity sensor or plug.

End view of sensor block



2. Remove the sensor's protective cap or storage bottle and set aside for future storage of the sensor. If the connector end is covered with a cap, remove it also.
3. Remove any moisture or dirt from the area around the port where you will install the sensor, then use the sensor removal tool to remove the plug from the port. Retain the plug for use when with fewer than 4 removable sensors installed.



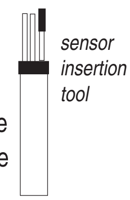
4. Remove any moisture or dirt from the port connector with a clean swab or tissue.
5. Check lubrication of the sensor o-rings.

The sensor o-rings require generous lubrication before installation. New sensors will be lubricated at the factory. If the o-rings appear dry, apply a silicone lubricant before installation.

6. Align the mark on the side of the sensor with the mark on the correct port (see diagram), or visually align the sensor connector pins with the port connector pins.

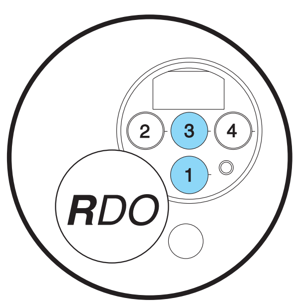
If the sensing element is at the end of the sensor, be careful to handle the sensor by the sides. Use the insertion tool to press the sensor into the port at step 7.

7. Press the sensor firmly into the port until you feel it dock with the connector at the bottom.

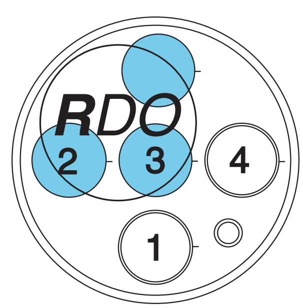


When the sensor is properly inserted, a small gap (the width of the sensor removal tool) remains between the instrument body and the widest part of the sensor, for ease of removal.

After installing a polarographic D.O. sensor, we recommend conditioning it for 2-4 hours, preferably overnight, before calibrating. For more on D.O. sensor conditioning, see Section 13.



End view with the RDO cable connect sensor plugged into ports 1 or 3



End view with the RDO direct connect sensor plugged into ports 3 and covering ports 2 and 5.

INSTALL THE SOFTWARE

WIN-SITU 4

Install Win-Situ 4 from the In-Situ software CD or the In-Situ website:

- Click on Win-Situ 4 and follow the instructions to install Win-Situ 4 to your local hard drive.

USB TROLL COM DRIVERS

- Select the option to install USB TROLL Com drivers during the Win-Situ installation. Two drivers will be loaded to your hard drive, (USB TROLL Com, USB TROLL Com serial port).

POCKET-SITU 4

For communication using a RuggedReader® handheld in the field, install the desktop component of Pocket-Situ 4 from the CD or website. The desktop component is the "Win-Situ Software Manager," and helps you install Pocket-Situ on the RuggedReader at any time.

- Click on Pocket-Situ 4 and follow the instructions to install the Win-Situ Software Manager to your local hard drive.

To install Pocket-Situ on the RuggedReader: When convenient, connect the RuggedReader to the PC, establish a connection in Microsoft ActiveSync®, launch the Win-Situ Software Manager, and follow the instructions.

WIN-SITU SYNC

If you plan to synchronize data files from the RuggedReader back to a desktop PC after collecting data in the field, also install Win-Situ Sync from the CD or website.

USB TROLL Com

When you plug in a USB TROLL Com, the USB drivers downloaded during Win-Situ installation will be installed as follows:

- Windows 2000, Windows Vista: When new hardware is detected, the drivers are installed automatically.
- Windows XP: Follow the instructions in the Found New Hardware Wizard. Select the option "Install software automatically."

After installation, you will need to determine which COM port the connected USB TROLL Com is using:

- Windows 2000 & Windows XP: Control Panel > System > Hardware > Device Manager > Ports. Click the plus sign to display the ports.
- Windows Vista: Control Panel > System > Device Manager (User permission required) > Ports. Click the plus sign to display the ports.

REMEMBER THE COM PORT NUMBER! You will need it when connecting to the TROLL 9500 in software.

CONNECT THE HARDWARE

TROLL 9500 TO TROLL COM

Connect the TROLL 9500 to the appropriate TROLL Com as shown.

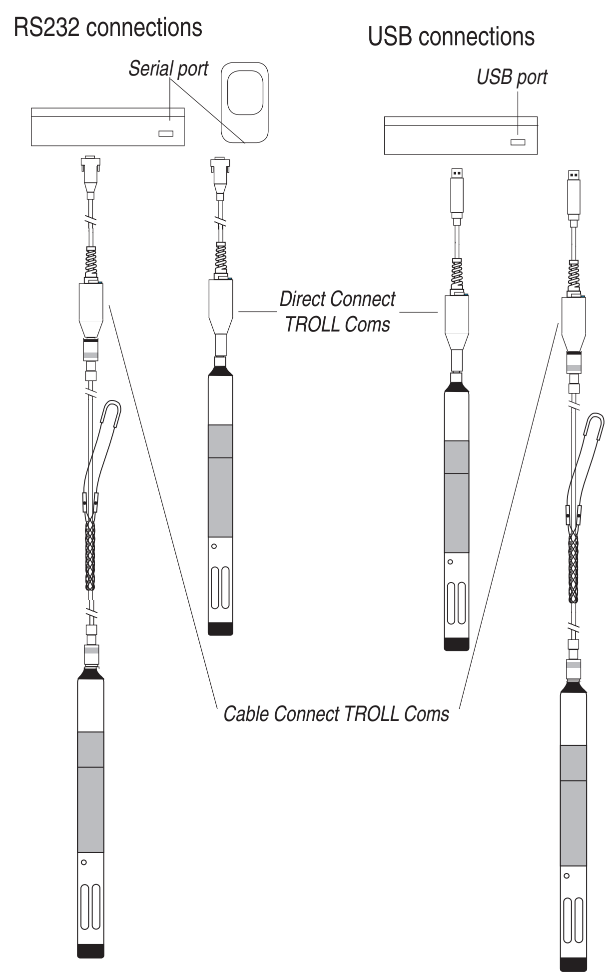
- Connect a **Direct Connect** model simply by pressing onto the connector at the back end of the TROLL 9500.
- Attach a **Cable Connect** model via locking Twist-Lock connector to the TROLL's RuggedCable—see the box on the next page.

TROLL COM TO COMPUTER

Plug an RS232 TROLL Com into a serial port on a desktop/laptop PC or a RuggedReader.

Plug a USB into a USB port on a desktop/laptop PC. Install drivers and check the virtual COM port—see the box below.

After connections are made, you are ready to launch the software and program the MP TROLL 9500.



(continued on page 16)

TWIST-LOCK CABLE CONNECTIONS

RuggedCable mates to the TROLL 9500 and to Cable Connect TROLL Coms with a bayonet-type Twist-Lock connector.

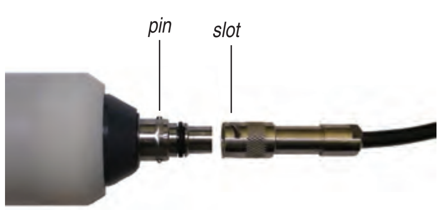
1. Remove the soft protective caps from the TROLL 9500 and the cable.

TROLL 9500 (or Cable Connect TROLL Com) *Cable*

TIP: *Keep the dust caps to protect the connector pins and o-ring when the connectors are not mated.*

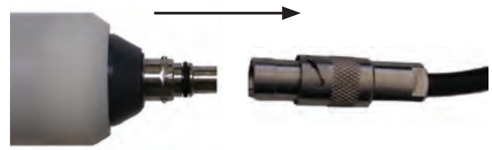
2. Take a moment to look at the connectors. Each has a flat side.

   Note the pins on the body connector (one on each side) and the diagonal slots on the cable connector (one on each side).

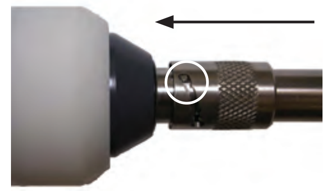


3. Slide back the sleeve on the cable connector.

4. Orient the flat sides so they will mate up, and insert the body connector firmly into the cable connector.



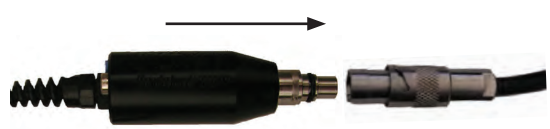
5. Slide the sleeve on the cable toward the body until the pin on the body pops into the round hole in the slot on the cable.



6. Grasp the textured section of the cable connector in one hand and the body in the other. Push and twist firmly so that the pin on the body slides along the slot on the cable and locks securely into the other hole. The "click" ensures the cable is securely attached.

To attach a Cable Connect TROLL Com, first remove the desiccant from the cable (if present): Grasp the textured section of the cable connector in one hand and the desiccant in the other. Twist in opposite directions to unlock the desiccant from the cable.

Orient the "flats" so they will mate up, and insert the TROLL Com connector firmly into the cable connector.



Push, twist, and click to lock.

ESTABLISH COMMUNICATION WITH THE MP TROLL 9500

1. Start Win-Situ 4 by double-clicking the shortcut created on the desktop during installation  .

   Or tap the Pocket-Situ 4 shortcut on the PDA Start Menu.

2. The Connection Wizard starts to help you set up the port:
   - **Connection type:**
     - Direct, for use when the Multi-Parameter TROLL 9500 is attached directly to the host PC
     - Modem for a dial-up modem
     - Spread-Spectrum Radio
   - **Devices connected:** Select "one" to speed up connection to a single device, or "more than one" for a network.
   - **Port:** Select the COM port to which the device is attached. If using a USB TROLL Com, be sure to select the correct COM port (see the box on page 14). For a Modem connection, enter the phone number—up to 40 characters; a comma designates a pause.
   - **Baud Rate:** Select any rate (19,200 is the default); baud rates are automatically synchronized between devices and the host PC.
   - **Name (optional):** A default connection name is suggested.
   - To have the wizard connect automatically to the attached device(s), be sure the option **Connect and find devices on "Finish"** is checked.

3. When you finish the Wizard, the software "finds" (connects to) the device, and displays it in the Navigation tree.

TIP: *For an introduction to the appearance and controls of the user interface, turn to Section 4, Control Software.*

What do I do if the MP TROLL 9500 does not appear in the Navigation tree?

First try double-clicking the connection. If the device still does not appear, there may be a communication problem. Check these likely culprits:

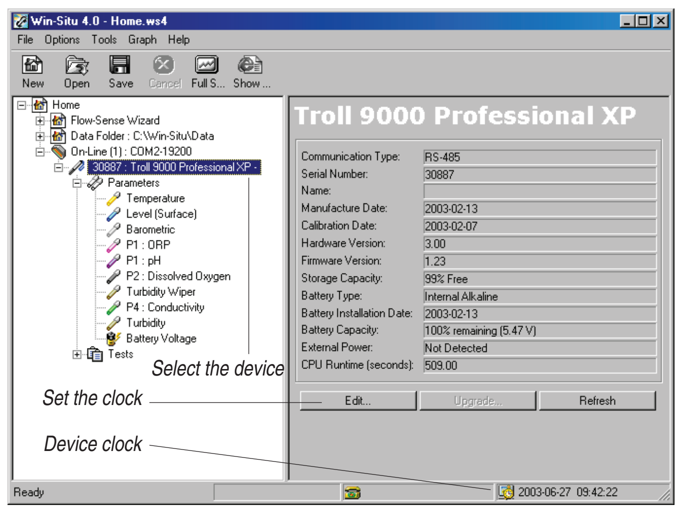
- *Be sure you selected the correct COM port for your PC.*
- *Check that all cable connections are tight.*
- *Be sure the MP TROLL 9500 has sufficient battery power, or that external power is being supplied.*

SET THE REAL-TIME CLOCK

Data collection schedules depend on the device's real-time clock, shown in the lower right corner of the desktop PC interface. If the device clock is wrong, be sure to correct it before scheduling tests. Set the clock as follows:

1. With the device selected in the Navigation tree, press ***Edit***.
2. In the Device Wizard, select ***Clock.***
3. Follow the instructions to synchronize the MP TROLL 9500's internal real-time clock to the host computer.
4. When you finish the Wizard, Win-Situ sends the information to the device and updates the display.

TIP: *Due to the size of the PDA screen, the device clock is not displayed in the Pocket-Situ interface. We recommend you edit the device—Tap the device, tap Edit, tap Clock— to synchronize the device clock to the PDA clock.*

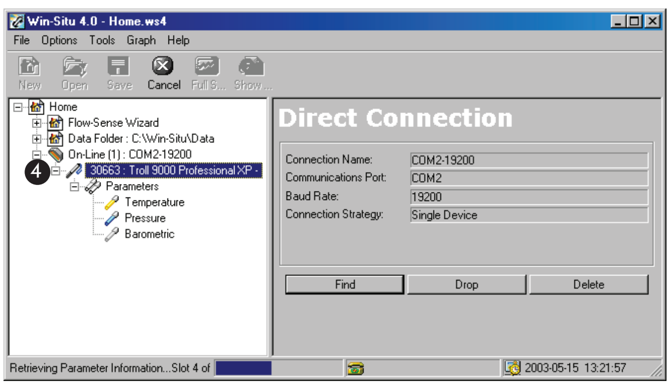


QUICK-CAL THE BASIC WATER-QUALITY SENSORS

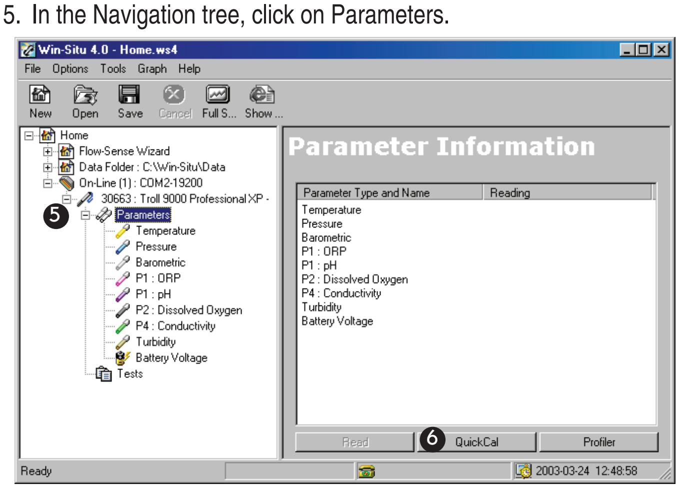
You will need:

- MP TROLL 9500 with Basic sensors installed (pH or pH/ORP, polarographic D.O., Conductivity), plugs in any unused ports.
- Cal Cup. Remove sponge if present.
- Quick Cal solution, at room temperature. Shake well before use.

1. Fill the Cal Cup with the Quick Cal solution. See guidelines in the sidebar on this page.
2. Remove the restrictor (if attached) and insert the front end of the MP TROLL 9500 into the Cal Cup. Thread the Cal Cup onto the body until seated against the o-ring, then back off slightly to avoid overtightening.
3. Connect the MP TROLL 9500 to a PC and establish a connection in Win-Situ 4 or Pocket-Situ 4.
4. Select the MP TROLL 9500 in the Navigation tree. The software will automatically detect and display the installed sensors.



5. In the Navigation tree, click on Parameters.



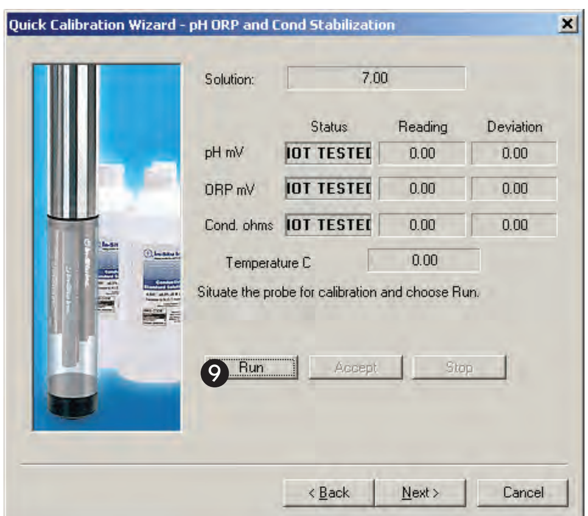
6. In the Information pane, select **QuickCal**.

Quick-Cal Tips

- A Quick Cal is the fastest way to calibrate pH, conductivity, polarographic D.O., & ORP. But for best results, if your software supports it, we recommend traditional calibration for pH, conductivity, and D.O., as described in Sections 11-13.
- Be sure to condition a new polarographic D.O. sensor for 2-4 hours, preferably overnight, before calibrating. See Section 13 for information. If the sensor is installed when you receive the instrument, it is conditioned and ready to calibrate.
- Guidelines for filling the Cal Cup with Quick Cal solution:
  - With a full complement of sensors installed, use the lower line as a guide (about half full).
  - With 1 or 2 sensors installed, fill to the upper line.
  - When calibrating a high-range conductivity sensor, insure the side ports are immersed in solution. Dislodge any bubbles that may appear. For a Quick Cal with a full set of sensors, we suggest you fill the Cal Cup above the line labeled "Recommended Fill Line - High." Use about a half-inch of additional fluid, depending on the sensor load. Some experimentation may be needed.
- When Quick-Calibrating polarographic D.O. with a high-range conductivity sensor installed, the increased fill level suggests handling with care when you invert the Cal Cup at step 11—allow the excess fluid to spill into a sink, or remove the Cal Cup from the instrument and pour some fluid out, re-attach the Cal Cup, then invert it and loosen the end cap to achieve the correct atmospheric pressure for a polarographic D.O. calibration. The D.O. sensor membrane should be in air, the temperature sensor should be completely submerged.
- For best accuracy, conductivity sensors should be wetted for 15-30 minutes immediately prior to calibration. This immersion can be in either clean water or the Quick Cal solution.
- For best results at temperatures at or below 15°C, de-select the conductivity sensor when perfoming a Quick-Cal; follow up with a single-parameter calibration uisng 8000 microSiemens/cm.
- If an RDO Optical Dissolved Oxygen sensor is installed, use the special soft plastic cal insert (it has an orange base) to Quick Cal the standard sensors, since the standard Cal Cup will not fit when the RDO sensor is installed. Fill the cal insert with calibration solution, slide it up around the sensors, including the RDO cable, and use the RDO restrictor as a support during calibration.
- If your MP TROLL 9500 includes a turbidity wiper, insure the pad does not absorb Quick Cal solution. **Either** carefully remove the wiper head (see Wiper Maintenance in Section 18), **or** soak the front end of the TROLL in water before calibrating; allow the pad to become saturated.
- Quick Cal is not available for these sensors: Nitrate, Ammonium, Chloride, Turbidity, Optical D.O. Traditional calibrations should be performed for best results from these sensors.

The Quick Calibration Wizard starts. A screen like this is displayed.

7. Insure there is a check beside the sensors you wish to Quick-Cal.
8. Click **Next**. The pH, ORP, and Conductivity screen appears.



9. Click **Run** to start the calibration.

The display will continuously update as readings are taken and compared against the stabilization criteria (see sidebar).

All 3 parameters must indicate NOMINAL or STABLE before the calibration can continue.

- When pH, ORP, and conductivity are STABLE, the polarographic D.O. calibration screen is displayed automatically if a polaro-graphic D.O. sensor is installed.

Status indicators during stabilization:

NOT TESTED may be displayed before the calibration begins.

UNSTABLE indicates the sensor response does not meet the criteria for a valid calibration point. All parameters start out at "Unstable" status.

NOMINAL indicates the change in the sensor response over time meets a relaxed stability criterion. "Nominal" stability will occur first, and can be accepted to shorten the calibration time.

STABLE indicates the change in the sensor response over time meets the stability criteria for a Quick Cal.

Reading: Current sensor response (in indicated units).

Deviation: Change in response between the last two readings. This enables you to follow the progress of the stabilization, but deviation from the previous reading is not necessarily the best indicator of stability as the software is looking at longer-term trends.

Run button: Starts the calibration

Accept button: Becomes available when Nominal stability is reached (see below)

Stop button: Stops the current phase of the calibration

Back button: Goes to the previous screen (when available)

Next button: Proceeds to the next screen (when available)

Cancel button: Cancels the calibration

Q: ***What is the difference between NOMINAL and STABLE?***

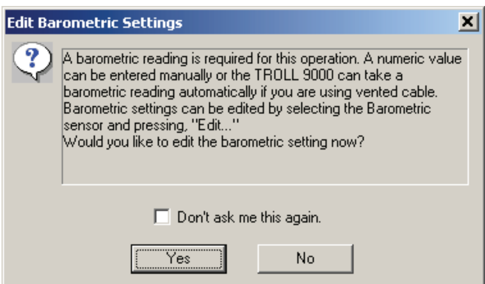
A: *To meet the criteria for a valid calibration point, the change (deviation) in sensor response is monitored over time. The software is looking for the calibration solution temperature and the sensor readings to settle over a specific time period. The criteria for STABLE are designed to meet the published specifications. The NOMINAL criteria are designed to shorten the calibration time when an approximate calibration is acceptable. When the deviation falls within the limits of the "loosened" specifications, NOMINAL is displayed in the Status area, and the Accept button becomes available to store the current calibration point.*

Accepting a NOMINAL value may save considerable time. In some cases, especially if the sensors have been soaking in the solution for several minutes prior to calibration, the accuracy achieved by accepting a nominal value may be very similar to that obtained by waiting for complete stability.

- Alternatively, you may click Accept to store the early values. The Accept button becomes available when NOMINAL or STABLE is indicated for all 3 parameters.
- If there is no polarographic D.O. sensor, the Quick Cal is complete. Go to step 14.

If performing a **Polarographic Dissolved Oxygen** calibration, continue with steps 10-13.

10. **Polarographic Dissolved Oxygen:** Before the D.O. segment of the Quick Cal Wizard starts, you will be asked how you want to handle barometric pressure.



Barometric pressure is important in converting measurement of D.O. concentration to percent saturation, and a value is required for accurate calibration. If the TROLL 9500 cable is vented, an accurate barometric pressure value can be read from the onboard barometric pressure sensor. If the TROLL cable is non-vented, then a barometric pressure value should be entered manually.

Do one of the following in this screen:

- If the TROLL 9500 is on **vented** cable now and will take measurements using **vented** cable, click No — and you may want to check the "Don't ask me this again" box.
- If the device is on **vented** cable now but will take measurements on **non-vented** cable, click Yes. In the Edit Barometric Channel screen, check the box indicating non-vented cable for measurements but vented cable for calibration/programming.
- If the device is on **non-vented** cable now and will take measurements on **non-vented** cable, click Yes. In the Edit Barometric Channel screen, check the box indicating non-vented cable for measurements and enter a barometric pressure value. For help, see Section 9, Monitoring Barometric Pressure.

11. To complete the calibration, **expose the polarographic D.O. sensor to air:** Without disconnecting the cable, invert the probe so that the membrane at the tip of the sensor is in air and the temperature sensor is immersed in fluid. This will probably require you to remove the end cap from the Cal Cup and pour some fluid out.

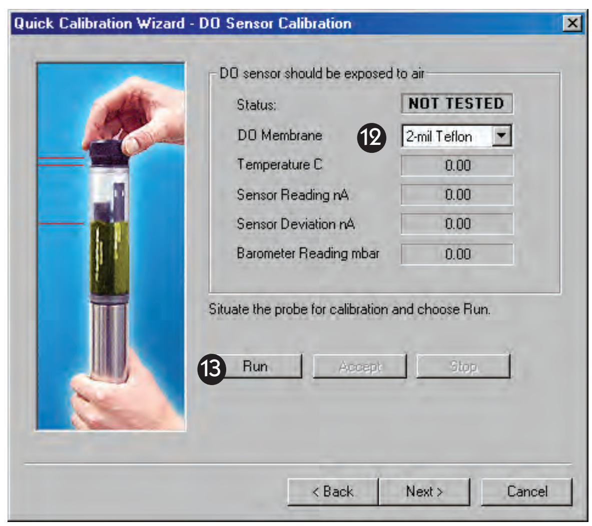
While you have the cap off, remove any droplets on the membrane by blotting gently with a clean swab or the corner of a tissue. Re-attach the end cap **loosely** to insure the volume is not pressurized.

TIP: *For proper venting, loosen the end cap until a small hole in the threads near the o-ring is at least partly visible.*

12. In the DO calibration screen, select the membrane type, stamped on the membrane module (if not indicated, select 1-mil Teflon).

13. Click **Run** to begin the stabilization.

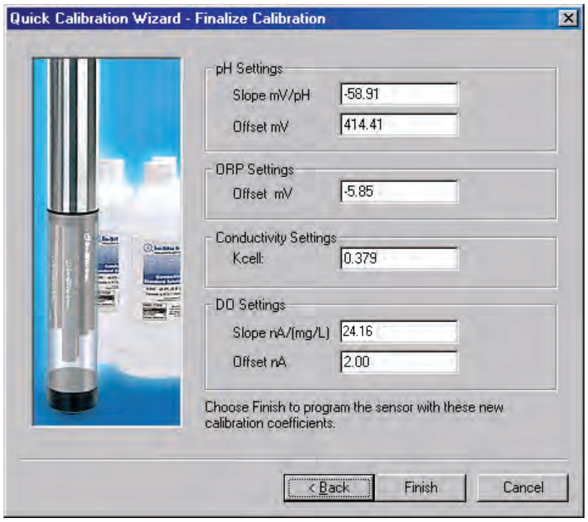
The display will continuously update as readings are taken and



compared against the stabilization criteria (see sidebar on the previous page).

14. When the sensor response is STABLE (or alternatively, when you accept the nominal value), the Quick Cal procedure is complete.

The Wizard displays a final calibration screen like the one below at the end of the Quick Calibration procedure. This information is also stored in the Calibration Report. Click **Finish** to continue. When you click **Finish,** the calibration information is written to the sensors.



The calibrated sensors are ready to take measurements.

Ideally, you chould calibrate just before using the MP TROLL 9500. However, if the the instrument will not be put to use immediately, store it as follows:

- Leave the sensors installed. Remove the Cal Cup and rinse it and the sensors. Add about 50-100 mL of tap water to the Cal Cup. Return the probe to the Cal Cup for transport to the field.

CALIBRATE THE EXTENDED SENSORS

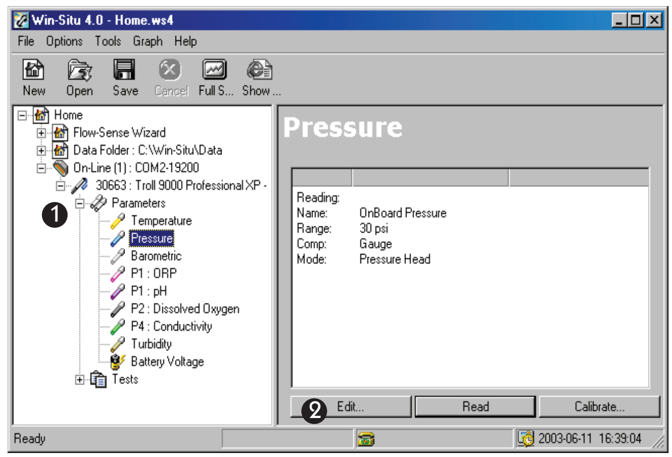
For some sensors, the Quick-Cal procedure is not available. A traditional calibration is recommended. To calibrate, select the sensor in the Parameters list and click or tap ***Calibrate*** to launch a Calibration Wizard. Complete calibration information is in the following sections of this manual:

RDO Optical Dissolved Oxygen	Section 13 (second part)
Ammonium	Section 15
Chloride	Section 16
Nitrate	Section 17
Turbidity	Section 18

SET UP CUSTOM PRESSURE/LEVEL MEASUREMENTS

You can configure a pressure channel to display measurements just the way you want them—as raw pressure head above the sensor, as depth, or as water level with a reference. The specified settings are easily changed from one mode to another, and any choice can be redone or undone later, when viewing test data.

1. With the MP TROLL 9500 connected to a host PC, select the pressure parameter in the Navigation tree.
2. Click or tap ***Edit...***.



The Parameter Wizard will help you enter the required information. The choices are explained in greater detail in Section 7 below.

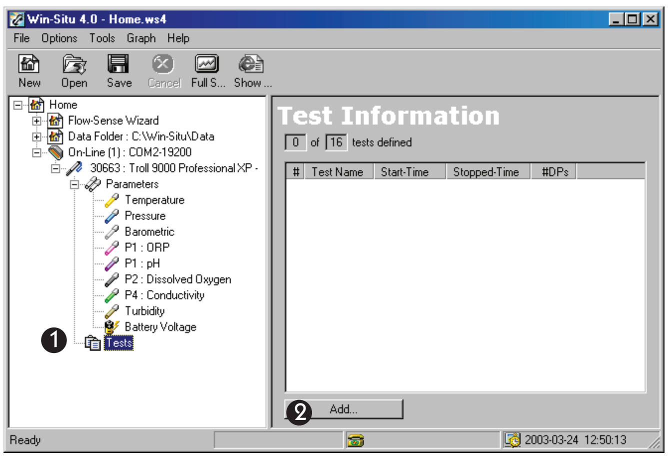
3. When you finish the Wizard, the information is written to the device and the display is updated. The pressure channel is ready to take measurements

TIP: *For complete information on setting up the pressure parameter, refer to Section 7 of this operator's manual.*

SET UP TO LOG DATA (SET UP A TEST)

A “test” is a set of instructions to the instrument’s internal data logger for collecting a set of data—including which parameters to measure, how often, and when to start. Section 6 below contains detailed information on setting up tests.

1. With the MP TROLL 9500 connected to a host PC, click or tap Tests in the Navigation tree.
2. Click or tap **Add...**.



The Test Wizard will help you enter the information. The choices are discussed in detail in Section 6 below.

3. When you finish the Wizard, Win-Situ sends the information to the device and updates the display.

   If you added “scheduled” test (indicated by in the Navigation tree), it will start at its programmed time.

   If you set up a test or a manual start (indicated by in the Navigation tree), you can start it at any time by pressing the Start button while connected in software.

TIP: *For complete information on setting up tests, refer to Section 7 of this operator’s manual.*

COMPLETE THE SETUP

If real-time readings are not required, remove the TROLL Com from the cable after programming.

Protect the “uphole” end of the cable with the cable dust cap or desiccant.

The cable dust cap is not waterproof. Be sure it is positioned above the highest anticipated water level. Avoid areas that may flood.

If cable will not be used, attach a Twist-Lock Hanger to the TROLL 9500.

The instrument is now ready for transport to the site where it will be used to take measurements.

4 CONTROL SOFTWARE

The interface from a desktop or laptop computer (PC) to the Multi-Parameter TROLL 9500 is provided by instrument control software called Win-Situ® 4. Instrument control is accomplished through a familiar, easy-to-use Navigation Tree interface.

For field use on a hand-held computer (PDA), optional Pocket-Situ 4 provides all of Win-Situ's functionality and features in a convenient field-portable platform.

Use Win-Situ or Pocket-Situ for these tasks:

- to calibrate water-quality sensors
- to convert pressure measurements to depth or level readings
- to set up data collection schedules ("tests")
- to take direct "manual" readings
- to take continuous real-time readings (Profiling)
- to transfer data from the Multi-Parameter TROLL 9500 to the host computer
- to view logged data in text or graph format
- to delete data from the Multi-Parameter TROLL 9500 in order to free up memory
- to monitor battery and memory usage
- to set the device clock
- to upgrade device firmware (when available)
- to choose measurement units and other custom display options
- to monitor indicator water-quality parameters during low-flow pumping
- to schedule automatic remote transmissions (if available)

TIP: *For software system requirements, see Section 2, Components & Features. Software installation is covered in Section 3, Getting Started.*

LAUNCHING THE SOFTWARE

WIN-SITU 4

Use one of the following methods:

- Double-click the shortcut created on the desktop during installation.
- Select Win-Situ 4 from the In-Situ Inc program group on the Windows Start menu.

POCKET-SITU 4

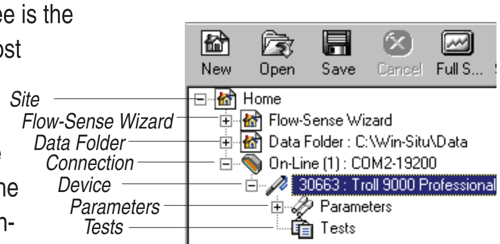
Tap Start to display the RuggedReader's Start Menu. Select Pocket-Situ 4.

- If you don't see a shortcut, tap Programs and select Pocket-Situ 4
- If it launches in "demo" mode, you can activate it with the license key and activation code from your In-Situ License Agreement

THE USER INTERFACE

Win-Situ 4 and Pocket-Situ 4 use the familiar "Navigation tree" to display your instrument network. The tree appears on the left of the screen in Win-Situ, and at the top of the screen in Pocket-Situ. The remainder of the screen is an "Information pane" with details about the "node" you have selected in the tree. The selected node and its information constitute a "view" in the interface.

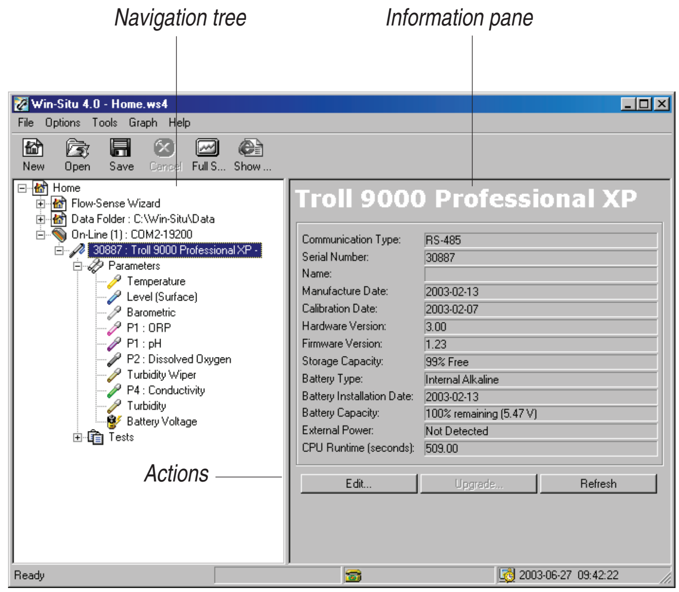
THE NAVIGATION TREE



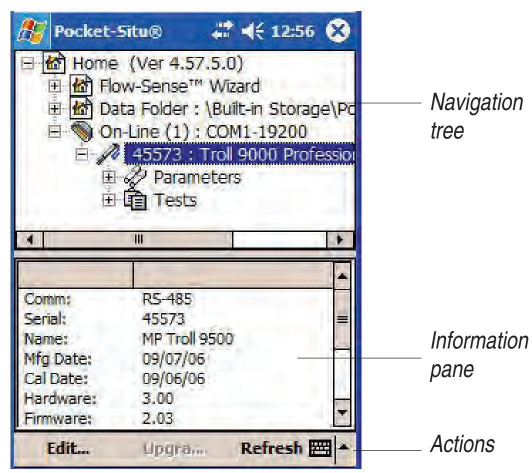
At the top of the tree is the "Home" site (the host computer). Below this is the Flow-Sense Wizard (see Section 20), then the Data Folder containing tests that have been extracted from the device to the host computer. This is followed by one or more connections (COM ports), and then one or more devices (Multi-Parameter TROLLs or other In-Situ instruments) accessible through each COM port. The Device node is further expandable to show the parameters the device can measure and the tests contained in the device's memory.

The site, wizard, data folder, connection, devices, parameters, and tests are all "nodes" in the Navigation tree. The symbol + means a node can be expanded to show more nodes below it. Each selection results in a unique "view" in the Navigation tree.

The Win-Situ 4 Application Window (desktop/laptop PC)



The Pocket-Situ 4 Application Window (PDA)



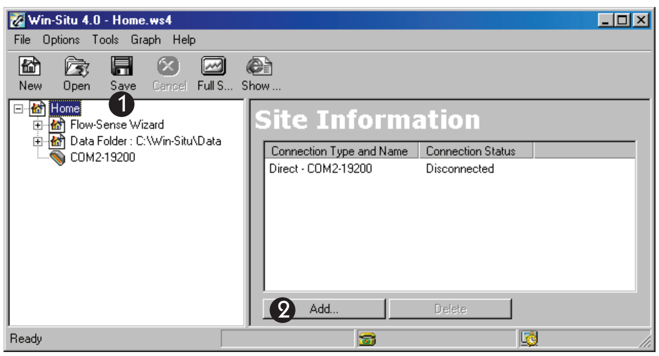
SOFTWARE FUNCTIONS

CONFIGURING THE PORT

When you start Win-Situ or Pocket-Situ for the first time, a new, empty site called “Home” is displayed at the top of the Navigation tree. The Connection Wizard starts automatically to help you add a connection to the site, specifying your computer’s COM port, desired baud rate, and other port properties.

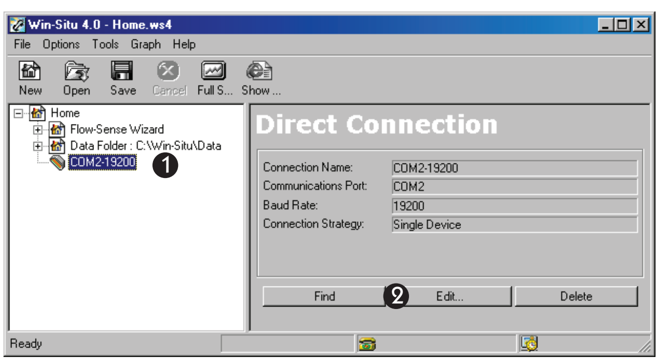
To add a new connection to the site—or if the Connection Wizard does not start automatically for some reason—proceed as follows:

1. Select the site.
2. Click or tap ***Add....***



To change the properties of a connection:

1. Select the connection.
2. Click or tap ***Edit....***



To delete a connection from the site:

1. Select the connection.
2. Click or tap ***Delete.***

For additional information on the port properties prompted by the Connection Wizard, refer to Section 3, Getting Started.

ESTABLISHING COMMUNICATION WITH THE MP TROLL 9500

New Connection

The last option in the Connection Wizard is to **Connect and find devices on “Finish.”** If you select this option, the software will automatically establish communication with the MP TROLL 9500.

If you did not select this option, proceed as for an existing connection .

Existing Connection

Each time you launch the software, the site and the connection saved in your last session are displayed in the Navigation tree. To connect:

1. Select the connection.
2. Click ***Find***. Or just double-click the connection.

Win-Situ or Pocket-Situ will open the connection, synchronize the baud rate, locate the device, and display it in the Navigation tree.

3. Click to select the MP TROLL 9500 in the Navigation tree.

If the device’s remaining battery capacity is 5% or less, the device may not be displayed in the tree. Replace the batteries before continuing.

DISPLAYING DEVICE INFORMATION

When you select the MP TROLL 9500 in the Navigation tree, the software first retrieves information about the device, then automatically detects the installed sensors and displays them in the tree.

TIP: *If one or more sensors is incorrectly installed, an error message will be displayed. Simply remove the sensor and install it in the correct position, then “refresh” the device to display the sensors in the Parameters list.*

With the MP TROLL selected in the Navigation tree, the Information pane displays a wealth of information about the device, as shown in the Win-Situ screen on the following page. You may need to scroll to view all the information in Pocket-Situ.

The Information pane also provides buttons for actions you can perform, such as upgrading the device features (if available), editing the device properties (including the real-time clock), and refreshing the connection.

Battery Capacity display: On battery power, the "loaded" battery voltage is reported (i.e., the device is drawing current from the batteries).

If external power is detected, an artificially high battery voltage may be reported depending on the device hardware. Hardware versions earlier than 3 report a constant, regulated voltage (approximately 3.3 V). Hardware version 3 will report the true battery voltage, but since switching to external power removes the load from the battery the number may change when you switch from external to battery and vice-versa.

UPGRADING FIRMWARE AND FEATURES

Firmware Upgrade

New software releases may include a new version of firmware for the MP TROLL 9500. If the software detects a newer version of firmware than that currently loaded in the device, you will be prompted to upgrade device firmware when you connect to the MP TROLL 9500. The upgrade process is brief and software-assisted.

For best performance, we recommend you upgrade to new firmware when prompted by the software.

***TIP:** In order for the software to detect it, the new firmware must be located in the Firmware folder in the folder where Win-Situ or Pocket-Situ is installed. Firmware is automatically copied to these locations when new software is installed.*

Features Upgrade

The MP TROLL 9500 is available in several models, each offering a different feature set. Some models may be field-upgraded to take advantage of a wider range of features. The field upgrade involves keying in an upgrade code, issued by In-Situ when an upgrade is purchased for a specific instrument serial number.

If you have an upgradable feature set, the Upgrade button will be available in the Information pane when the device is selected in the Navigation tree. If you have purchased a features upgrade for your MP TROLL 9500, press ***Upgrade*** and key in the upgrade code issued by In-Situ Inc. Follow the instructions in the Upgrade Wizard.

Device View of an MP TROLL 9500

The device displays its "family," TROLL 9000, in the Navigation tree

EDITING THE DEVICE PROPERTIES

Setting a Device Name

The software recognizes each device on the network by its type and serial number. In addition, you can assign a meaningful description—a well or site name, location coordinates, etc. This name will be displayed in the Navigation tree and in the header of test data files.

1. With the MP TROLL 9500 connected to a host PC and selected in the Navigation tree, press ***Edit...***.
2. In the Device Wizard, select ***Name,*** then **Next**.
3. Enter a new name for the device (up to 16 characters).
4. When you finish the Wizard, the information is sent to the device and the display is updated.

Setting the Real-Time Clock

Data collection schedules depend on the device clock, shown in the lower right corner of the desktop PC interface. If the clock is not correct, set it as follows:

1. With the MP TROLL 9500 connected to a host PC and selected in the Navigation tree, press ***Edit...***.
2. In the Device Wizard, select ***Clock,*** then **Next**.
3. Follow the instructions to synchronize the MP TROLL 9500's internal real-time clock to the host computer.
4. When you finish the Wizard, the information is sent to the device and the display is updated.

__TIP:__ Due to the size of the PDA screen, the device clock is not displayed in the interface. We recommend you edit the device as above to synchronize the device clock to the PDA clock.

Setting Battery Information

After replacing the batteries, update the device battery information:

1. With the MP TROLL 9500 connected to a host PC and selected in the Navigation tree, press ***Edit...***.
2. In the Device Wizard, select ***Battery Information,*** then **Next**.
3. Select the appropriate battery type and enter the installation date.
4. When you finish the Wizard, the information is sent to the device and the display is updated.

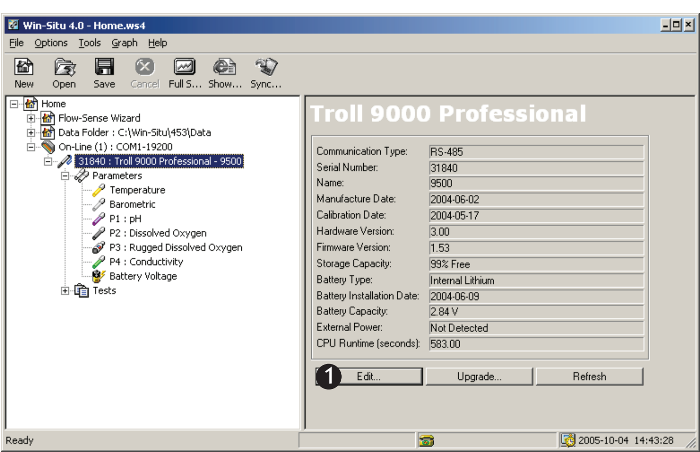
SDI-12 and ASCII Mode Preferences

Preferences for these communication modes may be set in the Device Wizard.

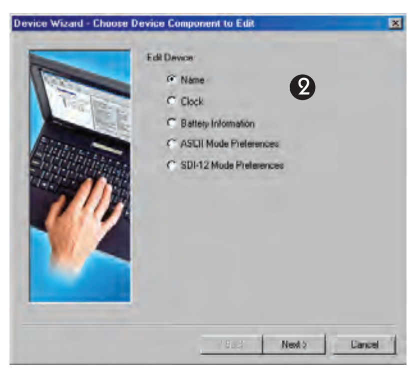
1. With the MP TROLL 9500 connected to a host PC and selected in the Navigation tree, press ***Edit...***.
2. In the Device Wizard, select the desired mode to edit, then **Next**.
3. Change the settings as appropriate.

To communicate via SDI-12, insure SDI-12 is __enabled__ (factory default) in the device. For telemetry applications, SDI-12 should be disabled.

Editing the Device Properties



1. Select the device in the Navigation tree and click Edit.



2. Select the device property to edit.

CHOOSING MEASUREMENT UNITS AND OTHER PREFERENCES

Preferences can be set at any time, and are saved with the site. A connection to the instrument is not required.

User-selectable preferences include:

- Parameter measurement units & elapsed time units
- Data file view—report or graph
- Calendar date & time of day format
- Metric or English units for the Flow-Sense Wizard

The following Settings Options are also available:

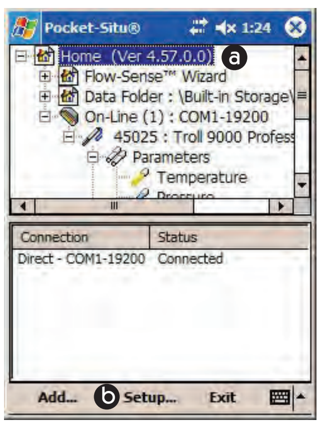
- Start the application in Profiler mode
- Specify desired Profiling rate
- Re-display the “Don’t Ask Again” dialogs

To display the Preferences window, do one of the following:

- In Win-Situ, select Preferences from the Options menu.
- In Pocket-Situ:

  a. Tap the Home site in the Navigation tree...

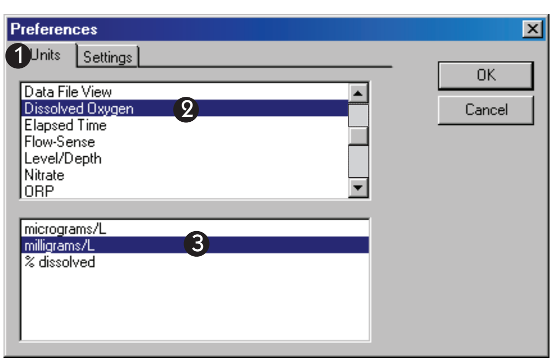
  b. then tap **Setup...** in the command bar.



Units

Default units are used for the display of data unless you specify other preferences. To set unit preferences, first display the Preferences window as above.

1. Select the Units tab.
2. In the top of the Units window, select a parameter whose unit you wish to change.

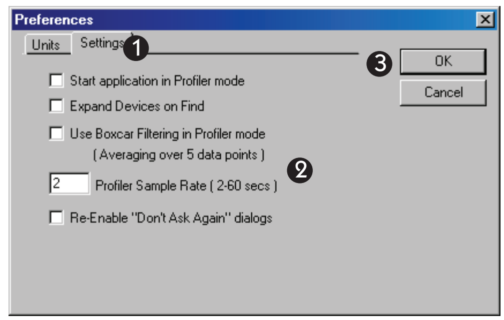


3. In the bottom of the window, select the unit you want for the highlighted measurement. Repeat for as many units as you like.
4. Do one of the following:
   - Click ***OK*** to apply the new units and close the window.
   - Click the Settings tab to change other settings.

Other Preferences

To change other aspects of Win-Situ/Pocket-Situ operation, first display the Preferences window as above.

1. Click the Settings tab.



2. Select the options you want:
   - Start application in Profiler mode. This will take effect at your next session.
   - Expand Devices on Find. This will take effect the next time you click “Find.” The software will automatically display all nodes in the device tree without any further action from you.
   - Set desired Profiling rate—the Profiler default rate is 2 seconds, but you may select any rate from 2 to 60 seconds.
   - Re-display the “Don’t Ask Again” dialogs. This appears if you have selected “Don’t ask me this again” in any WIn-Situ or Pocket-Situ dialog boxes.

   Boxcar filtering is no longer available.
3. Select ***OK*** to close the window and apply the settings.

TIP: *Preferences are saved with the site (on the PC), not in the device.*

CHOOSING PRESSURE DISPLAY & CONVERSION OPTIONS

Measurements from the optional pressure sensor may be displayed as raw pressure head above the sensor, as depth, or as water level with a reference. When measuring depth or level, you have a choice of methods for conversion from pressure measurements. The specified settings are easily changed from one mode to another, and most choices can be redone or undone later, when viewing test data.

TIP: *For more on the pressure channel setup, refer to Section 7.*

To set the custom display options and pressure-to-level conversion options for a pressure channel:

1. With the MP TROLL 9500 connected to a host PC and selected in the Navigation tree, expand the Parameters node and select the pressure parameter.
2. Click ***Edit...***.

The Parameter Wizard starts. Refer to Section 7 for complete information on the display and conversion options.

3. When you finish the Wizard, the information is sent to the device and the display is updated.

PERFORMING WATER-QUALITY CALIBRATIONS

Although satisfactory results may be achieved in some cases without field-calibrating the water-quality sensors, for best results we recommend a preliminary calibration procedure before the first field use, and periodic checks and recalibrations as necessary.

The software provides several options for sensor calibration. Choose a method based on the time you are willing to spend calibrating and the accuracy you wish to achieve.

- **Traditional Calibration** guided by software wizards can achieve accuracy and resolution equivalent to laboratory-based meters. Some sensors require a single-point calibration, some present a choice of single- or multi-point, requiring more than one calibration standard.

  A detailed, step-by-step description of each water quality calibration may be found in the relevant parameter section (Sections 11-18) of this manual.

- **Quick Cal** calibrates the basic sensors (pH, ORP, polarographic D.O., conductivity) simultaneously to achieve adequate performance with minimal labor.

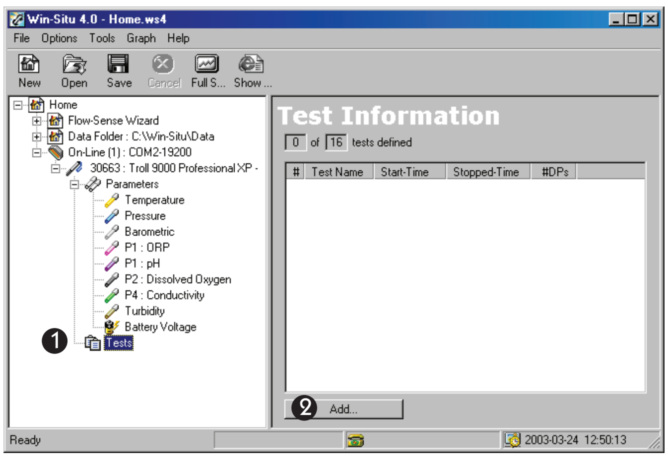
  Refer to Section 3, Getting Started, for the Quick Cal procedure.

LOGGING DATA (ADDING A TEST)

Logging data with the MP TROLL 9500 is called “running a test.” To tell the instrument how to run the test—which parameters to measure, how often, when to start, etc.—you “add” a test to the device.

TIP: *For more on logging, extracting, viewing, and deleting data, refer to Section 6.*

1. With the MP TROLL 9500 connected to a host PC and selected in the Navigation tree, click or tap Tests.
2. Click or tap ***Add...***.



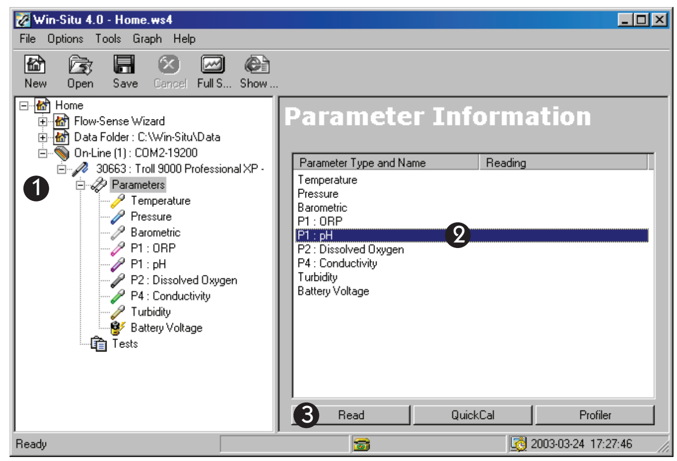
The Test Wizard starts. See Section 6 for a description of the elements that constitute a complete test definition.

3. When you finish the Wizard, the information is sent to the device and the display is updated.

TAKING “MANUAL” READINGS

The MP TROLL 9500 collects data in “tests” but you can get a quick “manual” reading from any device apart from a test, even while a test is running.

1. With the MP TROLL 9500 connected to a host PC and selected in the Navigation tree, click or tap Parameters.
2. In the Information pane, select one or more parameters to read. To select multiple parameters, hold the Control key while selecting. (To display the CTRL key on a PDA, tap the keyboard symbol in the Command bar.)



3. Click or tap ***Read***.

TIP: *For continuously updated real-time “manual” readings of all parameters, select **Profiler** in the Information pane. Refer to Section 5 for Profiler information.*

EXTRACTING AND VIEWING DATA

Logged data (“tests”) reside in the MP TROLL 9500 until you “extract” them. The extract operation copies test data from the device memory to the host computer. Once a test has been extracted to the host computer, it can be viewed. A test can be extracted and viewed at any time, even while it or another test is running.

TIP: *For more on logging, extracting, viewing, and deleting data, refer to Section 6.*

To extract a test:

1. With the MP TROLL 9500 connected to a host PC and selected in the Navigation tree, expand the Tests node to display all the tests in the device.
2. Select a test and click or tap ***Extract***.
3. To view the test immediately, select the **View** option at the end of the download.

TIP: *After the test has been extracted to the host computer, it will appear in the Data Folder node in the Navigation tree. A connection to the instrument is not required to view the extracted data.*

DELETING DATA FROM INSTRUMENT MEMORY

The Extract operation copies a test data file to the host PC, but does not remove it from the MP TROLL 9500. Test data files remain in the Multi-Parameter TROLL 9500’s memory until you delete them. Deleting tests frees up device memory.

CAUTION: *Be sure to extract data you want to save before deleting from the device. Once a test is deleted, the data cannot be retrieved!*

1. With the MP TROLL 9500 connected to a host PC and selected in the Navigation tree, expand the Tests node to display all the tests in the device.
2. Select a test and click ***Delete***.
3. Click ***Yes*** to confirm your selection.

The selected test is deleted and the display is updated.

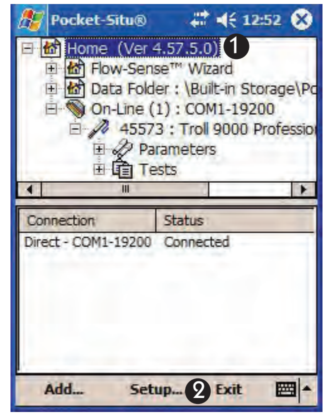
TIP: *If a test is running in the device, the Delete button is not available. You must stop the running test before tests can be deleted. See “Stopping a Test” in Section 6.*

EXITING THE SOFTWARE

WIN-SITU 4

Select **Exit** from the File menu.

POCKET-SITU 4



1. Tap the Home site in the Navigation tree...
2. then tap **Exit** in the command bar.

CAUTION: *Be sure to Exit Pocket-Situ as described above after each session. This releases allocated resources used by Pocket-Situ, assuring that the COM port is available the next time you connect to the MP TROLL 9500, or to a desktop PC using ActiveSync.*

5 PROFILING

All models of the Multi-Parameter TROLL 9500 include a software feature called the Profiler that delivers instant real-time readings on all available channels. Readings are continuously updated as long as the Profiler is running. This provides a convenient way to characterize surface waters using a hand-held controller running Pocket-Situ.

PROFILER FEATURES

- Auto detect—the software automatically identifies all properly connected sensors
- Continuously updated readings from all available channels
- Optional data logging to the connected PC
- Optional start device in Profiler mode
- Optional selectable Profiler interval (2-60 seconds)

You will need—

- MP TROLL 9500 with water quality sensors installed and calibrated
- RuggedCable
- Cable connect TROLL Com (RS232 for RuggedReader)
- Laptop PC running Win-Situ 4 or RuggedReader running Pocket-Situ 4

STARTING THE PROFILER

TIP: *If you set up the software to start in Profiler mode, steps 1-4 are done automatically when launching Win-Situ or Pocket-Situ. For details on this setting, see Choosing Measurement Units and Other Preferences in Section 4.*

1. Connect the MP TROLL 9500 to a host PC and establish communication in Win-Situ 4 or Pocket-Situ 4.

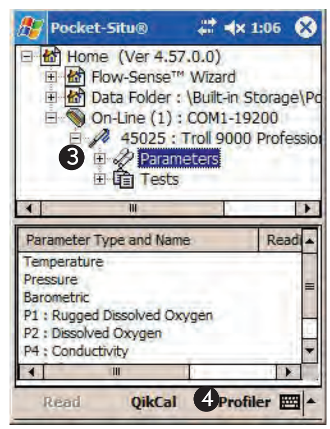
Can I do profiling if the MP TROLL 9500 is running a test?

Yes, but you may need to wait to get a reading if the test measurement interval is short. The Profiler will defer to the test measurement schedule.

2. Click to select the MP TROLL 9500 in the Navigation tree.

   The software will automatically detect the installed sensors and display them in the Information pane.

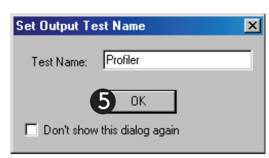
   If one or more sensors is incorrectly installed, an error message will be displayed. Remove the sensor, install it in the correct position, and refresh the display before continuing.



3. Click or tap Parameters in the Navigation tree.

4. Click or tap ***Profiler*** to start the Profiler.

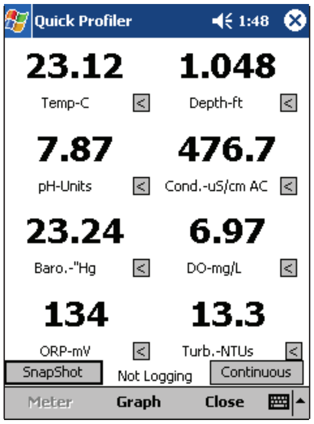
5. You will be asked if you want to set a filename for logged Profiler data (logging the data is optional)



   - To use the default name click **OK**.
   - To specify another name, key it in and click **OK**.
   - To avoid this question each time you start the Profiler, check the option box and click **OK**.

   In a moment, each active channel will be read sequentially, and the readings will be displayed. Up to 8 channels can be shown.

   TIP: *Don't let the PDA time out while Profiling. To locate this setting in most PDAs, display the Start menu, select Settings, System tab, Power.*



- Readings are updated approximately every 2 seconds as the Profiler cycles through the available channels in turn.
- The currently selected measurement unit is shown below each reading.

***TIP:** You can use the Setup option to change the Profiler's reading rate and/or the displayed units. See Customizing the Profiler later in this section for details.*

- A window without a reading indicates the channel is not available to read, usually because there is no sensor installed in the port.

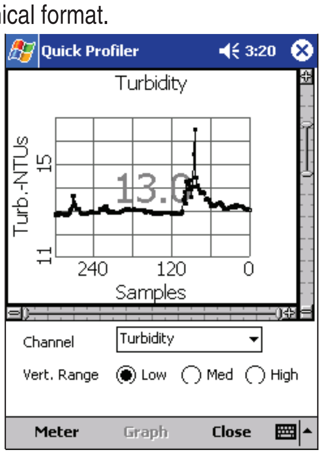
***TIP:** If a channel you wish to see is not displayed, click the < symbol below a reading you can do without and select the channel you want to add from the list of available channels. This is particularly useful for RDO readings.*

GRAPHING PROFILER DATA

To see a graph of any channel during the current Profiler session, do one of the following:

- Click or tap any reading.
- Click or tap **Graph**, and select the channel from the drop-down list.

Readings for the selected channel since the start of profiling will be displayed in graphical format.



The profiler can graph up to 300 readings. A range slider (scroll bar) on the right side of the graph allows you to change the range of visible data. Like the channel display, the graph will be continuously updated. A range slider at the bottom of the graph lets you zoom in on a narrower time period.

To switch back to the display of active channels, click Meter.

PROFILING DISSOLVED OXYGEN

The ability of the polarographic D.O. sensor to respond to a change in the dissolved oxygen content of the medium—for the sensor to accurately "see" a change—varies with the membrane thickness.

- A 1-mil membrane responds in about 1–2 minutes to significant DO changes;
- A 2-mil membrane responds in about 1.5–3 minutes to significant DO changes.

The RDO Optical D.O. sensor has a response time of T(90) = 30 sec and T(95) = 37.

PROFILING PRESSURE OR DEPTH

Profiler readings from a pressure channel are displayed as pressure head or depth according to the pressure channel setup. Refer to Section 7 below for pressure display and conversion options. Level mode readings with a user-entered reference are primarily for use in aquifer tests.

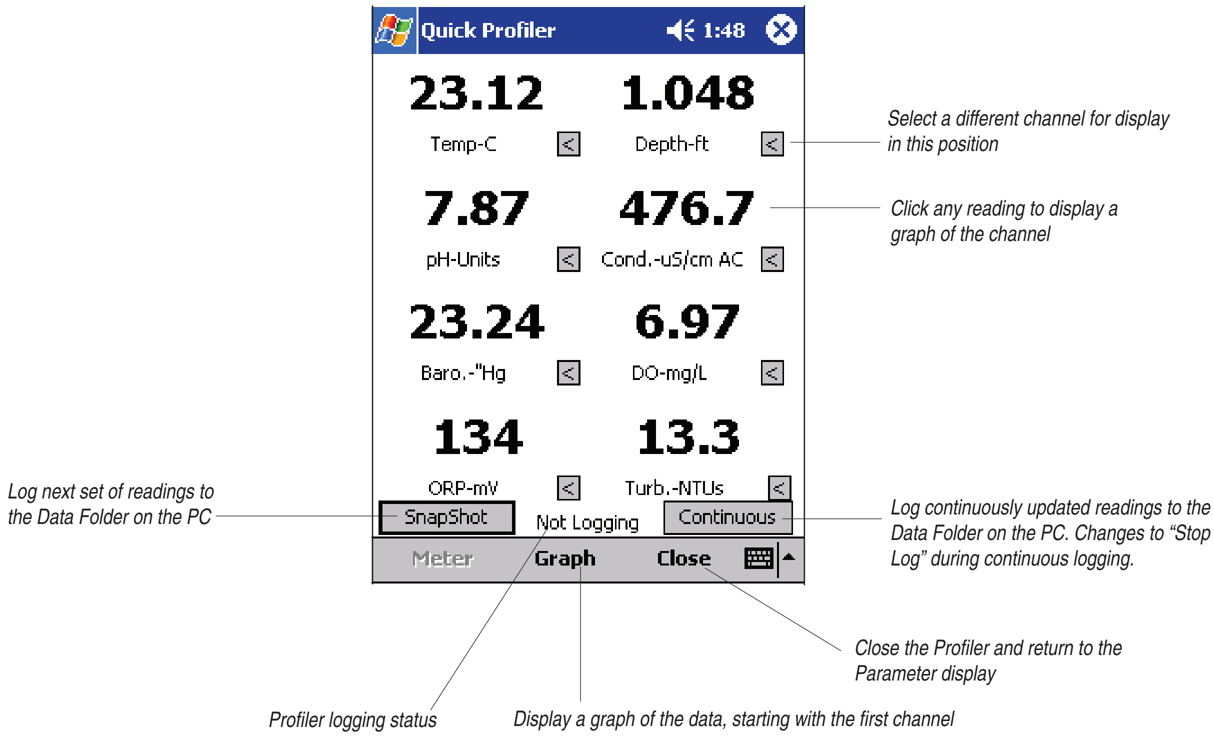
***TIP:** Profiling with the MP TROLL's default pressure settings (no channel setup) will display pressure head in psi (pounds per square inch). To display depth, edit the pressure channel as described in Section 7.*

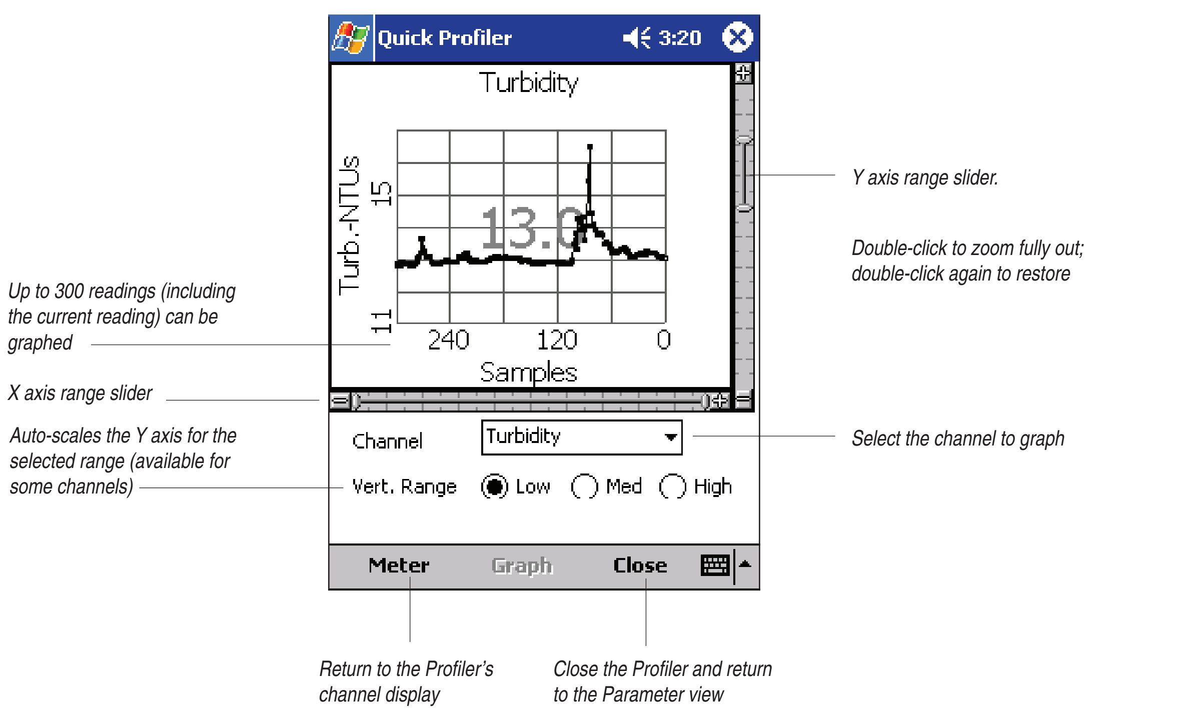
PROFILING TURBIDITY

The turbidity sensor requires a 5-second warmup before the first reading. Subsequent readings do not require a warmup.

If a turbidity wiper accessory is installed in the TROLL 9500, it performs an initial wipe of the sensor optics—this takes about 15 seconds—then displays the first turbidity reading. If the profiling rate is longer than 15 seconds, this 15 second wipe will happen before each reading. To avoid this delay, set the profiling rate to less than 15 seconds. See Customizing the Profiler later in this section for details.

Section 18 below has additional information on the turbidity wiper.


Quick Profiler
1:48
23.12
Temp-C
1.048
Depth-ft
7.87
pH-Units
476.7
Cond.-uS/cm AC
23.24
Baro.-"Hg
6.97
DO-mg/L
134
ORP-mV
13.3
Turb.-NTUs
SnapShot
Not Logging
Continuous
Meter
Graph
Close
Select a different channel for display in this position
Click any reading to display a graph of the channel
Log next set of readings to the Data Folder on the PC
Log continuously updated readings to the Data Folder on the PC. Changes to “Stop Log” during continuous logging.
Close the Profiler and return to the Parameter display
Profiler logging status
Display a graph of the data, starting with the first channel


Quick Profiler
3:20
Turbidity
Turb.-NTUs
15
11
13.0
240
120
0
Samples
Channel
Turbidity
Vert. Range
Low
Med
High
Meter
Graph
Close
Y axis range slider.
Double-click to zoom fully out; double-click again to restore
Up to 300 readings (including the current reading) can be graphed
X axis range slider
Auto-scales the Y axis for the selected range (available for some channels)
Select the channel to graph
Return to the Profiler’s channel display
Close the Profiler and return to the Parameter view

CUSTOMIZING THE PROFILER

Changing the Channels Displayed

The arrow ◁ below each Profiler reading displays a drop-down list that may be used to assign a different channel to each position, if desired. You can use this button to add a channel, such as RDO Optical Dissolved Oxygen, that is not displayed by default. However, only 8 channels can be shown.

Changing Measurement Units

Close the Profiler. In Win-Situ, select Preferences on the Options menu. In Pocket-Situ, select the Home site, then tap Setup in the command bar.

Changing the Sample Rate

Close the Profiler. In Win-Situ, select Preferences on the Options menu, then select the Settings tab. In Pocket-Situ, select the Home site, tap Setup in the command bar, then select the Settings tab. You may select any sample rate between 2 and 60 seconds.

Starting in Profiler Mode

In Win-Situ, select Preferences on the Options menu, then select the Settings tab. In Pocket-Situ, select the Home site, tap Setup in the command bar, then select the Settings tab. Check ✔ Start application in Profiler mode. This will take effect at your next session (or exit and re-start to apply this setting).

LOGGING PROFILER DATA

Profiler data may be logged to the connected PC while in the "Meter" view.

- **Snapshot:** To log a single set of Profiler readings, click or tap the **SnapShot** button in the "Meter" view.
- **Continuous:** To log continuous readings, click or tap the **Continuous** button in the "Meter" view. Readings will be logged until you cancel the operation by clicking **Stop Log**.

Can I see Dissolved Oxygen readings in mg/L and % saturation at the same time?

Yes, so long as your preferred unit for DO is mg/L. Select Dissolved Oxygen for one window, and Dissolved Oxygen % Saturation for another window.

TO STOP LOGGING

The Snapshot function logs a single set of readings and stops logging automatically.

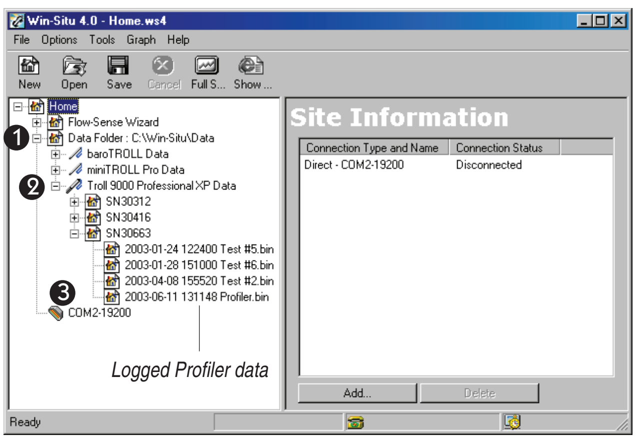
In Continuous mode, click **Stop Log**. Note that this does not stop Profiling; readings will continue to be updated on the screen.

RETRIEVING LOGGED PROFILER DATA

In either Snapshot or Continuous mode, Profiler data are logged to the connected PC and accessible through the Data Folder. The data may be retrieved at any time. A connection to the instrument is not necessary.

To retrieve logged Profiler data:

1. Expand the Data Folder in the Navigation tree by tapping the **+**.
2. Expand the node for the device type and serial number.
3. Look for a data file named with date and time of the profiler reading, and with the ending profiler.bin—or whatever custom name you may have specified when starting the Profiler.



TIP: The time shown in the filename of a Profiler log is the time the Profiler started, which may be different from the time of the first data point logged. Similarly, the Elapsed Time indicated in the Report view of a continuous Profiler log is the elapsed time since the Profiler started.

For additional information on viewing data in the Data Folder, see the section "Viewing Logged Data" at the end of Section 6 below.

EXITING THE PROFILER

When you are ready to exit the Profiler, click **Close**. The Parameters view will return to the screen.

6 LOGGING DATA

Memory-equipped Professional models of the MP TROLL 9500 are ideal for monitoring and recording water quality data. Logging schedules can be set up in advance, and the collected data stored in the device's storage memory until needed.

Collecting a set of data with the instrument is called "running a test." A "test" is initially a set of user-defined instructions to the logger about how to collect the data:

- which parameters to measure
- how often to measure
- when to start taking and logging measurements

After it has "run," the completed test consists of a data file that was logged following the instructions above.

Many of the things you do through Win-Situ or Pocket-Situ control software can be visualized as actions performed on tests. For example,

- to give the device instructions for collecting data: **add** a test.
- when you want the device to end data collection: **stop** a test.
- to copy test data from the device to a host computer: **extract** the test.

These actions are initiated by buttons in the Information pane when the device's Tests node (group view of all tests) or a Single test is selected in the Navigation tree.

Advantages of the Tests node (group view): *(1) the Add action is available, and (2) group operations such as delete and extract can be performed on multiple tests simultaneously. For illustrations, see the box on page 39.*

ADDING A TEST TO A DEVICE: THE TEST WIZARD

The Add action programs the MP TROLL to collect data. The Test Wizard starts automatically to help you enter the required information.

1. With the MP TROLL 9500 connected to a host PC and selected in the Navigation tree, click or tap Tests.
2. Click or tap **Add**. The Test Wizard starts. The choices are discussed below.
3. When you finish the Wizard, the information is written to the device and the display is updated.

To add a test, (1) select the Tests node in the Navigation tree, (2) click Add.

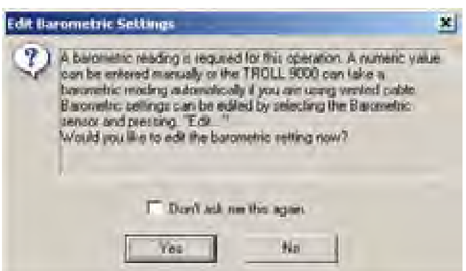
TIP: *Defining a test, setting up a test, adding a test—these terms all mean the same thing and may be used interchangeably in this manual.*

With a D.O. sensor installed (polarographic or optical)—

Before the Test Wizard starts, you will be asked how you want to handle barometric pressure. Barometric pressure is important in converting measurement of D.O. concentration to percent saturation. If the TROLL 9500 cable is vented, an accurate barometric pressure value can be read from the onboard barometric pressure sensor. If the TROLL cable is non-vented, then a barometric pressure value should be entered manually.

The dialog box shown below asks if you wish to edit the barometric settings in the absence of vented cable. Do one of the following:

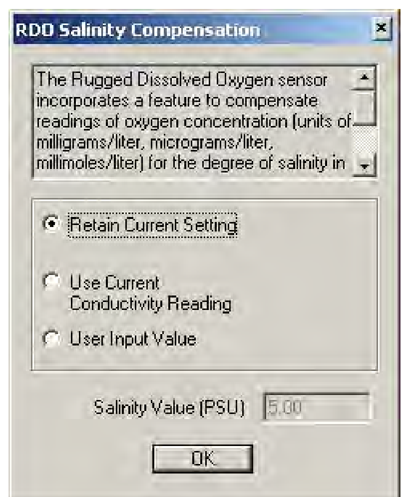
- If the TROLL 9500 is on **vented** cable now and will take measurements using **vented** cable, click No — and you may want to check the "Don't ask me this again" box.
- If the device is on **vented** cable now but will take measurements using **non-vented** cable, click Yes. In the Edit Barometric Channel screen, check the box indicating non-vented cable for measurements but vented cable for calibration/programming.
- If the device is on **non-vented** cable now and will take measurements on **non-vented** cable, click Yes. In the Edit Barometric Channel screen, check the box indicating non-vented cable for measurements and enter a barometric pressure value. For help in supplying information if the cable is not vented, see Section 9, Monitoring Barometric Pressure.



With an RDO® optical D.O. sensor installed—

Before the Test Wizard starts, you will be asked how you want to handle salinity compensation. The sensor does not react to changes in salinity. To compensate for the lower solubility of oxygen in salty water, a salinity value stored in the sensor can be applied. This ensures that the reported concentration of dissolved oxygen in the presence of significant water salinity is accurate. The compensation algorithm is applied internally before concentration is reported by the sensor. Choose one of the following:

- Retain Current Setting (shown below).
- Use Current Conductivity Reading: If a conductivity sensor is present, you may select the second option. However, the conductivity sensor is subject to fouling, and any conductivity errors thus created will be transmitted to the RDO sensor.
- User Input Value: When working in waters with a constant and known salinity, and a conductivity sensor is not present, select this option and enter the salinity value (in PSU, Practical Salinity Units). The fixed value is effective in situations where the salinity variability is low. The value can be changed at any time by selecting the RDO sensor in the Navigation tree and clicking "Edit," then Edit Salinity.



TEST SETUP PARAMETERS

A complete test definition has five parts. The choices available in each screen are tailored to reflect your selection in earlier screens.

1. Test Name (Optional)

You may enter up to 16 characters to identify the test. A default name is proposed. The test name is displayed in the Navigation tree, in the test data file, and in the filename of tests extracted from the device to the Data Folder on the host PC.

2. Parameters to Include

All available parameters are selected ☑ by default. De-select any parameter you do not want to measure during this test by clearing the checkbox. Remaining choices will be tailored to your selection.

The barometric pressure and temperature channels are automatically included when water-quality channels are selected so that their readings are available for compensating the measurements.

3. Measurement Schedule

The available schedules depend on your device's firmware and the parameters selected for inclusion in the test. This list is a quick overview. Additional details are given later in this section.

- **Linear.** All measurements are evenly spaced at a user-specified interval, and all measurements are stored in the device memory.
- **Event.** Measurements are evenly spaced, but you can record an "event" and conserve memory by having the device *store* only measurements that differ from the previous stored measurement of a designated parameter by a specified amount. Any available

parameter may be selected for event comparisons, and the "delta" or difference amount is prompted in the current basic parameter unit.

- **Linear Average.** This type of test can smooth out anomalous highs and lows that may occur, for example, when a water wave passes over the instrument. Each stored measurement is the average of several rapid measurements.

4. Measurement Interval

The interval specifies how often measurements will be taken during this test. Enter any combination of Days, Hours, Minutes, & Seconds. The minimum (fastest) allowable interval depends on your choice of measurement schedule and the parameters included in the test. For most parameters, the minimum interval is 5 seconds. If RDO Optical Dissolved Oxygen is included, the minimum interval is 10 seconds.

5. Start Mode

Choose one of the following options for starting this test:

- **Manual.** A manual test can be started at any time while the MP TROLL 9500 is connected to a PC by pressing the ***Start*** button. This mode is useful when you want to synchronize the start of data collection with an external event like starting a pump.
- **Scheduled.** A scheduled start test will start at the date and time you specify. The time proposed by the software is the next hour on the hour, calculated from the current device time plus 10 minutes. Arrows beside the list boxes may be used to change the start time and date, or key in the desired start time and date.

TIP: *In entering the Scheduled Start time, keep in mind that when this test starts, it will stop a running test.*

The time proposed for a Scheduled start is the next hour on the hour, calculated from the current device time plus 10 minutes. In Pocket-Situ this is your only indication of the device time. If the proposed time is wrong, cancel test setup and set the device clock before scheduling tests.

ENDING SETUP

After you select the test options and click ***Finish,*** the information will be sent to the device and the new test will appear in the Navigation tree.

To let you know which tests can be started with the Start button, the software displays a different symbol for each start type:

Manual start test (you start)
Scheduled start test (starts by itself)

Where do I enter the stop time for the test?

You will not be asked for a stop time because the end of a test cannot be programmed in advance. In most cases, the only way to stop data collection is to connect to a PC, select the test in the Navigation tree, and press the Stop button.

Exceptions: A test stops automatically under these conditions:

- *when another scheduled test starts.*
- *when the device's memory is full. In this case the test may indicate "ABEND" (ABnormal END) in the Navigation tree.*
- *if a loss of power occurs. In this case, the test may indicate "ABEND" in the Navigation tree.*

TIP: *If you wish to schedule the end of data collection, try this: Before starting your test, define another test to start at the time you want the "real" test to stop. Select a linear test with a long measurement interval—hours or days—and minimal sensors to conserve battery power. Schedule this test to start at the time you want the "real" test to end. The test will start at its scheduled time, stopping the earlier test and kicking into a sparse sampling schedule.*

MORE ON MEASUREMENT SCHEDULES

LINEAR

In Linear sampling, all selected channels are measured at the same Measurement Interval; all measurements are stored in memory.

EVENT

All selected parameters are measured at your chosen Measurement Interval, but a data point (reading from all active channels) is stored *only if the measurement on the designated "event" channel exceeds a user-defined value*. This value is called "Delta" because it relates to a change in the measurement. Here's how it works:

Delta

Each measurement on the selected "event" channel (pressure, for example) is compared to a reference. The initial reference is taken at the start of the test. When a pressure measurement varies from the reference by less than the Delta amount, the data point is not stored. When a pressure measurement varies from the reference by more than the Delta amount, the data point (all channel measurements) is stored. The stored pressure measurement is called a "Delta point" and **becomes the new reference for comparison**.

In an Event test, then, small and essentially insignificant changes are not stored, but larger and more significant changes are. This scheme will minimize the size of a data file by storing meaningful data.

EVENT (*continued*)

Minimum Delta Values

System accuracy is a function of many variables. It is theoretically possible to choose a Delta value so small that random system noise, however slight, might “look” significant. We recommend that you enter a reasonable Delta value for the parameter being measured to avoid triggering an event storage when no event has occurred.

TIP: *Units for the Event channel should be set to the “basic” parameter unit (e.g., psi). Derived (software-calculated) units are not available.*

Default Storage

Consider a situation where there is virtually no change through time in measured value. In this case, it is possible that almost no data would be stored to the data file. To avoid the possiiblity that a test may contain little or no stored data, sparse linear sampling also occurs whereby data points are stored to the data file every *n* measurements regardless of the measurement comparisons that are occurring. This type of data is called “default storage.” For example, if the Measurement Interval is 10 minutes and you specify a Default storage every 6 measurements—as shown in the event test setup screen below—then data will be logged every hour regardless of the Delta comparisons.

Data gathered in an Event test consist of both “Delta points” and “default storage.” There is no distinction made between them in the actual data file since they both represent measurements of the same physical property (pressure, temperature, conductivity, etc.).

LINEAR AVERAGE

This type of test can eliminate anomalous highs and lows that may occur—for example, if a wave passes over the instrument at the time a measurement is made. For every measurement stored in the data file, the device takes a specified number of measurements at a specified interval, averages them, and stores the average value.

You are prompted for

A the storage interval (how often an averaged measurement will be stored in the data file)

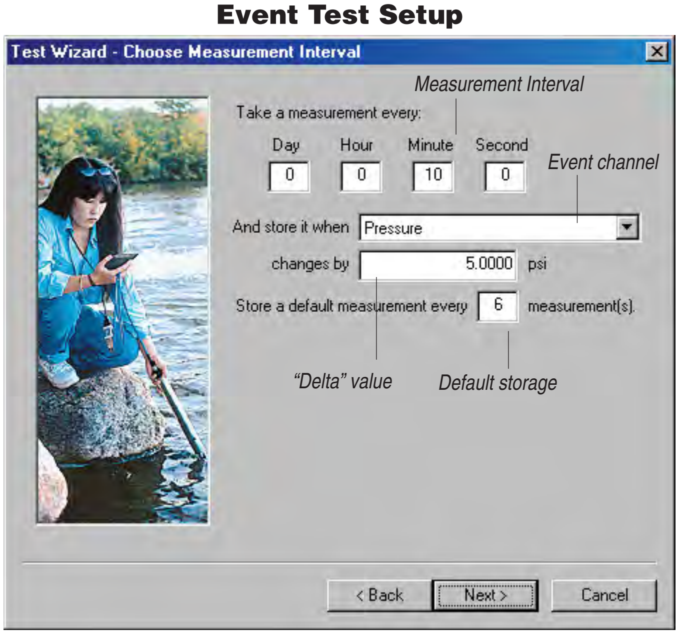
B the interval between the rapid measurements that will be averaged (1-255 seconds)

C the number of measurements that will be averaged for each stored measurement (2-99

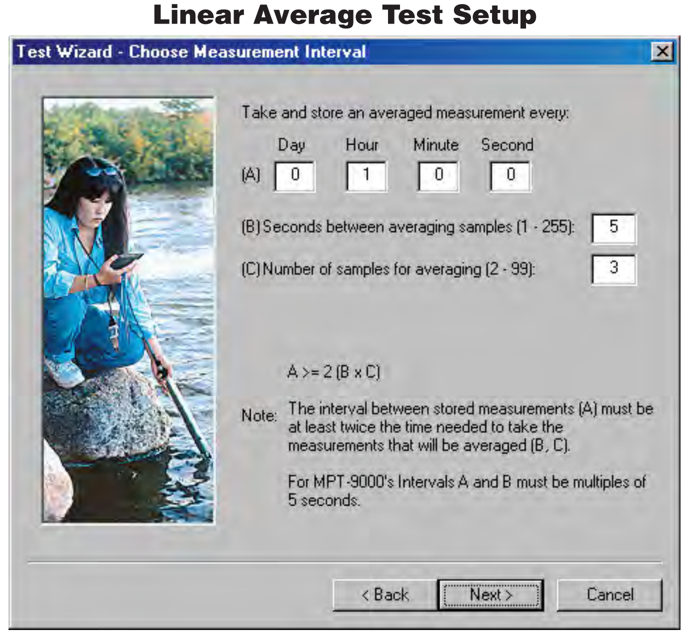
TIP: *The storage interval (A) must be at least twice as long as the rapid interval (B) times the number of measurements for averaging (C). In the example shown below, 5 seconds x 3 = 15) seconds, so the storage interval would have to be at least 30 seconds.*

In the linear average test example shown in the screen below, a measurement will be logged every hour (A). The logged measurement will consist of the average of 3 measurements (C) taken 5 seconds apart (B).

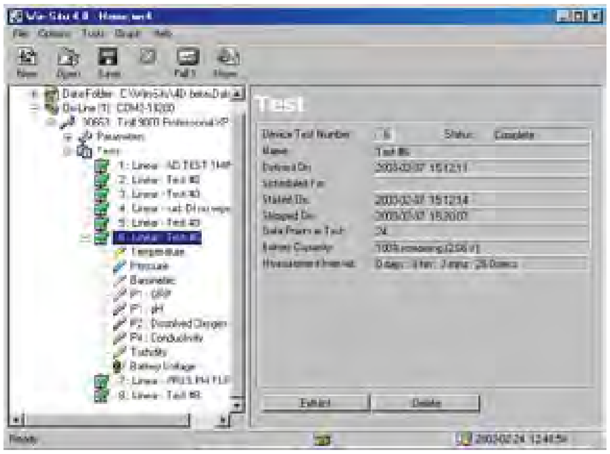
Event Test Setup



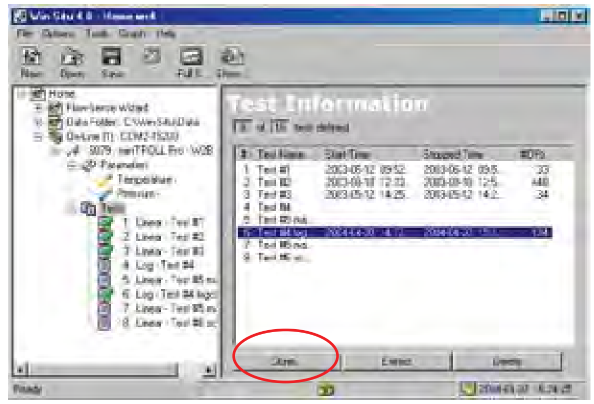
Linear Average Test Setup



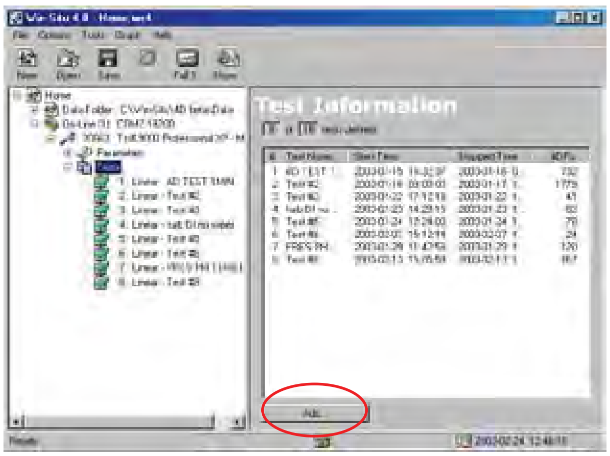
Single test view vs. Multiple test view



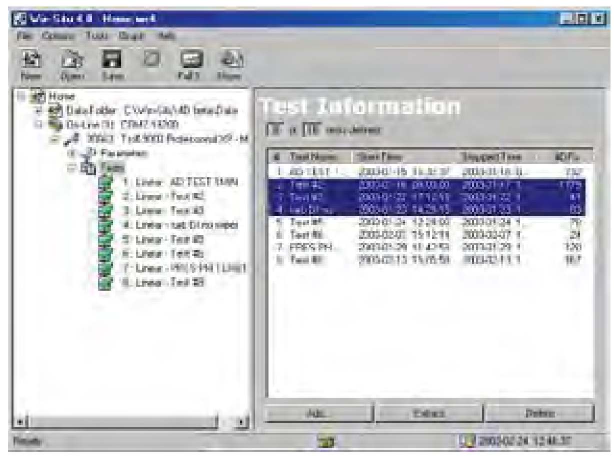
When a single test is selected in the Navigation tree, the Information pane shows details about the selected test.



When a test is selected in the Information pane, the ***Clone...*** *button is available to copy the test definition—saves time in setting up tests.*



When the Tests node (group view) is selected, the Information pane shows all tests and displays the ***Add...*** *button. #DPs is the number of data points logged.*



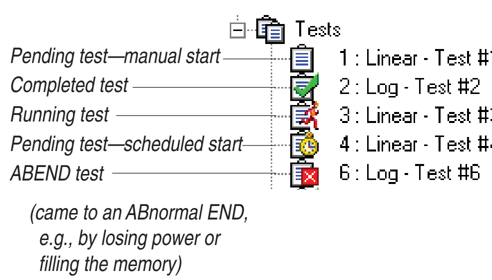
When multiple tests are selected in the Information pane, multiple tests may be extracted or deleted simultaneously.

OTHER TEST OPERATIONS

There are six basic test operations:

- **Add...**—programs the instrument to collect data. See the first part of this section for details.
- **Edit...**—allows you to change the pre-programmed test setup before the test runs. Editing a test launches the Test Wizard. See the first part of this section for details.
- **Start**—starts the selected test if it has been defined for a manual start.
- **Stop**—stops a running test.
- **Extract**—copies the selected test data from the instrument to the host computer. A copy of the data remains in the instrument.
- **Delete**—deletes the selected test from the instrument.
- **Clone**—makes a copy of the selected test definition setup.

The operations available depend on the status of the selected test. A different symbol is displayed for each test status:



STARTING A MANUAL START TEST

1. With the MP TROLL 9500 connected to a host C, select a pending manual test in the Navigation tree.
2. Click or tap ***Start***.

   TIP: *If a test is running in the device, the Start button is not available. You must stop the running test before you can start a new one. See "Stopping a Test" below.*

3. You will be asked to confirm your selection.
4. After you confirm, the test starts and the display is updated.

   TIP: *Once a test starts, the following actions will not be available: Add, Delete, Edit (device, parameter, test), Clone, Calibrate.*

STOPPING A TEST

The end of a test cannot be programmed in advance. In most cases, the ***Stop*** button is the only way to stop a running test. Exceptions: A test stops automatically when any of the following occurs:

- when another test starts
- if the device memory fills up
- if power is lost.

1. With the MP TROLL 9500 connected toa host PC, select a running test in the Navigation tree.
2. Click or tap ***Stop***. You will be asked to confirm your selection.
3. After you confirm, the test stops and the display is updated.

RETRIEVING LOGGED DATA

Retrieving, downloading, uploading, transferring—these terms are sometimes used interchangeably to mean the act of copying data from the place where it was logged to a host PC. The Extract operation in Win-Situ or Pocket-Situ retrieves test data from the MP TROLL 9500 memory and saves it to a file on the host computer. You may view the file immediately after the download, or later.

1. With the MP TROLL 9500 connected to a host PC and selected in the Navigation tree, click or tap Tests.
2. In the Information pane, select one or more tests to extract. To select multiple tests, hold the CTRL key while selecting. (To display the CTRL key on a PDA, tap the keyboard symbol.)
3. Click or tap ***Extract*** to extract the test(s).

   When the extraction is complete, the name(s) and locations of the test data file(s) on the host computer are displayed (see box on the next page). If a selected test has been extracted previously, only data logged since the last download is extracted and is automatically appended to the original file.

The software presents two options after the extraction:

- ***View*** launches the data viewer to view the selected file.
- ***Done*** returns to the Tests view in the software.

TIP: *The "Extract" operation puts a* <u>*copy*</u> *of a test data file on your PC, but does not delete the test from the device. To free up device memory, see Deleting Tests, next.*

TIP: *When extracting a large test to a PDA on battery power, avoid letting the PDA time out during the transfer. To locate this setting in most PDAs, display the Start menu, select Settings, System tab, Power.*

Q: ***Where do my extracted data files go?***

A: *Win-Situ 4 extracts tests to a folder named "Data" in the folder where Win-Situ 4 is installed. The file structure looks like this:*

Win-Situ \ Data \ SN30701 2004-02-12 150000 Test #3.bin

- *Device serial number*
- *Test start date (yyyy-mm-dd)*
- *Test start time (hhmmss)*
- *Test name*
- *File type*

TIP: *On a PDA, the Pocket-Situ \ Data folder is located in the device's non-volatile storage.*

DELETING TESTS

Tests are stored in the device memory until you delete them. The Delete operation **permanently** removes selected tests from the device, and reorganizes the memory to optimize future data storage. Depending on how full the memory is, the process may take several minutes.

1. With the MP TROLL 9500 connected to a host PC and selected in the Navigation tree, click or tap Tests.
2. In the Information pane, select one or more tests to delete. To select multiple tests, hold the CTRL key while selecting. (To display the CTRL key on a PDA, tap the keyboard symbol in the Command bar.)
3. Click or tap ***Delete***. You will be asked to confirm your selection.

   TIP: *If a test is running in the device, the Delete button is not available. You must stop the running test before tests can be deleted. See "Stopping a Test" above.*

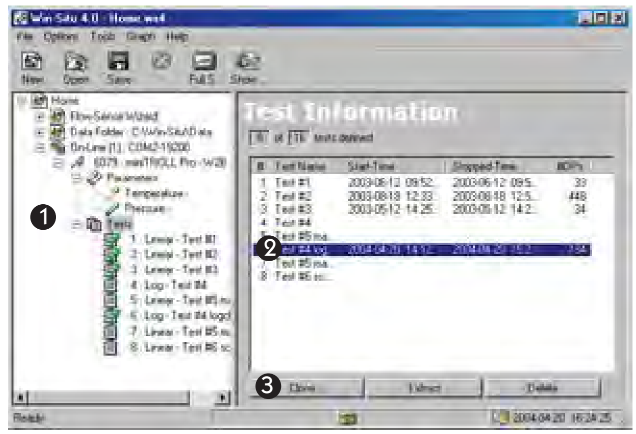
4. After you confirm, the selected test(s) are **permanently removed** from the device.

   TIP: *The Delete procedure can be used to cancel a pending scheduled test*

CLONING A TEST

The Clone function lets you copy all the elements of an existing test—the test name, selected channels, measurement schedule and interval—without having to define a new test "from scratch." You can clone a pending test or a completed test.

1. With the MP TROLL 9500 connected to a host PC and selected in the Navigation tree, click or tap Tests.
2. In the Information pane, select a test to clone.



3. Click or tap ***Clone*** to preview the test definition. The Wizard will still present all the screens, but you can just click Next to get through them quickly (or make any changes you want).
4. Click ***Finish*** to end the wizard. The information will be sent to the device and the new test will appear in the Navigation tree.

   TIP: *The proposed start type for a cloned test will always be Manual, regardless of the start type of the original test. This avoids scheduling a test to start in the past.*

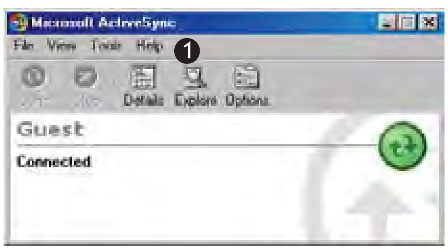
TRANSFERRING FILES FROM A PDA TO A DESKTOP PC

If Win-Situ Sync (or its earlier release, Pocket-Sync 4) is installed on your desktop PC, file transfer can be done automatically each time the computers are connected in ActiveSync.

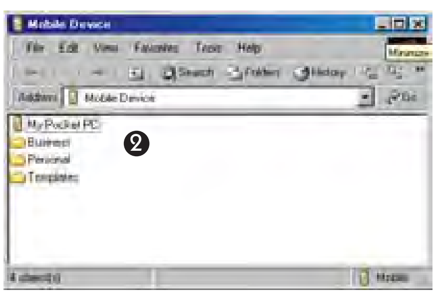
To transfer files "manually" proceed as follows. **NOTE THAT MICROSOFT ACTIVESYNC IS NEEDED TO CONNECT THE COMPUTERS even with an In-Situ synchronization utility installed (Win-Situ Sync or Pocket-Sync 4).**

TIP: *Install Microsoft ActiveSync on the desktop PC* ***before*** *the first connection to the PDA. Be sure to exit your last Pocket-Situ session. The following procedure is performed from the desktop PC side.*

1. With the computers connected and ActiveSync running, open up Explore on the ActiveSync tool bar.

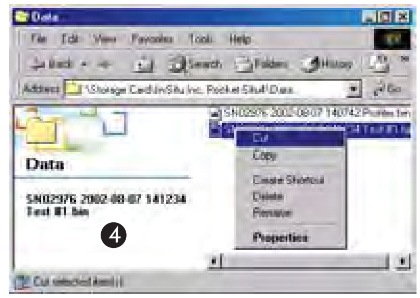


2. Double-click on "My Pocket PC."



3. Browse to the folder where Pocket-Situ Data is stored. On some PDAs this will be in a folder called "Storage Card" or "SD Card." On the RuggedReader, look in Built-in Storage. Open the Pocket-Situ Data folder (double-click) to display a listing of your extracted data (.bin) files.

4. Right-click the file(s) you want to transfer and select **Copy** or **Cut**. Selecting Cut will remove the data file from the PDA.



5. Open My Computer or Windows Explorer for the desktop PC and navigate to the folder where you want to place the data file(s). When the cursor is in the desired folder, right-click, and select **Paste**.

   We recommend placing the files in the following locations to ensure that they will be displayed properly in the Data Folder branch of the Win-Situ Navigation tree. The In-Situ synchronization utility, if used, will put the files in the proper locations automatically.

Test data files	Data folder in the folder where Win-Situ 4 is installed (normally, C:\Win-Situ\Data)
Low flow files	LowFlow subfolder of the Data folder
Calibration reports	Calibration Reports folder in the folder where Win-Situ 4 is installed. These will be accessible from Win-Situ's Tools menu.

VIEWING LOGGED DATA

Logged data sets from the Multi-Parameter TROLL 9500 are called "tests." Tests reside in the instrument until you extract them to the host computer. Any test that has been extracted can be viewed in text or graphical format. A test can be extracted and viewed at any time, even while it or another test is running.

The software provides two routes to view test data:

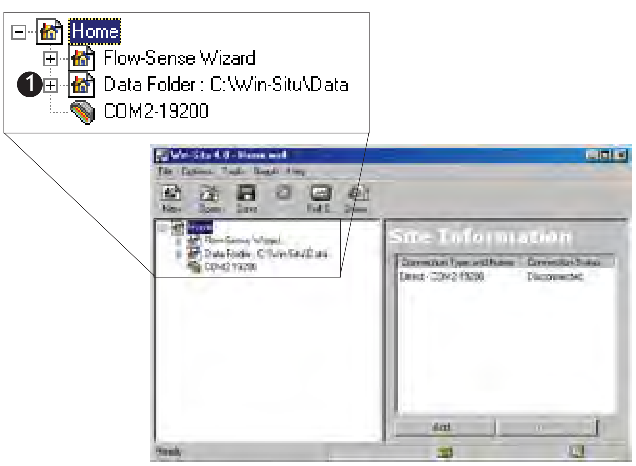
- If the test is in the instrument's memory, extract it and select the **View** option at the end of the download. This launches the data viewer.
- If the test has been extracted to the host computer, it will appear in the Data Folder node in the Navigation tree. A connection to the instrument is not required in order to view extracted data.

SELECTING DATA IN THE DATA FOLDER

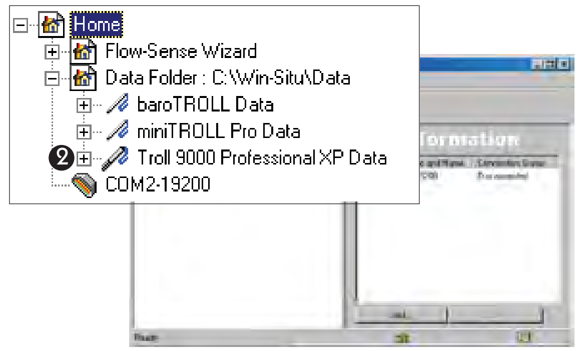
The Data Folder appears below the Home site in the Navigation tree. After data files have been extracted from the MP TROLL 9500 to the Data Folder, the node can be expanded to show device type, serial number, and extracted data files.

To view extracted test data:

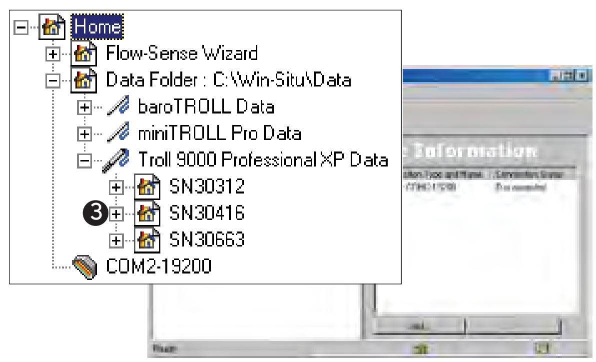
1. Click the + sign beside the Data Folder to expand the listings.



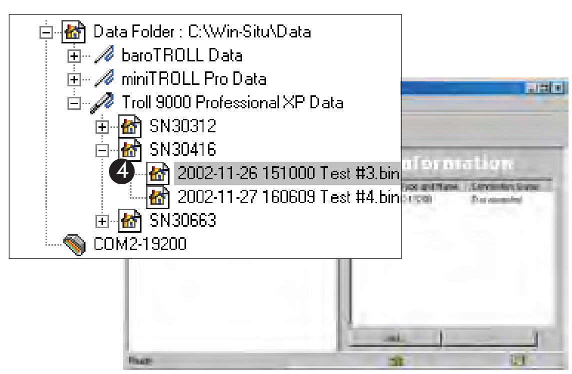
2. The Data Folder has a node for data from each device type. TROLL 9500 data will be listed under the TROLL 9000 "family" device. Click the + beside the TROLL 9000 to expand the listing.



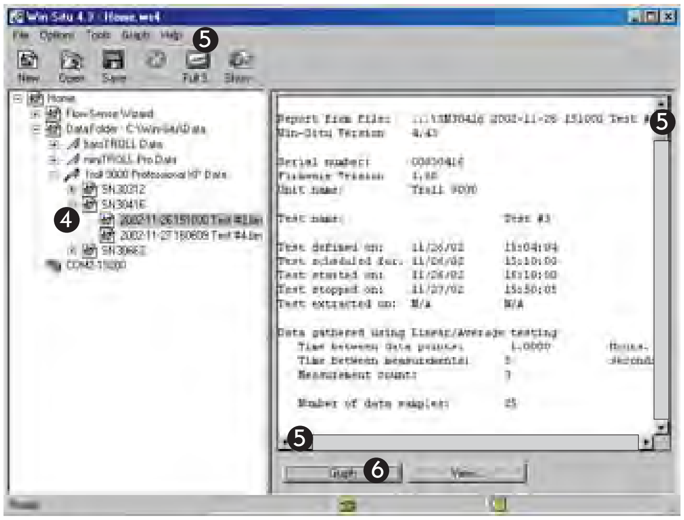
3. Device nodes are further subdivided by serial number. If tests from multiple TROLL 9500s have been extracted, the serial number of each will be displayed. Click the + beside the the serial number of the unit whose data you want to view.



4. The serial number node contains the extracted tests and logged Profiler data. Click to select the test you want to view.



The selected test is displayed in the Information pane—to the right of the screen in Win-Situ, or at the bottom in Pocket-Situ.



TIP: *The data file may appear in Report view or Graph view, depending on the preferences saved in your last Win-Situ or Pocket-Situ session.*

5. To view the test data below the header in Report view:
   - Use the vertical and horizontal scrollbars to scroll through the data file.
   - Or click Full Screen in the shortcut bar to enlarge the text display, and then use the scrollbars.

GRAPHING DATA

6. Click or tap **Graph** to display the individual parameter data in graph format. See the sidebar on this page for Win-Situ graphing controls, and on the next page for Pocket-Situ graphing controls.

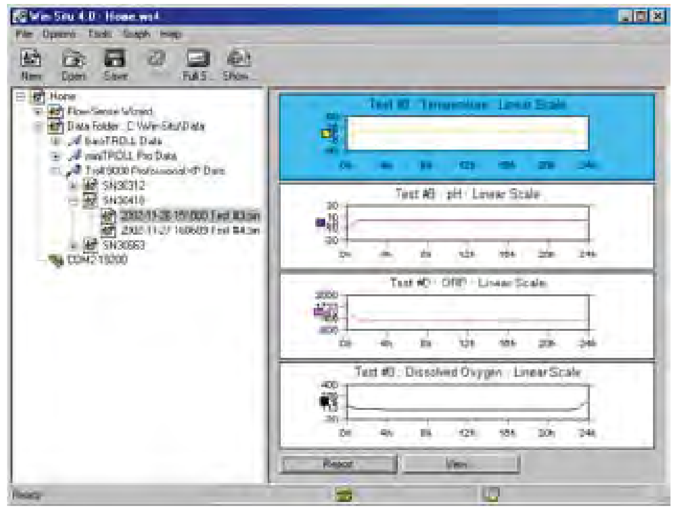
TIP: *You can easily switch from Graph view to Report view and back using the **Graph** and **Report** buttons in the Information pane. However, the view chosen in this way is not "persistent" into your next session. To change the view so it always comes up as Graph or Report, specify the desired Data File View in Preferences (Options Menu) in Win-Situ or Setup in Pocket-Situ.*

Win-Situ provides a range of options for viewing data in graph format. Here are some things you may wish to try:

- To enlarge the selected graph: Click Full Screen in the toolbar, then go to the Graph menu and select a different Number of Graphs
- To show two channels on the graph: select Graph Settings on the Graph menu, select a Primary channel and a Secondary Channel

Win-Situ Graphing Controls

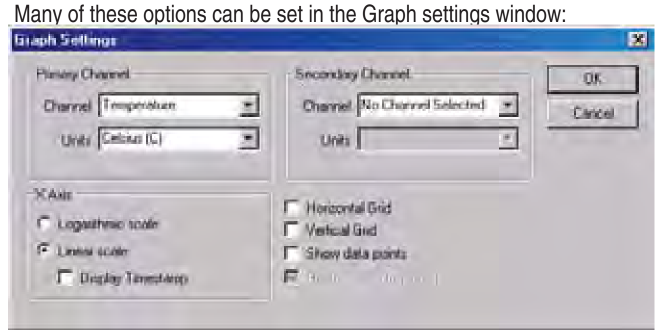
The Graph button displays data from the first four test channels in graph format. Time is shown on the X axis in the currently selected unit. The axes are auto-ranged. Click any graph to select it for formatting.



Each graph can display one, two, or all test channels. To change the appearance and content of any graph, display the Graph menu or right-click a graph. This provides access to the graph formatting options:

- change or add channels
- add data point indicators
- add grid lines to one or both axes
- add a logarithmic time scale
- change the range of the Y (data) axis
- change the parameter units
- add a time stamp to the X (time) axis
- zoom in on the graph

Many of these options can be set in the Graph settings window:



- To show all channels on the graph: select Graph Settings on the Graph menu, choose All Channels Selected

Pocket-Situ Graphing Controls

Pocket-Situ displays all the test channels in one graph. Time is shown on the X axis in the currently selected unit. The axes are auto-ranged.

The left Y axis represents the first channel in the test (usually temperature), or the first channel selected in the **View...** option in the command bar. The right Y axis represents the second channel.

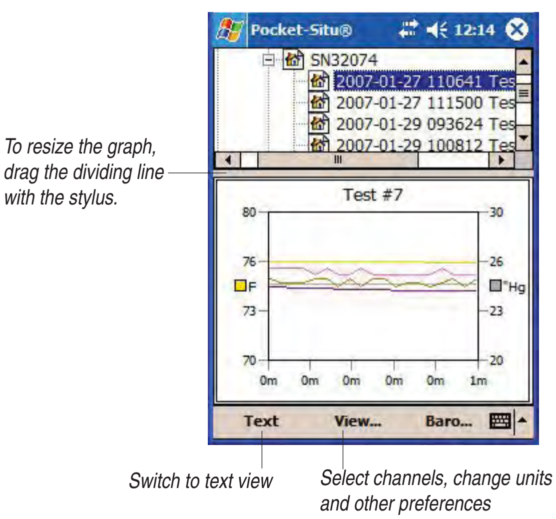
Tap **Graph** or **Text** in the command bar to change the view.

The graph area may be resized as follows:

With the stylus (or other suitable pointer), press on the line that separates the Navigation tree from the Information pane and drag it up or down to resize the screen.

The **View...** option in the command bar launches wizards to help you change the way test data are displayed.

- Select Channels to View: Tap Next, then tap a check box to show or hide a channel. Tap Finish to return to the graph. The Y axes will reflect your selection.
- Change Units and other preferences.
- Change Channel Settings: Redefine the display options for a pressure channel. Refer to Section 7 for details on the settings.



CHANGING THE DATA DISPLAY

The **View** button launches wizards to let you change the way test data are displayed.

- Select Channels to View (Report view): Tap Next, then tap a check box to show or hide a channel. Finish returns to the Report view.
- Change Units and other preferences.
- Change Channel Settings: Redefine the display options for a pressure channel. Refer to Section 7 for details on the settings.

TRANSFERRING DATA TO EXCEL FROM WIN-SITU 4

1. Select Report view.
2. On the File menu, select Export to Excel. If Microsoft® Excel® is properly installed on your PC, the data file will open in an Excel spreadsheet.

PRINTING DATA IN WIN-SITU 4

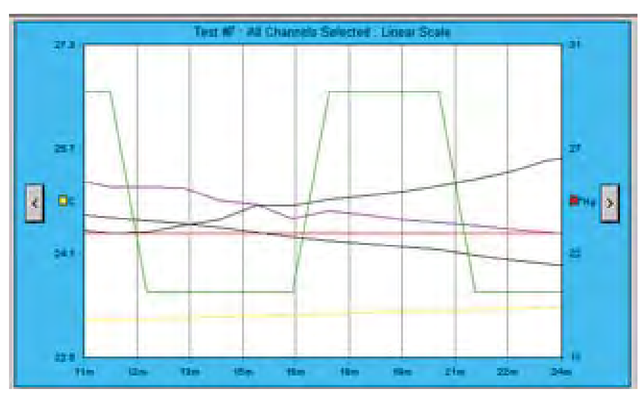
To print the graph or report as currently displayed:

1. Select Graph or Report view as desired.
2. On the File menu, select Print graph or Print report.

Additional information is available from your printer documentation.

SAVING TEXT FILES FROM WIN-SITU 4

1. Select Report view.
2. On the File menu, select Save Report.
3. In the window that opens, supply a filename in the usual way; the report will automatically be given a .TXT file type.



This graph was created with the following controls: Number of Graphs: One Graph, All channels selected, Zoomed in on 11-22 minutes, Vertical grid.

7 MONITORING PRESSURE (WATER LEVEL)

WHY MONITOR PRESSURE?

Water level or pressure head readings are taken for a number of reasons. In aquifer characterization, this type of data will help the user determine important hydrologic parameters of an aquifer, including hydraulic conductivity, transmissivity, permeability, storage coefficient, dispersivity, and porosity. Some or all of these parameters are important in the design of wells and well fields for various purposes.

In the design of a remediation system, the proper placement of wells for monitoring or extraction is of paramount importance if the system is to function effectively. Accurate data from slug and pump testing is one of the primary tools employed for aquifer characterization in the design process.

Step testing and constant-rate pump testing yield significant data in determining proper pumping rates. Improper rates can lead to aquifer depletion, salt water intrusion, and several other problems. Accurate data in designing the system and monitoring the system is essential for long-term success of the well and the proper maintenance of the aquifer.

The collection and use of water level measurements in the mining and coal bed methane industries are essential for the success of the mines and wells. Data derived from pilot testing of water wells constructed for coal bed methane extraction provide necessary information on bottom-hole pressure and appropriate pumping rates to accomplish the de-watering necessary to release the methane gas. Monitoring of water levels assures efficient production.

Water level measurements of surface water by pressure measurements yield significant data about the overall health of the hydrologic cycle. This information is also useful to government, agriculture, and industry as well as the scientific community when planning water use and when adjudicating water rights issues.

THE PRESSURE SENSOR

The optional pressure sensor of the Multi-Parameter TROLL 9500, if included, is permanently-installed and factory-calibrated. If your MP TROLL 9500 was ordered without a pressure or turbidity sensor, there will be a permanently installed plug in the pressure sensor slot. A pressure sensor can be added at the factory.

Do not try to remove the pressure sensor or permanently installed plug.

FACTORY CALIBRATION

The pressure sensor is calibrated across full pressure over a range of -5° to 50°C. The pressure reference is provided by a pressure control and measurement system (PCMS) that supplies a calibrated and certified pressure to the pressure sensor. The temperature reference is provided by a water bath with a thermal homogeneity of 0.0008 °C and measured with calibrated and certified digital thermometers. The calibration process results in a data set of raw analog to digital conversions (A/D readings) for both pressure and temperature from the device versus actual pressure and actual temperature from the calibrated references.

Pressure sensor

From a two-dimensional data set of temperature A/D versus reference temperature, and a three-dimensional data set of pressure A/D versus temperature A/D and reference pressure, numerical coefficients are generated to equations that map the MP TROLL performance across all temperatures and pressures.

OPERATING PRINCIPLE

A pressure transducer senses changes in pressure, measured in force per square unit of surface area, exerted by a column of water or other fluid above an internal media-isolated strain gauge. Common measurement units are pounds per square inch (psi) or newtons per square meter (Pascals).

NON-VENTED (ABSOLUTE) VS. VENTED (GAUGED) SENSORS

A non-vented or “absolute” pressure sensor measures all pressure forces detected by the strain gauge, including atmospheric pressure. Its units are **psia** (pounds per square inch “absolute”), measured with respect to zero pressure. Absolute pressure sensors are sometimes called “sealed gauge” sensors.

Absolute pressure measurements are useful during vacuum testing, in very deep aquifers where the effects of atmospheric pressure are negligible, and in unconfined aquifers that are open to the atmosphere.

With vented or “gauged” pressure sensors, a vent tube in the cable applies atmospheric pressure to the back of the strain gauge. The basic unit for vented measurements is **psig** (pounds per square inch “gauge”), measured with respect to atmospheric pressure. PSIG sensors thus exclude the atmospheric or barometric pressure component.

This difference between absolute and gauged measurements may be represented by a simple equation:

$$P_{gauge} = P_{absolute} - P_{atmosphere}$$

If your MP TROLL 9500 includes a pressure sensor, it is either absolute or gauged. The pressure sensor type is not software-selectable.

However, psia measurements from absolute pressure sensors can be readily compensated for atmospheric pressure in the software due to the presence of the MP TROLL 9500’s onboard barometric pressure sensor, as long as the instrument is connected to vented cable. See “Correcting Absolute Pressure Readings for Barometric Pressure” later in this section.

PRESSURE VS. DEPTH VS. LEVEL

Display options for pressure measurements are completely software-selectable. Pressure sensor data may be displayed as raw pressure head, as depth, or as water level with a reference. When choosing depth or level, the software presents additional options for converting from pressure readings (in psi) to depth or level (in feet or meters), including a very accurate conversion that compensates pressure readings for fluid density, altitude, and latitude.

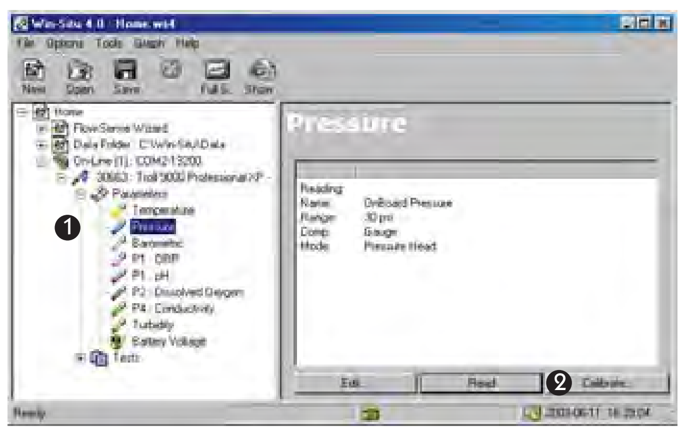
ZEROING THE PRESSURE SENSOR

The following procedure may be used, **with caution,** to “zero” the offset of a pressure sensor to correct for electronic drift. The drifted offset is visible when the sensor is in air and reading other than zero.

It is recommended you **do not** zero the offset if it is outside the specified accuracy of your pressure sensor, as shown in the table below. If the reading in air deviates from zero by more than the amounts shown, you may want to consider a factory recalibration. See the Appendix for additional information on electronic drift.

Sensor range	Accuracy (% full scale)	Acceptable Offset from zero
15 psig	± 0.05% FS	± 0.0075 psig
30 psig	± 0.05% FS	± 0.015 psig
100 psig	± 0.05% FS	± 0.05 psig
300 psig	± 0.05% FS	± 0.15 psig

1. With the MP TROLL connected to a host PC and selected in the Navigation tree, click or tap the Pressure parameter in the Parameters list.
2. Click or tap **Calibrate**. You will be prompted to ensure the device is in air.



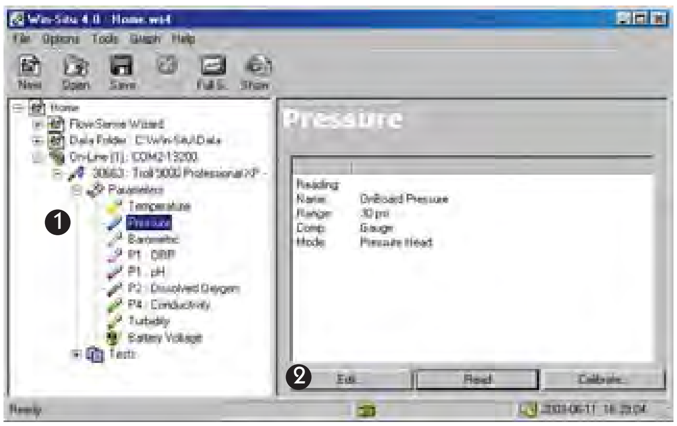
3. When the device is in air, click Yes.

The current pressure reading will be set to zero. To check this, take a reading with the “Read” button.

SETTING UP PRESSURE MEASUREMENTS: THE PARAMETER WIZARD

Win-Situ's Parameter Wizard can help you configure a pressure channel to display measurements just as you want them. The specified settings are easily changed from one mode to another, and any choice can be redone or undone later, when viewing test data.

1. With the MP TROLL connected to a host PC and selected in the Navigation tree, select the pressure parameter.
2. Click or tap ***Edit...***. The Parameter Wizard starts. The choices are discussed below.



3. When you finish the Wizard, Win-Situ sends the information to the device and updates the display.

PRESSURE SETUP CHOICES

Win-Situ prompts for the following when editing a pressure channel. You may not see all of these depending on your early choices.

> **Q:** ***What do I get with out-of-the-box pressure measurements (no setup)?***
>
> **A:** *The pressure channel defaults in Win-Situ and Pocket-Situ result in the following measurements, with no setup:*
>
> - *Pressure head is measured*
> - *Default units are psi*
> - *No conversion from psi to depth/level*
>
> *Remember that all these settings can be changed quite easily when you view the data after the test.*

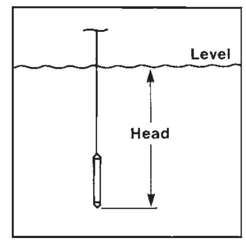
1. NAME (OPTIONAL)

The pressure channel name is displayed in the Information pane and in test data files. A default name is proposed. If you choose, you may enter a custom name (up to 16 characters).

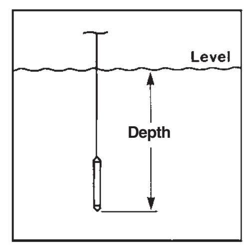
2. DISPLAY MODE

Select one of the following. Subsequent screens will be tailored to your choice.

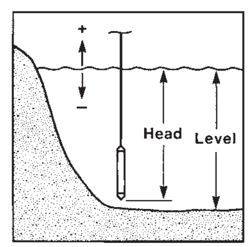
- **Pressure Head** displays the raw pressure exerted by the column of water above the pressure sensor, in kiloPascals or pounds per square inch (psi). If you choose this mode, click Finish to end the Wizard. Then select units on Win-Situ's Options menu.



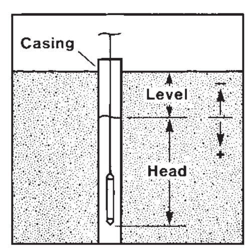
- **Depth** converts the pressure of the water column to a depth reading, in meters, centimeters, feet, or inches. If you choose this mode, you will be asked to choose a method for converting pressure to depth. Then select units on Win-Situ's Options menu.



- **Level - Surface:** Commonly used for surface water elevations. Data file readings are "positive up." Increasing water levels will result in increasing readings. Decreasing water levels correspond to decreasing readings.



- **Level - Top Of Casing:** Commonly used for drawdown in groundwater wells. This mode is "positive down." *Decreasing* water levels correspond to *increasing* readings, because the water level is getting further from the top of the well casing. *Increasing* water levels result in *decreasing* readings.



If you select depth or a level mode, you will be asked to choose a method for converting pressure to depth or level. For a level mode, you will be prompted to enter a level reference.

3. CONVERTING PRESSURE TO DEPTH OR LEVEL

The conversion from pressure in pounds per square inch (psi) to depth or level in meters or feet requires some knowledge of the properties of the fluid being monitored and optionally of the device's location on the earth's surface.

Conversion Using Specific Gravity

Pressure may be adequately converted to feet or meters of fluid using a dimensionless specific gravity value. A specific gravity of 1.0 (characteristic of pure water at 4°C) is adequate for many groundwater applications.

Conversion Using Density, Latitude, and Elevation

Pressure in the English unit psi is first converted to the SI unit Pascal (Pa). Conversion from Pascals to meters or feet requires two additional values:

- **Liquid Density.** Pure groundwater at 20°C has a density of 0.998 g/cm^3. A table of density by temperature appears on this page. The Appendix includes a method to experimentally determine liquid density if the working fluid is not pure water.
- **Gravitational Acceleration.** The acceleration due to gravity that an object experiences is location-specific. Given your latitude and elevation, Win-Situ can calculate a value for gravitational acceleration for your location.

TIP: ***Either*** *specific gravity* ***or*** *density, latitude & elevation may be used to convert from pressure (psi) to depth/level (meters or feet). A gain in accuracy may be realized by selecting the density, latitude & elevation option.*

4. LEVEL REFERENCE

If you selected a level display mode (Surface or Top of Casing), you will be prompted to enter a level reference. This is a user-specified starting point for level display modes, and can be any value you choose. Here are some examples:

- Surface: If you calculate the water level above mean sea level (MSL) and enter this as the Level Reference, then data will be displayed as elevations above MSL.
- Top of Casing: If you measure the distance to the water surface (DTW) from the top of the well casing and enter this number as the Level Reference, then data will be displayed as DTW values.
- A Level Reference of 0 is equivalent to "zeroing" the probe. Data will be displayed as changes, either positive or negative, from the starting water level.

Reference Time

The MP TROLL takes a "snapshot" of the sensor's raw pressure reading, then your Level Reference is substituted. You can specify that the snapshot be taken now or when the test starts. The data file will show the Reference (raw pressure) Reading and when it was taken.

- **Now:** the pressure is measured when you finish setting up the pressure parameter, and the value is stored until the test starts. All measurements taken during the test will be relative to the water level at the time you finished the wizard.
- **Start of Test:** the Reference measurement will be taken at time t=0. All measurements taken during the test will be relative to the water level at the moment the test starts.

TIP: *After setting up the pressure channel with the desired display options, select the units you want to see. Use Win-Situ's Options menu, or Pocket-Situ's Setup button.*

Liquid Density

The conversion from PSI units to meters or feet of fluid requires several conversion factors. One of these is the density (ρ) of the aqueous solution being monitored. Pure groundwater at 20°C has a density of 0.998 grams per cubic centimeter (g/cm^3).

Use the values in the table for density if you do not otherwise know it. However, since these data assume pure water, there is no accommodation for other variables (such as salinity) that can affect your actual water conditions. Alternatively, you could compute the fluid density using the procedure given in the Appendix.

Fluid density by temperature

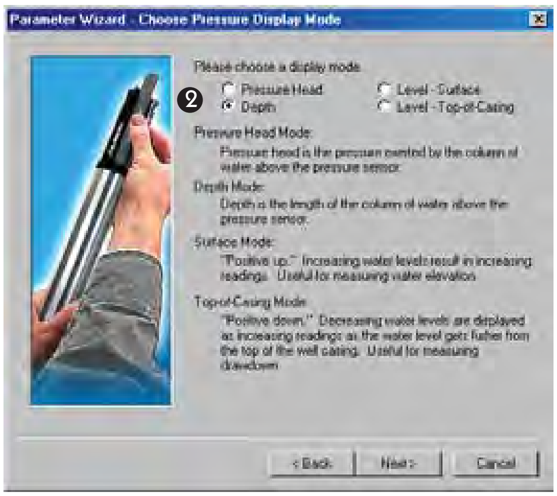
Temp. (°C)	Density (g/cm^3)	Temp. (°C)	Density (g/cm^3)	Temp. (°C)	Density (g/cm^3)
1	0.999900	11	0.999605	21	0.997992
2	0.999941	12	0.999498	22	0.997770
3	0.999965	13	0.999377	23	0.997538
4	0.999973	14	0.999244	24	0.997296
5	0.999965	15	0.999099	25	0.997044
6	0.999941	16	0.998943	26	0.996783
7	0.999902	17	0.998774	27	0.996512
8	0.999849	18	0.998595	28	0.996232
9	0.999781	19	0.998405	29	0.995944
10	0.999700	20	0.998203	30	0.995646

QUICK SUMMARY OF PRESSURE SETUP

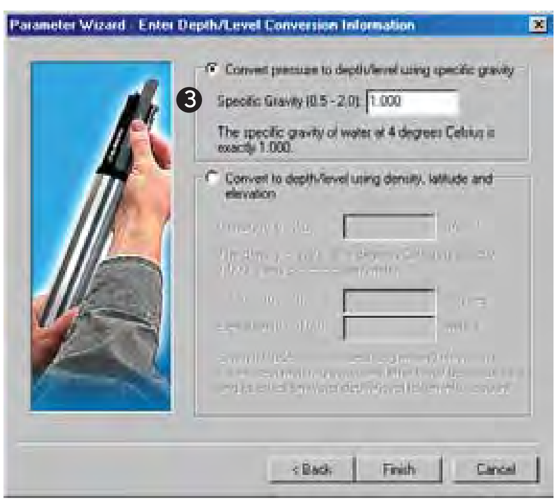
For **DEPTH:**

1 Select Pressure in Parameters list, select Edit

2 **Display Mode:** Select Depth, click Next.



3 Select Depth/Level Conversion: Specific Gravity 1.0. Click Finish.



For **AQUIFER TESTING:**

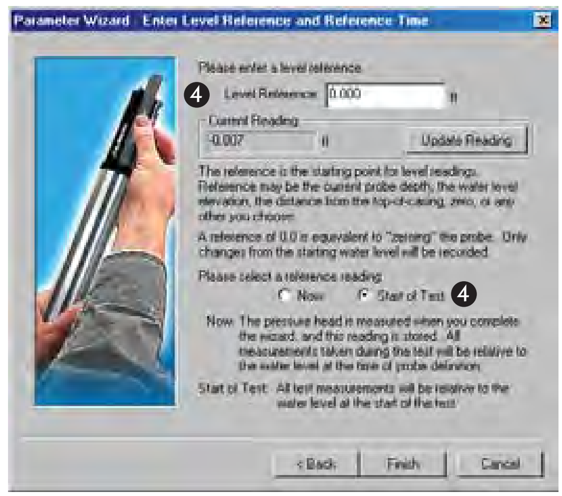
1 Select Pressure in Parameters list, select Edit

Display Mode	
Depth/Level Conversion	Specific Gravity 1.0

2 **Display Mode:** Select Level - Top of Casing, click Next.

3 Select Depth/Level Conversion: Specific Gravity 1.0. Click Next.

4 Select Level Reference 0 & Reference Reading Start of Test. Click Finish.



For **SURFACE WATER MONITORING** (install probe before setting these):

Display Mode	Level - Surface
Depth/Level Conversion	Specific Gravity 1.0
Level Reference	Current elevation or gauge height of water surface
Reference Reading	Now (with probe installed)

After setting the pressure mode, select the **UNITS** you want:

Win-Situ: Options menu > Preferences, scroll down to **LEVEL/DEPTH**, select unit, click OK

Pocket-Situ: Tap Home at top of screen, tap Setup at bottom of screen, scroll down to **LEVEL/DEPTH**, select unit, click OK

INSTALLATION FOR PRESSURE/LEVEL MEASUREMENT

Position the instrument below the lowest anticipated water level, but not so low that its range might be exceeded at the highest anticipated level. Lower the MP TROLL 9500 gently to the desired depth.

Pressure Sensor Pressure Ratings

Range		Usable Depth	
kPa	PSI	Meters	Feet
103.4	15	11	35
206.8	30	21	69
689.5	100	70	231
2068	300	210	692

If real-time readings are not required, remove the TROLL Com from the cable after programming. Protect the “uphole” end of the cable with the dust cap or optional desiccant. If cable will not be used, attach a Twist-Lock Hanger to the TROLL 9500.

SECURING THE CABLE

The RuggedCable has a handy device called a Kellems® grip near the surface end. You can slide it along the cable to the desired position by compressing it. When you pull on it, it tightens and stops sliding. You may need to pull on both ends of the Kellems grip to properly tighten it and keep it from slipping.

Use the loop of the Kellems grip to anchor the cable to a convenient stationary object. It works well with In-Situ’s “well dock” installation ring. Simply insert the loop into the locking clip on the well dock, and position the assembly on the top of a well. Insure the cable is secured to prevent the instrument moving while data is being logged.

Kellems grip

STABILIZATION TIME

Allow the instrument to stabilize to the water conditions for *about an hour* before starting a test. A generous stabilization time is always desirable. Even though the cable is shielded, temperature stabilization, stretching, and unkinking can cause apparent changes in the probe reading. If you expect to monitor water levels to the accuracy of the probe, it’s worth allowing the extra time for the probe to stabilize to the test environment.

TWIST-LOCK HANGER INSTALLATIONS

The non-vented Twist-Lock hanger accessory can be used to suspend a pre-programmed MP TROLL 9500 in a well or other site while taking data where barometric pressure changes are not crucial.

The Twist-Lock hanger allows use of inexpensive hanging cable, and requires no direct communication and no cable venting. This setup is ideal for use where barometric compensation of pressure measurements is not required—in vacuum testing, unconfined aquifers, or very deep applications where barometric pressure effects are minimal.

- Because the Twist-Lock Hanger has no communication capabilities, you must program the MP TROLL 9500 before installation
- Logged pressure data will show the effects of changes in barometric pressure. However, post-processing tools may be used to eliminate the effects of barometric pressure changes from the data, if required. See “Correcting Absolute Pressure Readings for Barometric Pressure” below for more information.

Installation Tips for Level/Depth/Pressure Monitoring

- Never let a probe “free fall” down a well. The resulting shock wave when it hits the water surface can damage the pressure sensor strain gauge (the “waterhammer” effect), as well as other sensors.
- It is always wise to check the level of water above the probe, then move it and read again to be sure that the probe is giving a reasonable reading and showing change. It might not be located where you think it is — for example, it could be wedged against the casing with a loop of cable hanging below it. A probe in such a position might become dislodged and move during the test, giving a false change in level. *A secure placement is critical to accurate level measurements.*
- When monitoring pressure with vented cable, do not allow the cable (and its internal vent tube) to kink or bend. If the vent tube is obstructed, water level measurements can be adversely affected. The vent tube can become kinked and damage the internal components without any visible harm to the outside of the cable. The recommended minimum bend radius is 63.4 mm (about 2½ in) or more.
- Do not position the instrument below the level of the pump in a pumping well. The pressure transients generated by the pump will cause false level readings. Large pumps can swallow the probe and cause permanent damage to both the MP TROLL 9500 and the pump.

CORRECTING ABSOLUTE PRESSURE READINGS FOR BAROMETRIC PRESSURE

Pressure measured with an “absolute” or “non-vented” (psia) pressure sensor includes all pressure forces detected by the strain gauge—atmospheric pressure as well as the pressure due to the water column. “Gauged” or “vented” (psig) sensors remove the atmospheric pressure component (pressure due to the atmosphere), so that atmospheric pressure on a water surface is not doubled in the measurements from a sensor under the water surface.

Barometric compensation of absolute pressure measurements, if required, may be accomplished in a couple of ways.

MANUAL BAROMETRIC PRESSURE COMPENSATION

Using the MP TROLL’s Barometric Pressure Sensor

If your model of MP TROLL 9500 includes an onboard barometric pressure sensor, and the instrument is attached to vented cable, the barometric pressure sensor output can be used to correct measurements from a submerged absolute (psia) pressure sensor. In this case, set up the pressure channel in “pressure head” mode, and select the same units for both the water pressure channel and the barometric pressure channel. Set up and run a test that includes both pressure channels. Extract (download) the data, and subtract the barometric pressure measurements from the water pressure measurements.

Using a Second Unit and a Spreadsheet

If a barometric pressure sensor is not present, and/or the cable is not vented, barometric compensation of absolute pressure measurements may be accomplished with the use of a separate device—a Baro TROLL or Absolute miniTROLL—installed above the water surface, taking barometric pressure measurements. Set up both devices to use the same units and display mode—the only difference will be if a level reference is used; in that case the barometric reference should be zero, the downhole reference will be the water level. Schedule tests to start at the same time in each unit. Extract (download) the data from both tests, and subtract the barometric pressure measurements from the water pressure measurements (by hand or in a spreadsheet).

TIP: *For additional information on correcting absolute pressure measurements, see the Technical Note “Manual Barometric Corrections” in the Downloads section of our website at www.in-situ.com.*

AUTOMATIC BAROMETRIC PRESSURE COMPENSATION

A Baro Wizard in Win-Situ and Pocket-Situ allows for automatic barometric pressure compensation of absolute pressure data, either using a fixed user-specified value or by reference to a file of barometric pressure data collected at the same time by a BaroTROLL or other absolute (psia) instrument installed at the surface. The barometrically corrected absolute pressure data may be saved in a new file, if desired.

Collecting Barometric Pressure Data for Reference

Be sure to set the clock in the BaroTROLL (or other absoltue instrument). Add a test. Ideally, this test should start before the test in the Absolute MP TROLL 9500 starts and log data on approximately the same schedule. Run the test. Extract the test (it is not necessary to stop it.)

Collecting PSIA Data

Set the clock in the Absolute MP TROLL 9500. Add a test and run it as usual. Extract this test also.

Using the Baro Wizard

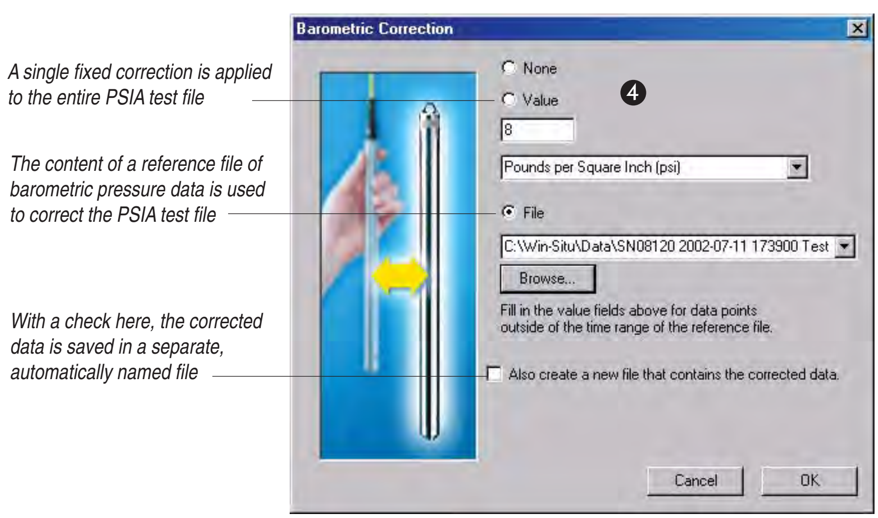
The difference in pressure between a BaroTROLL at the surface and a submerged MP TROLL 9500 with an absolute (psia) pressure sensor can be calculated from extracted test data files. This task is simplified if the BaroTROLL test covers the entire duration of the Absolute instrument’s test.

1. Launch Win-Situ 4 or Pocket-Situ 4. Connection to an instrument is not necessary after the tests have been extracted.
2. In the data folder, select a test extracted from an MP TROLL 9500 with an Absolute pressure sensor (PSIA data).
3. On the Tools menu, select Baro Wiz.

4. In the Barometric Correction window, select the type of correction to be performed:
   - None
   - Value: Enter a barometric pressure value to be subtracted from all data points in the test file. Units are selectable, and your entry is checked for validity. For example, in inches of mercury the valid range is 14.3 to 33.5 (covering altitudes from the Alps to the Dead Sea). You may not leave this entry blank, because a fixed value will be needed even with a reference file (next option, see below) in case the time stamps in the two files do not completely overlap.
   - File: Select a test of barometric pressure data collected by a BaroTROLL or other PSIA instrument. This becomes the Reference file from which barometric pressure corrections will be derived. If the time stamps in the files do not overlap completely, the fixed value will be applied.
5. To save the corrected data in a new file that will be automatically named, check the create new file checkbox.
6. Click OK. The correction is performed immediately and the corrected file is displayed.

RECALIBRATION RECOMMENDATIONS

Pressure sensor accuracy can be adversely affected by improper care and handling, lightning strikes and similar surges, exceeding operating temperature and pressure limits, physical damage or abuse, as well as normal drift in the device's electronic components. Aside from damage to the sensor, the need for factory recalibration is dependent upon the amount of drift a customer is willing to tolerate. Factory calibration every 12-18 months is recommended. Contact In-Situ Customer Service for information on the factory maintenance and calibration plan. Calculations of the accuracy drift of the MP TROLL 9500 over time are contained in the Appendix of this manual. Contact In-Situ Customer Service for information on periodic check-ups and recalibration.



8 MONITORING TEMPERATURE

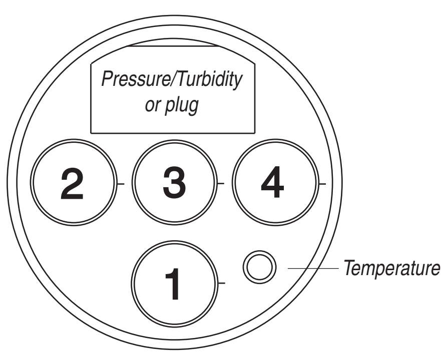
WHY MONITOR TEMPERATURE?

Water temperature plays an important role in water chemistry, which in turn influences the biological activity and growth of aquatic organisms. In general, the higher the water temperature, the greater the biological activity and the rate of chemical reactions. An important example of the effects of temperature on water chemistry is its impact on oxygen. Warm water holds less oxygen than cool water; the maximum amount of oxygen that can be dissolved in the water decreases as water temperature increases.

Artificially high temperatures are often referred to as “thermal pollution,” which may result from discharge of municipal or industrial effluents. Thermal pollution can have a significant ecological impact. In running waters, particularly small urban streams, elevated temperatures from road and parking lot runoff can be a serious problem for populations of cool or cold-water fish.

Changes in the growth rates of cold-blooded aquatic organisms and many biochemical reaction rates can often be approximated by the “Q_{10} rule,” which predicts that growth rate will double if temperature increases by 10°C (18°F) within their “preferred” range.

End view of sensor block



Knowledge of water temperature is essential to the measurement of dissolved oxygen, conductivity (salinity), pH, and many other water-quality parameters. In limnological studies, water temperature as a function of depth can be an important indicator. Industrial plants often require data on water temperature for process use or heat-transmission calculations.

These are only a few of many reasons for measuring and recording water temperature over the short or long term.

THE TEMPERATURE SENSOR

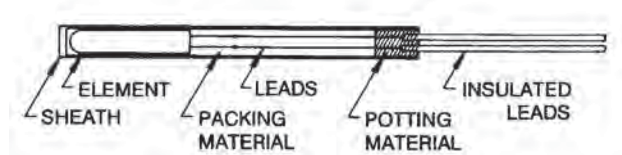
All models of the Multi-Parameter TROLL 9500 include a permanently installed, factory-calibrated sensor for measuring solution temperature.

Do not try to remove the permanently installed temperature sensor.

The MP TROLL 9500 temperature sensor is the Standard Platinum Resistance Thermometer specified by the ITS-90 (International Temperature Scale of 1990). A platinum resistance thermometer (PRT) is a type of resistance temperature detector (RTD).

***TIP:** After a drop or shock, if the end of the temperature sensor is slightly bent, it may be carefully bent by hand (no tools, please!) back to its original alignment. Note that a severe shock may affect the accuracy of the temperature sensor.*

Platinum Resistance Thermometer



ROLE OF THE SENSOR IN CALIBRATION

The temperature sensor has a primary function during calibration of temperature-dependent water-quality parameters such as conductivity. When the calibration temperature is known, temperature compensation can be provided during measurement of water-quality parameters. The temperature sensor also provides continuously updated real-time measurements of solution temperature when profiling.

Ensure that the temperature sensor is immersed in at least one-half inch of solution during calibration of all parameters. The fill line on the Cal Cup serves as a guide to the recommended quantity of calibration solution.

For best results, the water-quality sensors should be calibrated at the same temperature that will be encountered in the field.

SOFTWARE FUNCTIONS

Conversion of resistance (measured by the PRT) to temperature is automatic in the software. No user calibration is required.

The temperature channel is automatically included in tests so that solution temperature is available to compensate water-quality data from other channels.

Units

Temperature may be displayed in degrees Celsius (°C) or degrees Fahrenheit (°F).

TIP: *To change unit preferences: In Win-Situ, select Preferences on the Options menu. In Pocket-Situ, select the Home site, then tap Setup in the command bar.*

REFERENCES

Eaton, A.D., L.S. Clesceri, E.W. Rice, and A.E. Greenberg, eds., *Standard Methods for the Examination of Water and Wastewater,* 21st edition, Washington, D.C.: American Public Health Association, American Water Works Association, and Water Environment Federation, 2005. Section 2550, Temperature.

EPA, Methods for Chemical Analysis of Water and Wastes, EPA/600/4-79-020, revised March 1983. Method 170.1, Temperature, Thermometric. Approved at 40 CFR Part 136.

Mangum, B.W., and G.T. Furukawa, *Guidelines for Realizing the ITS-90,* NIST Technical Note 1265, U.S. Department of Commerce, 1990.

Water on the Web (WOW). University of Minnesota project initially funded by the National Science Foundation. On the web at wow.nrri.umn.edu.

9 MONITORING BAROMETRIC PRESSURE

WHAT IS BAROMETRIC PRESSURE?

Barometric, or atmospheric, pressure is the force exerted by the gases in the atmosphere everywhere on the surface of the earth. Barometric pressure is greatest at or below sea level, and decreases as altitude above sea level increases.

WHY MONITOR BAROMETRIC PRESSURE?

Barometric pressure influences the measurement of water levels in water bodies that are open to the atmosphere. It also determines the amount of atmospheric gases that can be dissolved in water; more oxygen, for example, can be dissolved in water at higher barometric pressure (lower altitude). Barometric pressure additionally influences other water-quality parameters such as pH.

A logged record of barometric pressure data during a test can be used to correct water level measurements made with an absolute pressure sensor to factor out the effects of barometric pressure fluctuations.

To measure barometric pressure, the probe must be vented to the atmosphere. A submerged Multi-Parameter TROLL on non-vented cable cannot accurately report barometric pressure.

If your MP TROLL 9500 is used with a non-vented backshell and/or non-vented cable, a software correction can substitute for barometric pressure venting. See the procedure in this section.

THE BAROMETRIC PRESSURE SENSOR

Most models of the Multi-Parameter TROLL 9500 include a permanent, factory-calibrated internal barometric pressure sensor. Its primary function is in calibration and measurement of water-quality parameters, such as dissolved oxygen, that are dependent upon barometric pressure. It may also be used to compensate fluid pressure measurements made with an absolute pressure sensor.

The sensor is automatically included in tests so that its value is available to compensate water-quality data from other channels.

Units

The following units are available for barometric pressure: Bars, milliBars, inches of mercury (in. Hg or " Hg), millimeters of mercury (mm Hg), cm, pounds per square inch (psi)

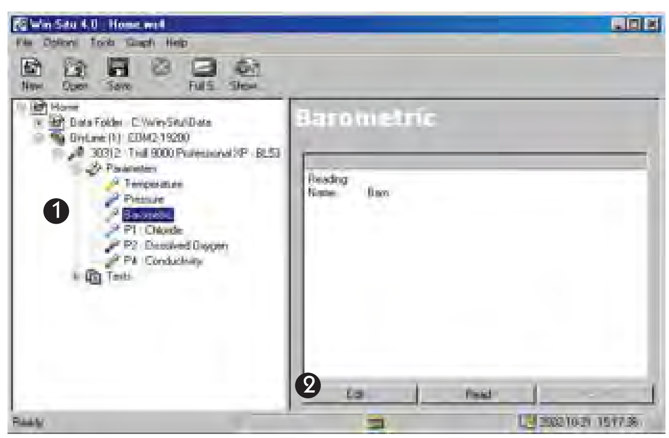
***TIP:** To change unit preferences: In Win-Situ, select Preferences on the Options menu. In Pocket-Situ, select the Home site, then tap Setup in the command bar.*

COLLECTING ACCURATE MEASUREMENTS WITHOUT VENTED CABLE

Win-Situ and Pocket-Situ cannot determine whether the MP TROLL 9500 is on vented or non-vented cable. However, you can supply the software with this information, and also enter a fixed barometric pressure value to be used in the absence of cable venting.

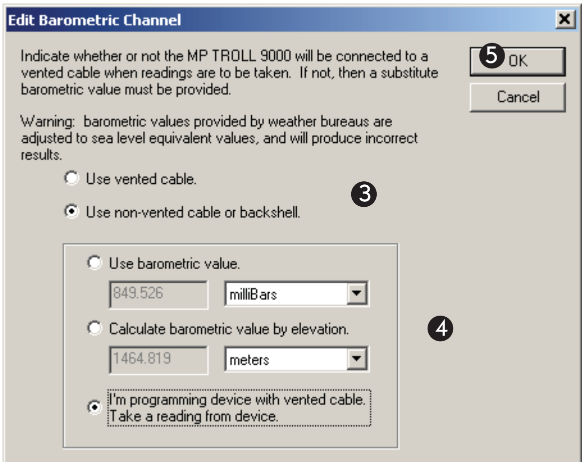
Procedure:

1. Select the barometric channel in the Navigation tree.



2. Click or tap **Edit...**. The Edit Barometric Channel screen appears. Several options are presented:

***TIP:** This screen can also be accessed during test setup and dissolved oxygen calibration.*



3. Do one of the following:
   - If this MP TROLL 9500 has a barometric pressure sensor and **vented** cable, select “Use vented cable.” Go to step 5.
   - If the device is on **non-vented** cable now and will take measurements using **non-vented** cable, select “Use non-vented cable or backshell.” Continue to step 4.
   - If the TROLL is on **vented** cable now but will take measurements on **non-vented** cable, select “Use non-vented cable or backshell” and also check the last box so a reading can be taken from the barometric pressure sensor while it is available.
4. Supply a barometric pressure value for the software to use in the absence of vented cable. Choose one of these options:
   - Supply a fixed pressure value in your choice of units (select units by clicking the arrow on the list box). This value will be used each time barometric pressure is required elsewhere in the software—for example, when calibrating dissolved oxygen.
   - Enter your elevation and let the software calculate barometric pressure based on the values in the table on this page. Please note that *this fixed value will not be recalculated if the elevation changes.*
5. Click **OK** to store this information.

Conversions

bars ∗ 29.530 = inches of mercury
psi ∗ 2.036 = inches of mercury
atmosphere ∗ 101325 = Pascals
psi ∗ 6.894757 ∗ 10^3 = Pascals
bars ∗ 14.50337 = psi

PRESSURE VS. ELEVATION

(based on U.S. Standard Atmosphere)

Elevation		Pressure			
ft	m	in. Hg	mm Hg	PSI	Bars
-1,000	-304.8	31.02	787.9	15.25	1.051
- 500	-152.4	30.47	773.8	14.94	1.030
0	0	29.92	760.0	14.70	1.013
500	152.4	29.38	746.4	14.43	0.995
1,000	304.8	28.86	732.9	14.18	0.977
1,500	457.2	28.33	719.7	13.90	0.958
2,000	609.6	27.82	706.6	13.67	0.942
2,500	762	27.31	693.8	13.41	0.924
3,000	914.4	26.81	681.1	13.19	0.909
3,500	1066.8	26.32	668.6	12.92	0.891
4,000	1219.2	25.84	656.3	12.70	0.875
4,500	1371.6	25.36	644.2	12.45	0.858
5,000	1524	24.89	632.3	12.23	0.843
5,500	1676.4	24.43	620.6	12.00	0.827
6,000	1828.9	23.98	609.0	11.77	0.811
6,500	1981.2	23.53	597.6	11.56	0.796
7,000	2133.6	23.09	586.4	11.34	0.781
7,500	2286	22.65	575.3	11.12	0.766
8,000	2438	22.22	564.4	10.90	0.751
8,500	2590.8	21.80	553.7	10.70	0.737
9,000	2743.2	21.38	543.2	10.50	0.723
9,500	2895.6	20.98	532.8	10.30	0.710
10,000	3048	20.58	522.6	10.10	0.696
10,500	3200.4	20.18	512.5	9.91	0.692
11,000	3352.8	19.79	502.6	9.73	0.670
11,500	3505.2	19.40	492.8	9.53	0.657
12,000	3657.6	19.03	483.3	9.35	0.644
12,500	3810	18.65	473.8	9.15	0.631
13,000	3962.4	18.29	464.5	8.97	0.618
13,500	4114.8	17.93	455.4	8.81	0.607
14,000	4267.2	17.57	446.4	8.63	0.595
14,500	4419.6	17.22	437.5	8.46	0.583
15,000	4572	16.88	428.8	8.28	0.571
15,500	4724.4	16.54	420.2	8.13	0.560
16,000	4876.8	16.21	411.8	7.96	0.549
16,500	5029.2	15.89	403.5	7.81	0.538

10 MONITORING WATER QUALITY: OVERVIEW

WHY MONITOR WATER QUALITY?

At a time of increasing demands on the finite natural resources of our planet, public organizations and private individuals alike have become acutely aware of the responsibility to maintain the quality of the earth's air and water supplies.

Recent rapid advances in knowledge and technology have made it possible to deliver accurate, timely, and reliable data on processes we cannot necessarily examine visually. New-generation sensors for in-situ measurement of surface waters and groundwater can be an efficient alternative to time- and labor-intensive programs of field sampling and transportation to a laboratory for analysis, or can supplement such programs. If it is possible to collect, interpret, and respond in a timely fashion to accurate information about water supplies and water quality, we can design better systems for protection of those supplies.

Monitoring water-quality parameters can reveal much about the presence and movement of natural and unnatural components of water—the presence of harmful bacteria, potential pollution sources, depletion of nutrient requirements for aquatic life, salt-water intrusion into fresh water bodies, changes in water level or temperature that can alert observers to the onset of an "event" that can adversely affect the quality of the resource.

Monitoring water quality in surface and groundwater resources may be required by Federal, state, or local regulations. Digital records of monitoring can document compliance with guidelines and standards mandated by regulatory bodies.

Profiling and logging water-quality data can provide timely information on continually changing conditions—profiling to provide instantaneous real-time feedback, logging to track trends and demonstrate compliance.

THE SENSORS

The Multi-Parameter TROLL 9500 takes advantage of new technologies to monitor water-quality parameters in-situ with high accuracy. Each sensor has been manufactured to our rigid specifications and is designed to operate with the entire suite of sensors and with the MP TROLL 9500 electronics. These "smart" sensors retain serial number identification and calibration information, and are detected and identified by the instrument. A sensor may be calibrated in any MP TROLL 9500 and moved to another port that accepts the sensor type, or used in another MP TROLL 9500, without recalibration. The most accurate results will be obtained when a sensor is calibrated and operated in the same MP TROLL 9500.

The water quality sensors available for the Multi-Parameter TROLL 9500 may be classed in two general types:

BASIC SENSOR SET

- pH
- Combination pH/ORP (Oxidation-Reduction Potential)
- Dissolved Oxygen, polarographic (DO)
- Conductivity (and Specific Conductance, Salinity, Total Dissolved Solids, Resistivity)

The pH sensor is a Single ISEs (ion-selective electrode). The Combination pH/ORP sensor is a Multiple ISE.

The Basic sensors can be factory-calibrated and pre-installed in the MP TROLL 9500. They are ready for use right out of the box with a brief Quick Cal. However, for best results, if your software supports it, we recommend that you perform a traditional two-point calibration for pH and DO, and a specific range calibration for conductivity as described in sections 11-13 below. The accuracy that can be achieved from the instrument is proportional to the time and care you put into calibration.

EXTENDED SENSOR SET

The Extended Sensor set includes:

- Ammonium
- Chloride
- Nitrate
- Turbidity (factory-installed)
- RDO® Optical Dissolved Oxygen

INSTALLING SENSORS

The diagram below represents a head-on view of the "sensor block" in the front end of the MP TROLL 9500. There are four sensor ports, plus permanently installed pressure and/or turbidity and temperature sensors. Pressure and turbidity sensors are optional—if your instrument does not include one or both of these sensors, there will be a permanently installed plug in the port.

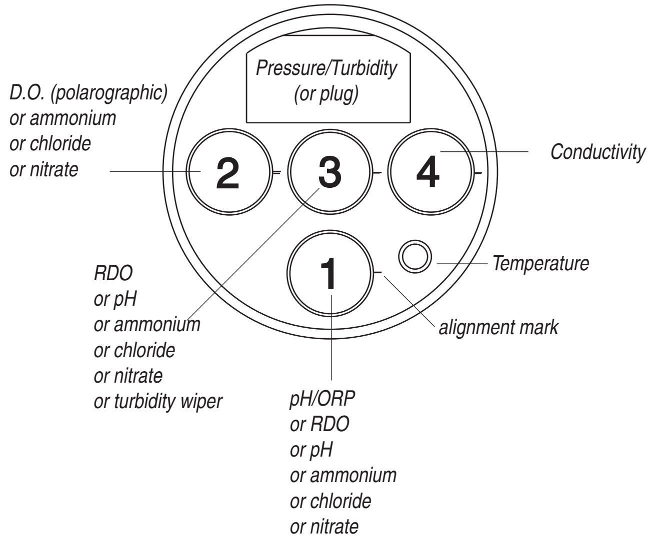
Do not try to remove the pressure or turbidity sensor or permanently installed plug.

Although the sensor design permits any sensor to install into any sensor port without damage to either the sensor or the instrument, for proper functioning please insure that sensors are installed in their intended ports, as shown in the diagram.

To install sensors:

1. Remove the restrictor or Cal Cup from the front end of the MP TROLL 9500. This allows access to the sensor block shown below.

End view of sensor block



Q: *Will a sensor work if installed in the wrong port?*

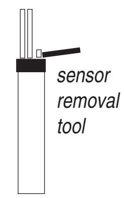
A: *Physically, a sensor may be plugged into any port. However, a sensor that is detected in the wrong port for its type will generate an error message in the software. The message will let you know which port or ports the incorrectly installed sensor should be moved to.*

In this case, remove the offending sensor and install it in the correct port. Then "refresh" the device view in the software to update the display.

2. Remove the cap or storage bottle from the sensor. Retain the cap or bottle for future storage and protection of the sensor. If the connector end is covered with a cap, remove it also.

__TIP:__ To ensure optimum membrane response for new ion-selective electrodes (pH, ORP, nitrate, ammonium, chloride), soak the sensor in calibration solution for at least 15 minutes and up to several days before calibration.

3. Remove any moisture or dirt from the area around the port where you will install the sensor, then use the sensor removal tool to remove the plug from the port. Retain the plug for use with fewer than 4 removable sensors installed.

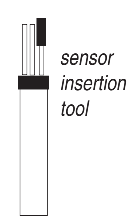


__TIP:__ If you are installing a sensor in port 3 (the central port), install it first. This will make it easier to install sensors in other ports.

4. Remove any moisture or debris from the connector in the bottom of the port with a clean swab or tissue.
5. Check lubrication of the sensor o-rings.

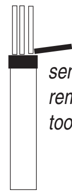
The sensor o-rings require generous lubrication before installation. New sensors will be lubricated at the factory. If the o-rings appear dry, apply a silicone lubricant before installation.

6. Align the mark on the sensor with the alignment mark on the correct port (see diagram), or visually align the sensor connector pins with the port connector pins.
7. Press the sensor firmly into the port until it is securely seated. When properly inserted a small gap (width of the sensor removal tool) remains between the instrument body and the widest part of the sensor, for ease of removal.



REMOVING SENSORS

Sensors may be removed for inspection, cleaning, routine maintenance, and storage. Because the smart sensors retain calibration information, they may be removed and re-installed—even in another MP TROLL 9500— as often as necessary.



Remove a sensor by positioning the yoke of the sensor removal tool at the point where the sensor enters the sensor block. Firmly pry the sensor upward until it pops out.

Sensor O-Rings

Two Viton® o-rings on each sensor provide a watertight seal against water leakage into the instrument body. We recommend that you inspect these o-rings each time you remove or install a sensor. Check carefully for cracks, tears, splitting, shredding, and other damage. If the o-rings are in good condition, apply silicone lubricant before installing the sensor again. Remove excess lubricant with a tissue, and take care to keep grease away from the area around the connector at the bottom of the sensor. Should lubricant get into this area, it can be removed with a clean cotton swab.

If the o-rings become damaged to the extent that no longer provide an effective seal, they should be replaced. Sensor o-rings and lubricant are available from In-Situ Inc. or your distributor.

CALIBRATION OVERVIEW

The MP TROLL 9500 and its control software provide several options for calibration of the water-quality sensors. Select the method that suits the time you have at your disposal and the degree of accuracy you want to achieve when measuring water-quality parameters.

Satisfactory results may be achieved using the Quick Cal procedure. Some sensors can even return nominal results straight out of the box using the factory-supplied default calibration coefficients. However, for best results we recommend a full traditional calibration procedure before the first field use, and periodic checks and recalibrations as necessary thereafter.

The following available options are briefly described in the next two pages:

- Traditional Calibration
- Quick Calibration
- Out-of-Box
- Factory Defaults

TRADITIONAL CALIBRATION

A full traditional calibration, guided by software wizards, can achieve the highest level of accuracy. Some sensors require a single-point calibration, others present a choice of single- or multi-point, requiring more than one calibration standard. A single-point calibration gives good results in the range of values represented by the selected calibration solution. When a wide range of values are expected, a multi-point calibration is recommended.

With the sensor installed in the MP TROLL 9000 and immersed in calibration solution, the sensor is powered at regular intervals and its response is monitored. The difference (deviation) between the minimum and maximum response over a predetermined time period is tracked by the software. When the peaks of the response fall within predetermined limits for the time period, the sensor response is considered sufficiently stable to provide a valid calibration point. The length of time and allowable deviation are specific to each sensor type, and furthermore are specific to the determination of nominal stability or complete stability. The time period of interest is shorter for nominal stability than for complete stability, allowing for a shortening of the calibration soak time while still returning a valid calibration point.

- Available for: All water-quality parameters.
- Requirements: MP TROLL 9500, sensors (installed), Cal Cup, and one or more calibration solutions for each parameter to be calibrated. Suitable calibration solutions are supplied in In-Situ's individual calibration kits.
- Where to find the method in this manual: Sections 11-19.

Q: ***What is the difference between NOMINAL and STABLE?***

A: *To meet the criteria for a valid calibration point, the change (deviation) in sensor response is monitored over time. The software is looking for the calibration solution temperature and the sensor readings to settle over a specific time period. The criteria for STABLE are designed to meet the published specifications. The NOMINAL criteria are designed to shorten the calibration time when an approximate calibration is acceptable. When the deviation falls within the limits of the "loosened" specifications, NOMINAL is displayed in the Status area, and the Accept button becomes available to store the current calibration point.*

Accepting a NOMINAL value may save considerable time. In some cases, especially if the sensors have been soaking in the solution for several minutes prior to calibration, the accuracy achieved by accepting a nominal value may be very similar to that obtained by waiting for complete stability.

QUICK CALIBRATION

A "Quick Cal" calibrates the Basic sensors simultaneously to achieve adequate performance with minimal labor using a single "universal" calibration solution.

- Available for: pH, ORP, polarographic Dissolved Oxygen, and Conductivity.
- Requirements: MP TROLL 9500, sensors (installed), Cal Cup, and Quick Cal solution.
- Where to find the method in this manual: Section 3, Getting Started.

OUT OF THE BOX

Some sensors may be installed and used right out of the box using factory-supplied default calibration coefficients.

- Available for: pH, ORP, and Conductivity.
- Requirements: MP TROLL 9500, sensors (installed).
- Where to find the method in this manual: No method required, plug-and-play.

DEFAULT COEFFICIENTS

This option resets the sensor's factory defaults and is best when the sensor is new.

- Available for: pH, ORP, and Turbidity.
- Where to find the method in this manual: See pH calibration in Section 11, ORP calibration in Section 14, Turbidity calibration in Section 18.

The cell constant for a conductivity sensor may be entered "by hand," without performing a complete calibration, if desired. See the procedure in Section 12 below.

TIP: *When using Pocket-Situ to perform calibrations, do not let the PDA time out during the procedure. To locate this setting in most PDAs, display the Start menu, select Settings, System tab, Power.*

PREPARING TO CALIBRATE

CALIBRATION KITS

Kits of calibration solutions for various parameters and ranges are available from In-Situ Inc. Our calibration solutions are certified to N.I.S.T. standards, packaged in quarts, each providing sufficient fluid for at least 6 calibrations. Kits include deionized water if that substance is recommended for rinsing a particular sensor during calibration.

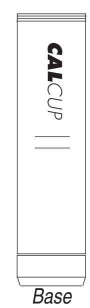
The Quick Cal kit provides a convenient "universal" calibration solution, designed to calibrate multiple parameters simultaneously.

THE CALIBRATION CUP

The clear acrylic Cal Cup shipped with your MP TROLL 9500 is used to hold solution during sensor calibration. When fitted with a small moist sponge, it also provides a convenient way to protect and hydrate the sensors of the MP TROLL 9500 between uses.

The base of the Cal Cup is removable so that the stirrer may be attached for calibrations where continuous agitation of the solution is recommended. A small hole in the threads of the base near the o-ring permits venting during 100% dissolved oxygen calibration with the Cal Cup and probe inverted.

The Cal Cup's fill lines indicate the recommended amount of solution for most calibrations, and ensures the temperature sensor is immersed.



- With a full complement of sensors installed, use the lower line as a guide.
- With only 1 or 2 removable sensors installed, fill to the upper line.

The temperature sensor should always be immersed in at least one-half inch of fluid.

When attaching the Cal Cup to the front end of the MP TROLL 9500, align carefully and thread the Cal Cup onto the body until seated against the o-ring, then back off slightly to avoid overtightening.

When attaching the Cal Cup to the instrument body, be careful not to overtighten.

EFFECT OF TEMPERATURE ON CALIBRATION

The most successful calibrations reproduce field conditions as nearly as possible, especially temperature. It is best to calibrate at the expected field temperature.

RINSING

As a general guideline, we recommend you rinse the Cal Cup, the front end of the MP TROLL 9500, and the installed sensors prior to beginning calibration. This will remove trace contaminants or solutions used in previous calibrations, and prepare the instrument for a clean calibration.

A good way to do this is to fill the Cal Cup with water, attach to the instrument, and shake vigorously. This may need to be done a couple of times.

Rinse first in tap water, followed by a rinse with distilled or deionized water.

Shake or wipe with a clean lint-free tissue to dry. It is not necessary to dry thoroughly.

Some calibration procedures also recommend a rinse in the selected calibration solution. In this case, drying is not necessary.

STIRRING

When to Stir?

The stirrer accessory should be used during a calibration procedure if it will also be used during field use—for example, if the instrument will be in stagnant or very slowly moving water. The more closely calibration conditions reflect field conditions, the more successful the calibration. This is especially important when calibrating the ISE sensors (ammonium, chloride, and nitrate).

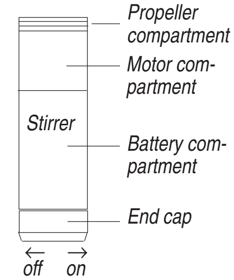
ISE sensors in close proximity to each other can sometimes create interferences. Constant stirring can enhance the performance of the ISE sensors.

Attaching the Stirrer for Calibration

To use the battery-powered stirrer for calibration, attach it to the MP TROLL 9500 and Cal Cup as follows. See illustration C on the following page.

1. Remove the restrictor (nose cone attached) from the MP TROLL 9500 and set it aside.
2. Remove the black end cap from the Cal Cup.
3. Screw the top of the stirrer (propeller end) to the bottom of the Cal Cup (the end from which you just removed the end cap).
4. Fill Cal Cup to fill line with solution.
5. Attach Cal Cup/stirrer assembly to front end of MP TROLL 9500.

Starting the Stirrer



The stirrer is powered by two alkaline D-cells (installed). To start the motor, tighten the end cap.

The magnetic stir bar in the propeller compartment will start to spin. The stir bar is protected by a guard plate that may be removed for cleaning if necessary.

***TIP:** Should the stir bar not start spinning, try giving it a gentle nudge by sliding a narrow tool such as a screwdriver or key between the protective bars of the guard plate.*

To turn the stirrer off, back off the end cap until the stir bar stops spinning.

CALIBRATION PROCEDURES

Refer to the following sections for specific calibration procedures and guidelines:

Quick Cal	Section 3
pH	Section 11
Conductivity	Section 12
Dissolved Oxygen (polarographic)	Section 13, first half
Dissolved Oxygen (optical)	Section 13, second half
ORP	Section 14
Ammonium	Section 15
Chloride	Section 16
Nitrate	Section 17
Turbidity	Section 18

AFTER CALIBRATION

When you finish calibrating with any method, the following happens:

- The newly calculated calibration coefficients are written to the “smart sensor” memory.
- You have the option of viewing the calibration report. The report may be viewed immediately after calibration, or at any time. See Calibration History, below.
- The sensors are ready to take measurements.

MP TROLL 9500

A. with restrictor and nose cone

B. with Cal Cup in place of restrictor and nose cone

C. with Cal Cup and stirrer, for stirring calibrations

D. with Restrictor and stirrer, for monitoring water quality in stagnant water

SENSOR STORAGE

It is best to calibrate just before field use. However, should you need to store calibrated sensors, there are a couple of options:

- If the instrument will be used in a day or so, leave the sensors installed. Remove the Cal Cup and rinse it and the sensors. Moisten a sponge and place it in the bottom, or add a little water (deionized, distilled, or tap) to the Cal Cup—just enough to create a moist environment. Return the probe to the Cal Cup for transport to the field site.

  TIP: *Deionized water is preferred over tap water, but it is not essential; especially if the local tap water is of good quality.*

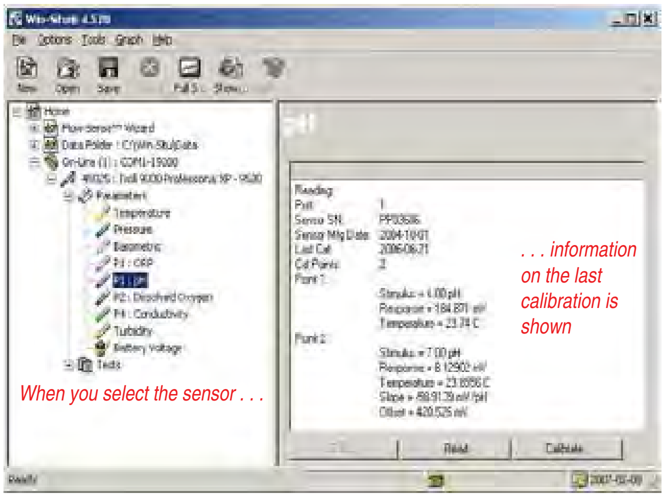
  To seal the Cal Cup against leakage, seat it lightly against the o-ring on the instrument body. It is best not to over-tighten.

- For longer storage, remove the sensors from the MP TROLL 9500. Store the conductivity sensor dry. Store the DO, pH, and pH/ORP sensors in their storage bottles (located in the sensor kits): DO in clean water, pH and pH/ORP in the solution they were shipped in, or with a moist sponge in the sensor storage bottle to avoid depleting the reference solution.

CALIBRATION HISTORY

Each time a sensor is calibrated, the information is written to the sensor, where it is stored until the next calibration. Details on the most recent calibration are displayed by the software when a parameter is selected in the Navigation tree.

The software also creates a calibration report in html format each time a sensor is calibrated. A separate report is created for every calibration of every parameter—even for a calibration that was cancelled. You have the option to view the report immediately after calibration. Reports are stored for later retrieval and reference in a folder named “Calibration Reports” in the folder where Win-Situ 4 or Pocket-Situ 4 is installed. Reports include a detailed record of date and time, parameter, calibration type, number of calibration points, stimulus and response, and calculated coefficients. An index in html format is also created and updated each time a calibration is performed.



pH calibration information for a combination pH/ORP sensor in port 1

The calibration reports are accessible from the Tools Menu and the Show Calibration Report button on the toolbar. They may also be accessed like other files through Windows Explorer (desktop PC) or File Explorer (PDA); they are not displayed in the Data Folder. They may be viewed or printed to provide a complete calibration history.

***TIP:** Here's how to find the calibration report indexes:*

Desktop or laptop PC—Calibration Reports subfolder in the folder where Win-Situ 4 is installed

PDA—Calibration Reports subfolder in the folder where Pocket-Situ 4 is installed

Example of a calibration report index

Folders:

Folder
SN32072
SN45025

Click a folder to see its listings

Click a tile to open it

SN32072

Files:

File Name
SN32072 2006-04-17 171530 TURB.html
SN32072 2006-06-18 102309 DO.html
SN32072 2006-08-14 134200 QuickCal.html
SN32072 2006-11-25 121530 PH.html
SN32072 2007-01-11 154322 Cond.html

MP TROLL 9500 serial number — *Cal Date* — *Cal Time (hhmmss)* — *Parameter*

HOW OFTEN TO CALIBRATE

No sensor will remain in calibration forever. The calibration frequency is almost completely determined by the chemical properties of the fluid being monitored, and the accuracy you wish to achieve from the instrument. For example, when used in relatively clean water, in a normal pH range, at a relatively stable temperature, some sensors could remain in calibration for a couple of weeks or longer. On the other hand, in surface water with a high nutrient content and wide temperature fluctuations, the sensors may need to be cleaned and recalibrated every few days. Your own measurement results are the best guide to the need to recalibrate.

When a sensor or instrument is new, we recommend checking the readings often (say, once a day) to get an idea of the stability of the sensor.

Changes in flow also affect readings. Constant flow will increase the accuracy. This can be achieved with the stirring accessory.

The table below may be used as a very general guideline to how long sensors may be expected to remain in calibration under optimum conditions:

pH, ORP	1-2 months
Conductivity	2-3 months
D.O. (polarographic)	2-4 weeks
D.O. (optical, RDO)	up to a year if foil is not damaged
ISEs	1 day

***TIP:** For additional information on calibration schedules, see the Technical Note on Instrument Calibration in the Downloads section at www.in-situ.com.*

HOW TO CHECK IF A SENSOR IS STILL IN CALIBRATION

Immerse the sensor in a calibration standard of known value and at the same temperature as the original calibration. Compare the sensor reading to the solution value. Some drift is to be expected, but generally the readings should fall within the sensor's accuracy specification. If readings fall outside the accuracy specification by an amount that is not acceptable for your current application, recalibration is recommended. You will quickly learn by experience how often you need to recalibrate a given sensor based on usage.

***TIP:** Quick Cal solution may be used for a quick check of pH, ORP, and conductivity. Refer to the values printed on the label.*

WHEN TO REPLACE A SENSOR

After a certain amount of use even a complete recalibration will not be able to accurately calculate calibration coefficients. The slope will gradually become lower and lower. At this point the sensor should be replaced. Specific slope guidelines for individual sensors are given in the individual parameter sections below.

USING A STIRRER

In-Situ's stirrer accessory provides continuous sample circulation or agitation, which can improve the performance of water-quality sensors in a number of applications.

Dissolved oxygen (DO) measurements drop in very stagnant water due to depletion of oxygen next to the membrane. A slight perturbation to the system will cause the DO measurements to return to normal. Stirring is recommended if the instrument is anchored to a fixed structure in stagnant conditions—for example, attached to a pier in a calm lake that has no underwater currents. If the wind is blowing and waves are slightly moving the cable, then stirring is probably not necessary.

ISE sensors in close proximity to each other can sometimes create interferences. Constant stirring can enhance the performance of the ISE sensors.

Sample agitation can also help to improve sensor response time when water-quality conditions are subject to change (e.g., in a moving contaminant plume) and can speed up temperature stabilization.

Attaching the Stirrer for Field Use

The stirrer accessory is easily installed on the MP TROLL 9000. See illustration D earlier in this section.

1. Remove the nose cone from the MP TROLL 9500. Leave the restrictor attached to the instrument.
2. Screw the top of the stirrer (propeller end) to the stainless steel restrictor in place of the nose cone.
3. Start the stirrer; see Starting the Stirrer earlier in this section.

The instrument is ready for use in stagnant water.

Q: ***How can I find the serial number of a water quality sensor—pH for example?***

A: *The software can display the sensor serial number. Do this:*

1 Select pH in the Navigation tree

2 Look at the information displayed The serial number is displayed in the Information pane on the right side of the screen (or at the bottom on a PDA)

REFERENCES

Eaton, A.D., L.S. Clesceri, E.W. Rice, and A.E. Greenberg, eds., *Standard Methods for the Examination of Water and Wastewater,* 21st edition, Washington, D.C.: American Public Health Association, American Water Works Association, and Water Environment Federation, 2005.

A Fish Farmer's Guide to Understanding Water Quality. LaDon Swann, Dept. of Animal Sciences, Illinois-Indiana Sea Grant Program, Purdue University. On the web at AquaNIC (Aquaculture Network Information Center), aquanic.org.

Rundle, Chris C., A Beginners Guide to Ion-Selective Electrode Measurements. Nico2000 Ltd., London, UK. On the web at www.nico2000.net

Water on the Web (WOW). University of Minnesota project initially funded by the National Science Foundation. On the web at wow.nrri.umn.edu

Water Quality Sensor Pressure Ratings

Sensor	Pressure Rating PSI	Usable Depth Meters	Usable Depth Feet
pH	300	210	692
pH/ORP	300	210	692
Conductivity	350	246	807
D.O. polarographic*	350	246	807
Turbidity	350	246	807
Wiper	350	246	807
Chloride	100	70	231
Ammonium	20	14	46
Nitrate	20	14	46
RDO	*exceeds rating of the TROLL 9500*		

** Submersion and retrieval at up to 4 feet per second.*

11 pH

WHAT IS pH?

The term pH is derived from "p" meaning power and "H" for the element hydrogen and literally means "power of hydrogen." pH is defined as the negative logarithm of the hydrogen ion activity (or concentration in moles/liter):

$$pH = - \log [H^+] \quad \text{or} \quad [H^+] = 10^{-pH}$$

Water (H_2O) dissociates into hydrogen ions (H^+) and hydroxide ions (OH^-) in aqueous solution. At 25°C there are 1.0 x 10^{-7} moles/L of hydrogen ions and 1.0 x 10^{-7} moles/L of hydroxide ions in pure water. Thus the water is neutral (pH = 7) because there are equal amounts of each ion. Addition of a substance with hydrogen or hydroxide ions will shift the balance and cause the water to become either acidic or basic.

The pH scale ranges from 0 (most acidic) to 14 (most basic or least acidic). A change of 1 pH unit corresponds to a tenfold change in hydrogen ion concentration.

WHY MEASURE pH?

A pH value indicates the amount of hydrogen ion that is present in an aqueous environment. The hydrogen ion concentration gives an indication of the acidity of a substance. pH is an important measurement in natural waters because most chemical and biochemical processes are pH dependent. The physiological chemistry of most living organisms can tolerate only small changes in pH and still provide the chemical reactions that sustain life. The solubility of many chemicals is pH dependent. Thus, pH determines their availability to living organisms.

Typical pH values

Fluid	pH units
Acid rain	< 5
Distilled water	5.6
Most natural waters	8
Safe for freshwater fish	6-9
Properly chlorinated swimming pool	7.2 - 7.6

Natural waters usually have pH values in the range of 4 to 9. Most natural waters are slightly basic (~ pH 8) because of the presence of carbonates (CO_3^{2-}) and bicarbonates (HCO_3^-). Extremely fresh water can even be slightly acidic (~ pH 6), depending on the concentration of dissolved carbon dioxide (CO_2). The carbon dioxide combines with water to form a small amount of carbonic acid (H_2CO_3) and this process lowers the pH. Nitrogen oxides (NO_x) and sulfur dioxides (SO_2) from automobile exhaust and the burning of coal combine with water in the atmosphere to form nitric (HNO_3) and sulfuric acid (H_2SO_4). This falls to the ground as acid rain and accumulates in surface water. Runoff from mining spoils and the decomposition of plant materials can also cause acidic surface water.

pH values below 5 in natural waters are generally considered to be too acidic. Freshwater fish seem to do well in the pH range of 6 to 9. Acidic drinking water is a concern because of its corrosive characteristics to plumbing and appliances. pH also affects the ammonia/ammonium (NH_3/NH_4^+) equilibrium in water. Even a small amount of ammonia is detrimental to fish while a moderate amount of ammonium is tolerated. At a pH of 6.5 almost all ammonia is in the form of ammonium. However, as the pH becomes slightly basic, ammonium is changed into harmful ammonia. The lethal dose of ammonia for trout is only 0.2 mg/L.

THE pH SENSOR

pH electrodes use a potentiometric method to measure the pH of a solution. The pH sensor consists of a pH-sensitive glass whose voltage is proportional to the hydrogen ion concentration. A second sensor (electrode) serves as a reference, which supplies a constant stable output. Electrical contact is made with the solution using a saturated potassium chloride (KCl) solution. The electrode behavior is described by the Nernst equation:

$$E_m = E_o + (2.3\ RT/nF) \log [H^+]$$

where

E_m is the potential from the pH electrode,

E_o is related to the potential of the reference electrode,

R is the Gas Law constant,

F is Faraday's constant,

T is the temperature in Kelvin,

n is the ionic charge (+1 for Hydrogen), and

$[H^+]$ is the hydrogen ion concentration in moles/L.

The MP TROLL 9500 reads the signal from the pH electrode, the reference electrode, and the temperature and then calculates the pH using the Nernst equation.

SENSOR INSTALLATION

The MP TROLL 9500 may be shipped with a pH or combination pH/ORP sensor installed. If installation is necessary, unpack and install the sensor in the MP TROLL 9500 as follows.

A combination pH/ORP sensor will work properly only in port 1. A pH sensor may be installed in port 1 or 3.

***TIP:** To ensure optimum response for a new or previously stored sensor, rinse off the soaking solution, then soak the sensor in clean water for at least 15 minutes before calibrating.*

1. Remove the restrictor or Cal Cup from the front end of the MP TROLL 9500. This allows access to the sensor block shown below.
2. Remove the sensor hydration bottle and set aside for future use.
3. Rinse the sensor in clean water to remove the soaking solution. Soak the sensor in clean water for at least 15 minutes before calibrating.
4. Remove any moisture or dirt from the area around the port where you will install the sensor, then use the sensor removal tool to remove the plug from the port. Retain the plug for future use.

5. Remove any moisture or dirt from the port connector with a clean swab or tissue.
6. Remove the cap from the sensor connector. Check lubrication of the o-rings. If they appear dry, apply a silicone lubricant before installation.
7. Visually align the sensor connector pins with the port connector pins.
8. Press the sensor into the port until you feel it dock with the port connector. When properly inserted a small gap (the width of the sensor removal tool) remains between the instrument body and the widest part of the sensor, for ease of removal.

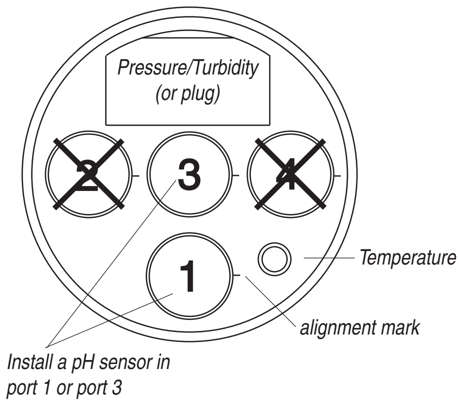
CALIBRATION

OVERVIEW

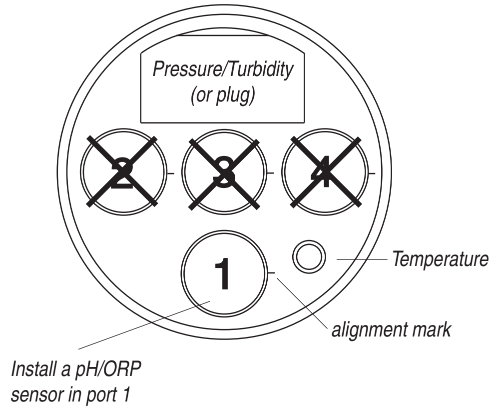
Several options are available for pH calibration.

- **Quick Cal:** Calibrates all basic sensors (pH, ORP, polarographic D.O., conductivity) at the same time with one convenient solution. A one-point calibration in pH 7; default slope, calculated offset.
- **Traditional calibration–1 point:** requires a single solution; results in calculation of sensor offset for a single pH value (pH 4, 7, or 10). Select a calibration solution for the region of the pH range you expect to measure. A one-point calibration may be used with good results when the sensor is new.
- **Traditional calibration–2 point:** requires two solutions; results in calculation of sensor slope and offset for one pH range (pH 4-7 <u>or</u> pH 7-10). Choose solutions that bracket the expected pH range:

pH Sensor Positions



pH/ORP Sensor Position



- 4.0 and 7.0 pH buffer solutions for neutral to acidic conditions
- 7.0 and 10.0 pH buffer solutions for neutral to basic conditions

- **Traditional calibration–3 point:** requires three solutions; results in calculation of slope and offset for 2 ranges (pH 4-7 *and* pH 7-10). The correct slope for the pH values being monitored will automatically be applied. A 3-point calibration is useful when the pH range of the environmental fluid is completely unknown.
- Resets the sensor's factory defaults. No solutions are required.

Nominal vs. Stable

To shorten the calibration time, you have the option to accept the calibration when "Nominal" stability conditions are achieved. If the early value is accepted, the calibration point will be designated "USER SET" in the calibration report. If the calibration report indicates that calibration was performed through to stability then the instrument will operate as intended by In-Situ's quality standards.

CALIBRATION SOLUTIONS

Calibration solutions certified to N.I.S.T. standards are supplied in the In-Situ pH Calibration Kit: pH 4, pH 7, pH 10 buffer, and deionized water. Catalog No. 0032080. Solutions are also available separately.

TIP: *Most solutions are usable beyond their stated expiration date, depending on storage conditions; however, the results cannot be guaranteed.*

Primary standard buffer salts are available from the National Bureau of Standards, and may be used in situations where extreme accuracy is required. Commercially available pH buffers may be used.

RECOMMENDED CALIBRATION FREQUENCY

Calibration frequency will depend on the nature of the sample and the degree of accuracy required. In clean water samples, the pH sensor should retain its accuracy for 2-6 weeks before requiring recalibration. Recalibrate the sensor—

- after replacing the reference junction and/or the filling solution,
- during routine, scheduled maintenance,
- every 2-6 weeks in the absence of other indications.

RECOMMENDED CALIBRATION ORDER FOR PH AND ORP

The pH/ORP sensor requires separate calibrations for pH and ORP. A suggested calibration scenario is as follows:

A. First, Quick-Cal ORP (plus, optionally, other installed Basic sensors). For the procedure, see Section 3, Getting Started.

B. Then, perform a 2- or 3-point Traditional pH calibration as described here.

pH QUICK CAL

The procedure to Quick Cal the pH sensor (a 1-point calibration at pH 7), along with other sensors in the Basic Sensor Set, may be found in Section 3, Getting Started.

To perform a more accurate traditional calibration, follow the procedure below.

TIP: *The pH calibration procedure is the same for pH sensors and pH/ORP sensors.*

TRADITIONAL pH CALIBRATION PROCEDURE

1. With a pH or pH/ORP sensor installed and plugs or sensors in the other ports, rinse the front end of the MP TROLL 9500 in tap water, then again in deionized water. Shake to dry.

   For the most accurate results, follow this with a rinse in a portion of the selected calibration solution.

2. Insure the black PVC base is attached to the Cal Cup, and fill the Cal Cup to the fill line with the selected calibration solution.
   - Begin with the lowest buffer value when performing a multi-point calibration.
   - With a full complement of sensors installed, use the lower line as a guide.
   - With 1 or 2 removable sensors installed, fill to the upper line.

❸

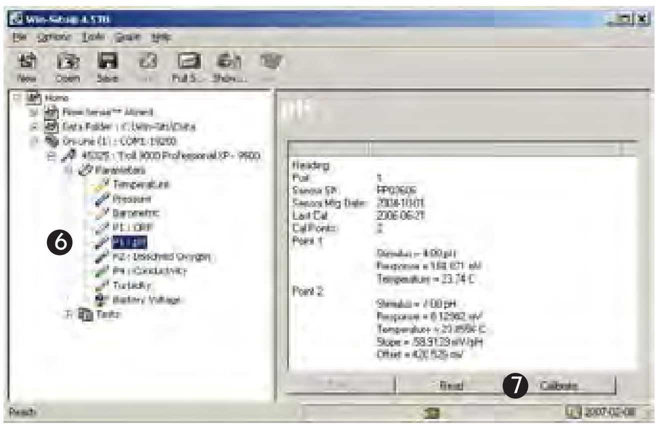
3. Insert the front end of the MP TROLL 9500 into the open end of the Cal Cup. Thread the Cal Cup onto the body until seated against the o-ring, then back off slightly to avoid overtightening.

4. Connect the MP TROLL 9500 to a PC and establish a connection in Win-Situ 4 or Pocket-Situ 4. Win-Situ screens are illustrated here. The Pocket-Situ interface is similar, with the Navigation tree at the top of the screen and the Information pane below it.

5. Select the MP TROLL 9500 in the Navigation tree.

   The software will automatically detect and display the installed sensors. If one or more sensors is installed in the wrong port, an error message will be displayed. Simply remove the sensor and install it in the correct position, then “refresh” the device before continuing.

6. Click to select pH in the Parameters list. The sensor serial number (SN) and recent calibration information is displayed.



7. Select **Calibrate** to launch the pH Calibration Wizard. A screen like this is displayed.

8. Select the number of calibration points for this calibration, and the pH value of the calibration solution for each point. Cal point 1 is the solution the sensor is soaking in now.

9. Select **Next** to continue.

10. In the next screen, select **Run** to begin the stabilization.

    The display will continuously update as readings are taken and compared against the stabilization criteria.

11. If doing a one-point calibration, go to step 14.

    For a multi-point calibration, the Wizard returns to the screen shown at step 10 and waits for you to situate the probe in the next calibration solution and click Run.

Indicators during Calibration

- **Status:**

  NOT TESTED is displayed until you begin the calibration by selecting Run.

  UNSTABLE indicates the sensor response does not meet the criteria for a valid calibration point.

  NOMINAL indicates the sensor deviation meets early stabilization criteria.

  The **Accept** button becomes available when nominal stability is achieved. You may accept the early value, or wait for complete stability. If you accept the early value, the calibration point will be designated “USER SET” in the calibration report. (For more on calibration reports, see “Calibration History” in Section 10.)

  STABLE is displayed when the readings have stabilized sufficiently to take a valid calibration point. The calibration proceeds automatically to the next screen.

- **Sensor Reading:** The current sensor response in milliVolts.

- **Sensor Deviation:** Change in sensor response between the last two readings. This enables you to follow the progress of the stabilization, but deviation from the previous reading is not necessarily the best indicator of stability as the software is looking at longer-term trends.

12. Remove the Cal Cup, discard the first solution, rinse the Cal Cup and the front end of the instrument, refill the Cal Cup with the second solution, and attach it to the instrument.

TIP: *The calibration solution may be flushed down the drain with running water, or saved in a separate container and used to rinse the next time you calibrate with the same solution.*

13. Select **Run** to begin the stabilization for the second calibration point. Status indicators and controls are the same as for the first calibration point (step 10).

    For a 3-point calibration, repeat steps 12 and 13.

14. The final screen shows the sensor slope and offset calculated during calibration. For a 3-point calibration, 2 sets of coefficients will be shown.

"Pivot pH" is the point at which the slope characteristics change with a 3-point (2-range) calibration. The correct slope for the pH values being monitored will automatically be applied.

15. Select **Finish** to program the sensor with the newly calculated calibration coefficients.

TIP: *You can look at the calibration report right after calibrating, or at any time. See "Calibration History" in Section 10 for details.*

Options for storing the sensor:

- If the instrument will be used in a day or so, leave the sensors installed. Remove the Cal Cup and rinse it and the sensors. Add 50-100 mL of tap water to the Cal Cup. Return the probe to the Cal Cup for transport to the field site.
- For longer storage, see Sensor Care and Handling, below.

RESETTING DEFAULT COEFFICIENTS

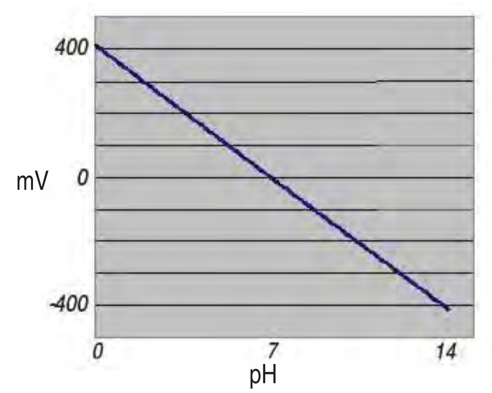
The sensor's calibration may be reset back to factory defaults at any time. As the sensor ages, the coefficients calculated during calibration will deviate more and more from the nominal values, which are derived from new sensors. Default coefficients will give reasonable results when the sensor is relatively new.

1. With a pH or combination pH/ORP sensor installed, establish a connection to the instrument in Win-Situ 4 or Pocket-Situ 4.
2. Select pH in the Parameters list and click **Calibrate**.
3. In the first screen, select Use Nominal Coefficients, then **Next**.
4. In the final screen, click **Finish** to send the values to the sensor.

SENSOR SLOPE AND OFFSET

The pH calibration curve pivots around pH 7 (0 mV response). The offset calculated by the software when calibrating at pH 7 will typically be between 372-450 mV. If the offset falls much outside these limits, replace the filling solution or the junction (see the following page).

The slope should fall between -54 mV/pH and -62 mV/pH. A calculated slope greater than -50 mV/pH or less than -66 mV/pH indicates that the sensor requires maintenance (see the following page).



UNITS AND CALCULATED MEASUREMENTS

Readings from pH channel are displayed in pH units. No calculated measurements are available.

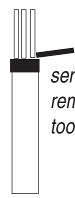
USAGE RECOMMENDATIONS AND CAUTIONS

- Temperature compensation is provided in the software to account for measurements taken at temperatures different from the calibration temperature. For most accurate results, try to calibrate at the same temperature as the expected sample temperature.
- A small error in pH will occur in basic solutions (>pH 10) that contain high levels of sodium salts (>0.01M) due to sodium interference. Contact In-Situ for more information.

- pH readings in pure water samples (<100µS/cm conductivity—also known as "low ionic strength" samples) require up to 20 minutes after calibration to stabilize and begin producing accurate results. You may wish to condition the sensor after calibration in a low conductivity solution.

SENSOR CARE AND HANDLING

SENSOR REMOVAL



sensor removal tool

Position the yoke of the sensor removal tool at the point where the sensor enters the sensor block and pop the sensor out.

MAINTENANCE/INSPECTION/CLEANING

If a film develops on the glass electrode, or if the sensing glass or junction should become dehydrated, the sensor response may be sluggish or erratic, or the sensor may fail to calibrate. In these cases, rinse the sensor in 90% isopropyl alcohol, then soak it in storage solution (Catalog No. 0065370) for at least an hour, or overnight if needed. If this does not restore the response, try soaking in 0.1 M HCl solution for 5-10 minutes, followed by a thorough rinse in clean water. If the response has still not improved, replace the filling solution, or possibly the junction.

Note: The following maintenance instructions apply to In-Situ's newest pH sensor (cat. no. 0059510). Older sensors (cat. no. 0032000, now discontinued) are not user-serviceable.

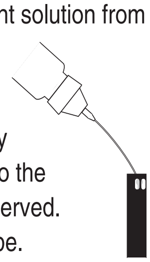
REPLACING THE FILLING SOLUTION

Replace the filling solution every five to six months, or when:

- The sensor fails to calibrate with reasonable slope and offset
- Readings drift
- Readings during calibration at pH 7 are outside the range 0±20 mV

1. Unscrew the reference junction as shown.

2. Holding the sensor at an angle, shake out the filling solution.
3. Protect the connector end of the sensor with the soft cap it shipped with, or wrap the sensor in a paper towel to prevent solution from entering the electrical connector.
4. Using the dispenser cap on the filling solution bottle, insert the tube into the **bottom** of the empty reservoir. Squeeze a steady stream of solution into the reservoir until it overflows and no bubbles are observed. Continue to add solution while withdrawing the tube.



5. Screw in the reference junction, and hand-tighten until snug. Some filling solution will overflow. Wipe the excess off the sensor body.
6. Soak the sensor in tap water for at least 15 minutes.
7. Recalibrate the sensor.

If necessary, thoroughly clean the electrical connector to remove filling solution: Using a disposable pipette, fill the connector with isopropyl alcohol (70% to 100%). Shake to dry. Repeat 3 times. Dry overnight. When thoroughly dry, recalibrate.

REPLACING THE JUNCTION

Replace the junction when the sensor fails to calibrate, even after replacing the filling solution.

1. Unscrew the reference junction and discard.

2. Replace the solution and screw in a new junction as above.
3. Soak for 15 minutes in tap water, then recalibrate the sensor.

TIP: *Keep the junction damp at all times to avoid a lengthy rewetting process.*

STORAGE

Short-Term Storage (several days)

Store in the Cal Cup in tap water.

Long-Term Storage (several weeks)

Remove the sensor and store it in the electrode storage bottle with 10-20 mL of storage solution (Catalog No. 0065370). Tighten the cap to prevent drying. Prior to use, condition the sensor by rinsing with deionized or tap water and soaking for 15 minutes.

REFERENCES

Eaton, A.D., L.S. Clesceri, E.W. Rice, and A.E. Greenberg, eds., *Standard Methods for the Examination of Water and Wastewater,* 21st edition, Washington, D.C.: American Public Health Association, American Water Works Association, and Water Environment Federation, 2005. Section 4500 H^+, pH Value.

EPA, Methods for Chemical Analysis of Water and Wastes, EPA/600/4-79-020, revised March 1983. Method 150.1, pH, Electrometric; Method 150.2, pH, Electrometric (Continuous Monitoring). Both approved at 40 CFR Parts 136 and 141.

12 CONDUCTIVITY

WHAT IS CONDUCTIVITY?

Electrical conductivity measures the ability of a material to carry an electric current. Lakes, rivers, oceans, and underground aquifers are typically good conductors because they contain dissolved salts and minerals. These salts and minerals dissociate in the presence of water to form negatively and positively charged particles called anions and cations. Anions and cations provide a pathway for the transportation of electrical charges throughout the aqueous medium. For the most part, the higher the concentration of dissolved salts and minerals in water, the better the conductor and the higher the electrical conductivity. Deionized/distilled water is a poor conductor because almost all anions and cations are removed during the deionization/distillation process.

WHY MEASURE CONDUCTIVITY?

Changes in the conductivity of a body of water are often used to indicate an environmental event. For example, a drastic increase in the electrical conductivity of an underground fresh water aquifer located near the ocean could indicate the beginning of salt water intrusion. On the other hand, an increase in the electrical conductivity of a small lake that is completely surrounded by farmland may simply be the result of runoff from a recent rain.

HOW IS CONDUCTIVITY MEASURED?

Conductance is the reciprocal of the resistance, in ohms, measured between two opposing electrodes of a 1 cm cube at a specific temperature. The unit 1/ohm or mho was given the name of Siemens (S) for conductance. It is not practical to require all conductance cells to have the dimensions of an exact cube. To enable the comparison of data from experiments with different conductance cells, the conductance is multiplied by the cell constant to give *conductivity* in Siemens per centimeter (S/cm). Cell constants are determined for each sensor using a standard solution of known conductivity. The cell constant depends on the electrode area and the amount of separation or distance between the electrodes.

Typical Conductivity values

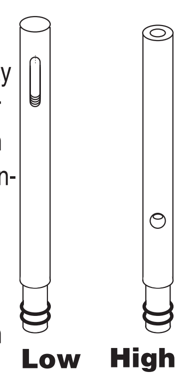
Ultra-pure distilled water	0.05 µS/cm
Distilled water	1.0 µS/cm
Drinking water	50 to 300 µS/cm
Surface water	100 to 10,000 µS/cm
Sea water	40,000 to 55,000 µS/cm
Great Salt Lake	158,000 µS/cm

Early conductivity measurements were performed using cells with two electrodes. This method required using three conductivity cells with different cell constants in order to span the range of 1 to 100,000 microSiemens per centimeter (µS/cm). Another inconvenience occurred when deposits formed on the electrodes, thus reducing the measured conductivity of the sample.

The modern four-electrode conductivity cell offers many advantages over the two-electrode method. It contains two drive electrodes and two sensing electrodes. The sensing electrodes are positioned in a low current area so that electrode fouling is minimized. An alternating current is used to drive the cell. This reduces errors caused by polarization resulting from the application of a direct current.

THE CONDUCTIVITY SENSORS

Two conductivity sensors are available, optimized for performance in different areas of the conductivity range. Chemically resistant electrodes are used for lower reactivity in high conducting samples (carbon electrodes in the low-range sensor, passivated stainless steel electrodes in the high-range sensor).



The conductivity sensors are shorter than the other water quality sensors in order to distance the conductivity cell from the KCl reference solutions in other sensors.

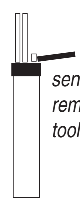
Type	Operating Range	Cell Constant Range
Low	3 to 50,000 µS/cm	0.33 – 0.39 cm^{-1}
High	70 to 200,000 µS/cm	4.4 – 5.8 cm^{-1}

SENSOR INSTALLATION

The MP TROLL 9500 may be shipped with a conductivity sensor already installed in port 4, as shown on the drawing below. If installation is necessary, unpack and install the conductivity sensor in port 4 as follows.

*The conductivity sensor will function properly only when installed in **port 4**.*

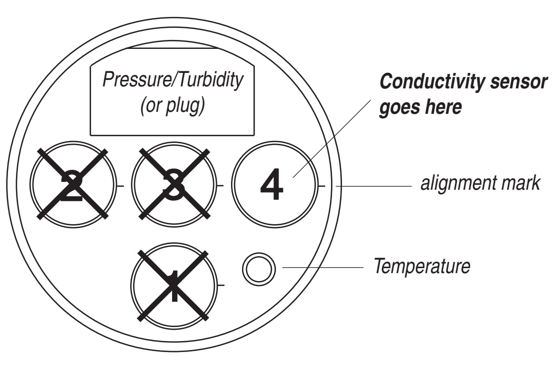
1. Remove the restrictor from the front end of the MP TROLL 9500. This allows access to the sensor block shown in the drawing below.
2. If there is a cap on the connector end of the sensor, remove it and set it aside for future use.
3. Remove any moisture or dirt from the area around port 4, then use the sensor removal tool to remove the plug from the port. Retain the plug for future use.



4. Remove any moisture or dirt from the port connector with a clean swab or tissue.
5. Check lubrication of the sensor o-rings.

***TIP:** The sensor o-rings require generous lubrication before installation. New sensors will be lubricated at the factory. If the o-rings appear dry, apply a silicone lubricant before installation.*

6. Align the mark on the side of the sensor with the mark on the port.
7. Firmly press the sensor into the port until you feel it dock with the connector at the bottom of the port. When properly inserted a small gap (width of the sensor removal tool) remains between the widest part of the sensor and the instrument body, for ease of removal.



CALIBRATION

OVERVIEW

The conductivity calibration calculates the cell constant for the conductivity sensor. A one-point calibration is sufficient. Best results will be obtained if you calibrate with the solution for the range you expect to measure, and at the temperature you expect during field use.

Nominal vs. Stable

To shorten the calibration time, you have the option to accept the calibration when “Nominal” stability conditions are achieved. If the early value is accepted, the calibration point will be designated “USER SET” in the calibration report. If the calibration report indicates that calibration was performed through to stability then the instrument will operate as intended by In-Situ’s quality standards.

CALIBRATION SOLUTIONS (PRIMARY STANDARDS)

Potassium chloride (KCl) calibration solutions certified to N.I.S.T. standards are supplied in the In-Situ Conductivity Calibration Kits. The value on the bottle indicates the solution’s specific conductance (conductivity at 25°C). Select an appropriate solution for your application from the following:

Fresh water	147 µS/cm solution
Fresh to brackish water	1,413 µS/cm solution
Brackish water	12,890 µS/cm solution
Sea water	58,670 µS/cm solution

The standard conductivity calibration kit includes a quart each of 147 µS/cm, 1,413 µS/cm, 12,890 µS/cm and deionized water. Catalog No. 0032090. Solutions are available separately, and specialized kits are available for fresh and salt water applications.

***TIP:** Most solutions are usable beyond their stated expiration date, depending on storage conditions; however, the results cannot be guaranteed. The 147 µS/cm solution should be refrigerated.*

Calibrating with Other Solutions

A custom solution may be used if its specific conductance value (in µS/cm) at 25°C is known. Calibration to secondary standards may also be performed. This involves a manual calculation of the cell constant. See the procedure later in this section.

RECOMMENDED CALIBRATION FREQUENCY

Your own experience is the best guide to how often the conductivity sensor will benefit from recalibration. Refer to the general guidelines under “How Often to Calibrate” in Section 10, and to the tech note on “Instrument Calibration.”

CONDUCTIVITY QUICK CAL

The procedure to Quick Cal the conductivity sensor (a 1-point calibration at approximately 8,000 µS/cm), along with other sensors in the Basic Sensor Set, may be found in Section 3, Getting Started. To perform a more accurate calibration for a specific conductivity range, follow the procedure below.

TRADITIONAL CONDUCTIVITY CALIBRATION PROCEDURE

1. With a conductivity sensor installed and plugs or sensors in the other sensor ports, rinse the front end of the MP TROLL 9500.

   To calibrate using a medium- to high-range solution, rinse in tap water and shake to dry.

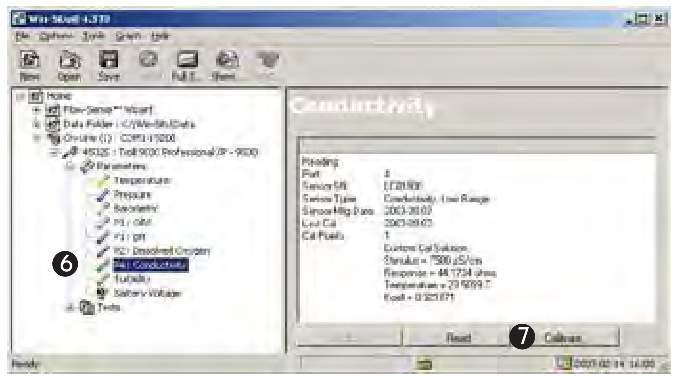
   To calibrate using a low-range solution, it is important to rinse well; we recommend a rinse with tap water, then with deionized water, followed by a rinse with the solution to be used for calibration.

   ***TIP:** For highest accuracy, conductivity sensors should be wetted for 15-30 minutes immediately prior to calibration. This immersion can be in either clean water or the conductivity calibration solution.*

2. Insure the black PVC base is attached to the Cal Cup, and fill the Cal Cup with the selected calibration solution.
   - Low-range sensor: Fill to the lower or upper line depending on the number of sensors installed (fewer sensors require more solution).
   - High-range sensor: Fill to or above the upper line, depending on the sensor load. You need enough solution to immerse the sensor's side ports.

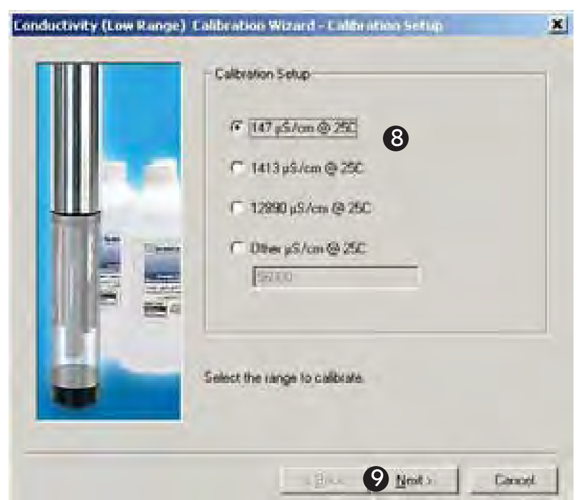
3. Insert the front end of the MP TROLL 9500 into the open end of the Cal Cup. Thread the Cal Cup onto the body until seated against the o-ring, then back off slightly to avoid overtightening.
   - Low-range sensor: the open area of the sensor should be completely immersed.
   - High-range sensor: the side openings should be completely immersed.
   - The temperature sensor should be immersed in about an inch of liquid.
   - If any air bubbles are visible on the sensor, tap the sides or bottom of the Cal Cup to dislodge them. Or invert the Cal Cup a couple of times.
4. Connect the MP TROLL 9500 to a PC and establish a connection in Win-Situ 4 or Pocket-Situ 4. Win-Situ screens are illustrated here. The Pocket-Situ interface is similar, with the Navigation tree at the top of the screen and the Information pane below it.
5. Select the MP TROLL 9500 in the Navigation tree.

   The software will detect and display the installed sensors. If any sensor is installed in the wrong port, an error message will be displayed. Simply remove the sensor and install it in the correct position, then "refresh" the device before continuing.
6. Select conductivity in the Parameters list. The sensor serial number (SN), type, and recent calibration information is shown.



7. Select **Calibrate**.

   The Conductivity Calibration Wizard starts. Available calibration ranges will depend on the sensor installed (high or low range)



8. Select the calibration solution the sensor is soaking in.

   For a custom solution, select **Other** and enter the Specific Conductance of the solution (conductivity corrected to 25°C) in µS/cm.
9. Select **Next** to continue.

10. In the next screen, select **Run** to begin the stabilization.

The display will continuously update as readings are taken and compared against the stabilization criteria.

- Status indicators:

  NOT TESTED is displayed until you begin the calibration by selecting Run.

  UNSTABLE indicates the sensor response does not meet the criteria for a valid calibration point.

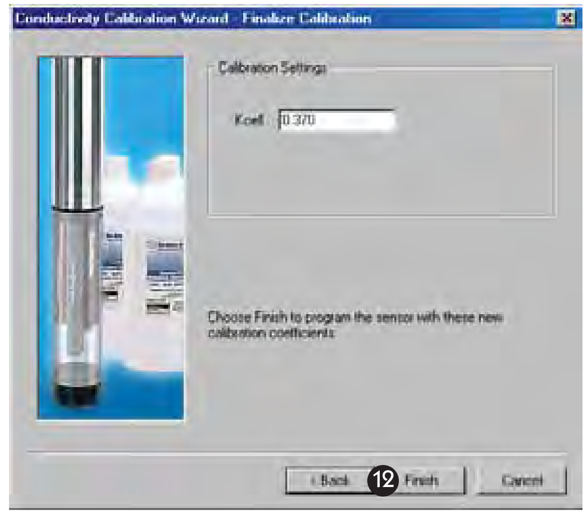
  NOMINAL indicates the sensor deviation meets early stabilization criteria.

  The **Accept** button becomes available when nominal stability is achieved. You may accept the early value, or wait for complete stability. If you accept the early value, the calibration point will be designated “USER SET” in the calibration report. (For more on calibration reports, see “Calibration History” in Section 10.)

  STABLE is displayed when the readings have stabilized sufficiently to take a valid calibration point. The calibration proceeds automatically to the next screen.

- Temperature at the time of calibration is displayed for your information.
- Sensor Reading: The current sensor response in ohms.
- Sensor Deviation: Change in sensor response between the last two readings. This enables you to follow the progress of the stabilization, but deviation from the previous reading is not necessarily the best indicator of stability as the software is looking at longer-term trends.

11. The final screen shows the new cell constant (Kcell) calculated for the selected range during the calibration process.



Typical cell constants:

Low-range sensor	0.32 – 0.39
High-range sensor	4.4 – 5.8

The displayed cell constant may be edited.

12. Select **Finish** to program the sensor with the displayed cell constant.

> ***TIP:*** *You can look at the calibration report right after calibrating, or at any time. See “Calibration History” in Section 10 for details.*

The conductivity sensor is now calibrated and ready to use in the range for which it was calibrated.

> ***TIP:*** *The calibration solution may be flushed down the drain with running water, or saved in a separate container and used to rinse the sensors the next time you calibrate with the same solution.*

Options for storing sensors:

- If the instrument will be used in a day or so, leave all the sensors installed in the MP TROLL 9500. The conductivity sensor does not require any special storage conditions, but other sensors do. Refer to the relevant sections of this manual for storage recommendations for other installed sensors.
- Remove the conductivity sensor from the MP TROLL 9500, rinse it, and store it dry.

USING A CONDUCTIVITY METER AS A SECONDARY STANDARD

If a conductivity meter is available for comparison, the cell constant (Kcell) for the conductivity sensor can be calculated by hand and entered manually into the software.

1. Note the current cell constant. Immerse the MP TROLL with conductivity sensor in a solution. Take and record the reading.
2. Take and record a reading in the same solution with a conductivity meter.
3. Solve the following for X:

$$\frac{\text{Current Kcell}}{\text{Reading with this Kcell}} = \frac{X}{\text{Conductivity meter reading}}$$

4. This is the new cell constant. Enter this value in the software as described below.

ENTERING A CELL CONSTANT MANUALLY

A cell constant may be entered “manually” without running a complete calibration.

1. With a conductivity sensor installed, establish a connection to the instrument in Win-Situ 4 or Pocket-Situ 4.
2. Select Conductivity in the Parameters list and click **Calibrate**.
3. Select Other, and key in any reasonable value. Press **Next** twice to get to the final screen.
4. In the final screen, key in the desired cell constant.
5. Click **Finish** to send the new value to the sensor.

UNITS AND CALCULATED MEASUREMENTS

Basic Unit: AC

Absolute (or “actual”) conductivity, without temperature compensation, is the basic unit for the conductivity sensor. Measurements may be displayed in:

microSiemens per centimeter (µS/cm AC)
milliSiemens per centimeter (mS/cm AC)

The following units are also available for displaying derived measurements calculated from the conductivity channel output:

TIP: *To change unit preferences: In Win-Situ, select Preferences on the Options menu. In Pocket-Situ, select the Home site, then tap Setup in the command bar.*

TIP: *Since the specific ionic composition of all analytes cannot be known, the conversions provided in the software are reasonably good estimates of Specific Conductance and Total Dissolved Solids. The resulting derived values should be treated with caution.*

Specific Conductance (SC)

Specific Conductance is conductivity corrected to 25°C. The software estimates what the conductivity would be at 25°C to enable comparison between measurements made at different temperatures.

The conversion requires a temperature coefficient for the solution being measured. By convention, the temperature coefficient for potassium chloride (KCl) calibration standards is used. Specific conductance is calculated from:

$$SC = \frac{AC}{[1 + 0.0191 * (Temp. - 25.0)]}$$

where

AC is the actual conductivity in µS/cm
0.0191 is a nominal temperature coefficient for KCl solutions
Temp. is the solution temperature in degrees C.

The correction factor of 0.0191 (1.91% / °C) for KCl solutions is a reasonable approximation for samples containing sodium and chloride salts (i.e., seawater). For comparison, the table below lists correction factors for other solution types.

Solution	Correction factor (%/°C)
5% H_2SO_4	0.96
10% HCl	1.32
5% NaOH	1.7
Dilute NH_3	1.88
KCl salt (default)	1.91
NaCl salt	2.12
98% H_2SO_4	2.84
Ultrapure water	4.55
Sugar solution	5.64

Units: microSiemens per centimeter (µS/cm SC)

Total Dissolved Solids (TDS)

A factor of 0.65 x specific conductance is used to estimate Total Dissolved Solids (TDS). This was chosen for general applicability. Remember that ions in solution will vary, and this general conversion factor will not fit all situations exactly. Units: mg/L

Resistivity

The reciprocal of conductance is resistance. Resistivity is the resistance times the cell constant. Resistivity is useful when monitoring pure water. Units: Kohms cm

Salinity

Calculated from conductivity and temperature using the Practical Salinity Scale adjusted for low salinities. Units: PSU (Practical Salinity Units)

The original Practical Salinity Scale (1978) was considered valid for a range of 2-42 PSU; “standard seawater” is defined as having a value of exactly 35. In 1986, there was an adjustment to the scale for better accuracy with low salinities. That adjusted scale is considered valid for a range of 0-40 PSU. Above 2 PSU there is no significant difference between the two scales. “Fresh” water would typically have values below 1, and typically very close to 0.

USAGE RECOMMENDATIONS AND CAUTIONS

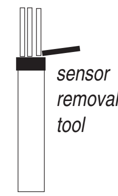
CONDUCTIVITY AND TEMPERATURE

Conductivity is a function of temperature. According to the EPA, temperature variations and corrections represent the largest source of potential error in conductivity measurements. A 0.1°C change in temperature can cause a 0.2% change in conductivity.

Specific conductance is the conductivity of a substance at 25°C, and measurements are usually standardized to 25°C when it is necessary to compare data. When the temperature of a sample and its conductivity at that temperature are known, the software can extrapolate the conductivity to 25°C.

SENSOR CARE AND HANDLING

SENSOR REMOVAL



Position the yoke of the sensor removal tool at the point where the sensor enters the sensor block and pry the sensor upward.

MAINTENANCE/INSPECTION/CLEANING

Check the sensor for fouling of the electrodes. If necessary, flush the sensor with water, or swish in a mild detergent solution and rinse with tap water. A swab or soft-bristle brush may be gently used to clean the electrodes. Remember that the electrodes are made of graphite, which is soft and easily damaged.

STORAGE

Store the sensor dry.

REFERENCES

Eaton, A.D., L.S. Clesceri, E.W. Rice, and A.E. Greenberg, eds., *Standard Methods for the Examination of Water and Wastewater,* 21st edition, Washington, D.C.: American Public Health Association, American Water Works Association, and Water Environment Federation, 2005. Section 2510, Conductivity. Section 2520 B, Salinity - Electrical Conductivity Method.

EPA, Methods for Chemical Analysis of Water and Wastes, EPA/600/4-79-020, revised March 1983. Method 120.1, Conductance, Specific Conductance. Approved at 40 CFR Part 136.

The International Association for Physical Science of the Ocean (IAPSO) Standard Seawater manufactured by Ocean Scientific International is available in North America from Guildline Instruments Inc. in Lake Mary, Florida.

13 DISSOLVED OXYGEN

WHAT IS DISSOLVED OXYGEN?

The amount of dissolved oxygen (D.O.) in both natural water and wastewater is a function of several parameters. D.O. is highly dependent on temperature and atmospheric pressure. An increase in temperature causes a decrease in the amount of oxygen that can dissolve in water. On the other hand, higher atmospheric pressures result in higher D.O. values. Salinity is also a factor. Oxygen solubility is greater in freshwater than in saltwater. There are also chemical and biochemical processes that affect D.O.

Most of the dissolved oxygen in water comes from the atmosphere, but oxygen from the photosynthesis of aquatic plants is also a key source. D.O. levels in lakes and other surface water will actually follow a cyclic or diurnal pattern over the course of a day, rising and falling as light intensity changes from dawn to dusk.

WHY MEASURE DISSOLVED OXYGEN?

Most aquatic life requires an average D.O. value greater than 5.0 milligrams dissolved oxygen per liter of water (mg/L) in order to survive. Although the amount of dissolved oxygen in a body of water fluctuates due to natural processes, large deviations from the norm are usually a result of human activity. Changes in D.O. levels are usually the result of a buildup in organic waste. Organic waste can enter surface water from sewage treatment facilities, runoff from agricultural feed lots or domestic areas and from industrial discharge. Organic wastes often contain nitrates and phosphates. Nitrates and phosphates are nutrients for aquatic plants and algae, stimulating overproduction when present in excessive levels. Accelerated growth of blooms increase the number of photosynthesizing plants, which temporarily increases the amount of dissolved oxygen. However submerged aquatic vegetation eventually experience a reduction in sunlight due to increased coverage on the surface. This decrease in sunlight leads to a reduction in photosynthesis and eventual death. Bacterial processes take over and consume even more dissolved oxygen. Fish and other aquatic species die due to lack of dissolved oxygen. This tragic process is known as eutrophication.

Typical D.O. values

100% DO, 0°C, 1 atm, 0 ppm Chlorine*	14.6 mg/L
100% DO, 20°C, 1 atm, 0 ppm Chlorine	9.09 mg/L
100% DO, 0°C, 0.75 atm, 0 ppm Chlorine	6.77 mg/L
100% DO, 20°C, 1 atm, 20 ppm Chlorine	7.35 mg/L
Safe level for most aquatic life	> 5.0 mg/L

** representative of solute concentration*

POLAROGRAPHIC MEASUREMENT OF DISSOLVED OXYGEN

THE POLAROGRAPHIC DISSOLVED OXYGEN SENSOR

THEORY OF OPERATION

The sensor is a Clark-type polarographic sensor consisting of two metallic electrodes in contact with an electrolyte and separated from the measurement water by a polymeric membrane. Dissolved oxygen and other gases diffuse through the membrane into the electrolyte. An electric potential is applied to the electrodes, which causes an electrochemical reaction. Oxygen is reduced at the cathode:

$$O_2 + 2H_2O + 4e^- \Rightarrow 4(OH)^-$$

while silver is oxidized at the anode:

$$4Ag + 4Cl^- \Rightarrow 4AgCl + 4e^-$$

The resulting current is proportional to the oxygen crossing the membrane. The electric potential is carefully selected so that only the dissolved oxygen is reduced.

The concentration of dissolved oxygen is usually reported in milligrams of oxygen per liter of water (mg/L), but the sensor actually measures the partial pressure of dissolved oxygen. Other gases such as nitrogen, carbon dioxide, and water vapor are also dissolved in the water. The partial pressure of the oxygen is the fraction of the oxygen multiplied by the total pressure of all the gases. This value is also a function of water temperature and water salinity. The maximum amount of oxygen that can be dissolved in water at a given atmospheric pressure, water temperature, and salinity (100% D.O.) can be calculated from first principles. D.O. measurements taken in the field are then compared to the 100% D.O. value. D.O. measurements of surface water are typically less than the 100% D.O. value due to the presence of biological and chemical processes that consume oxygen. Field measurements are corrected for changes in temperature, air pressure, and salinity.

During the electrochemical process dissolved oxygen is consumed while silver chloride (AgCl) is deposited on the anode. In time, both processes will adversely affect the stability and accuracy of the D.O. measurements. Depletion of oxygen near the membrane will cause readings to decrease when measuring D.O. in stagnant water. The use of a stirrer, or similar mechanism to increase water movement, alleviates this problem.

SENSOR CONDITIONING

As soon as the software "recognizes" and displays the D.O. sensor in port 2, powering of the D.O. channel begins. A low-level current is applied continuously to the D.O. circuitry, resulting in continuous polarization. This is similar to laboratory instruments for measuring dissolved oxygen, which are always "on." A certain amount of conditioning or "warm-up" time is necessary for the sensor to return accurate readings during calibration and use.

Before calibrating a new D.O. sensor, or a sensor with a new membrane, we recommend that you allow a minimum of two hours for conditioning. For stable long-term performance and faster stability during calibration, we recommend 10 hours of conditioning. If the D.O. sensor is installed when you receive the instrument, it will be conditioned and ready to calibrate. If you remove the sensor, be sure to allow for another period of conditioning before you calibrate.

TIP: *Testing has shown that 10 hours of conditioning yields very stable long-term performance.*

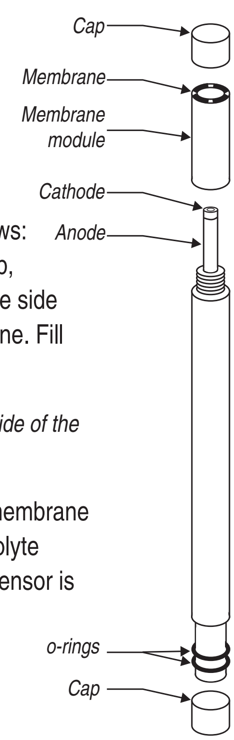
SENSOR INSTALLATION

The MP TROLL 9500 may be shipped with a polarographic D.O. sensor installed in port 2. When the sensor is shipped in the instrument, it is pre-conditioned and ready for calibration.

If installation is necessary, unpack, fill, install, and condition a polarographic D.O. sensor as follows.

FILL THE MEMBRANE MODULE

New sensors are shipped with a dry membrane module loosely attached.



1. Remove the soft protective caps from the membrane end and the connector end of the sensor.
2. Remove the membrane module from the sensor body and fill with electrolyte as follows: Holding the membrane module open-end up, position the electrolyte dispenser against the side of the module without touching the membrane. Fill slowly.

TIP: *To eliminate air bubbles, tap the side of the module briskly with your fingernail.*

3. Insert the sensor into the open end of the membrane module. To minimize air, some of the electrolyte should overflow from the open end as the sensor is inserted.

4. Thread the membrane module to the D.O. sensor.

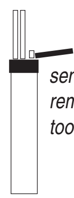
Be sure the membrane does not leak. You should not see any drops on the surface. There should be no visible air bubbles.

5. Install and condition the sensor as described below. Then you're ready to calibrate.

INSTALL THE SENSOR IN THE MP TROLL 9500

*The polarographic D.O. sensor will function properly only when installed in **port 2**.*

1. Remove the restrictor or Cal Cup from the front end of the MP TROLL 9500. This allows access to the sensor block shown in the drawing below.
2. Remove any moisture or dirt from the area around port 2, then use the sensor removal tool to remove the plug or sensor from port 2. Retain the plug for future use.



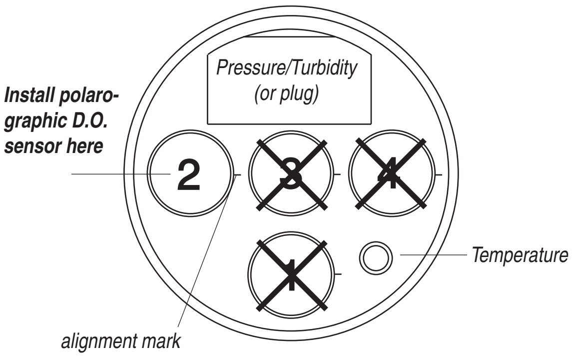
3. Remove any moisture or dirt from the port connector with a clean swab or tissue.
4. Check lubrication of the sensor o-rings.

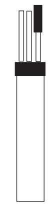
***TIP:** The sensor o-rings require generous lubrication before installation. New sensors will be lubricated at the factory. If the o-rings appear dry, apply a silicone lubricant before installation.*

5. Handling the sensor by the sides, not the tip, align the mark on the side of the sensor with the mark on the port.

Avoid touching the membrane at the tip of the sensor. Contaminants on the membrane can change its properties and affect measurements.

6. Use the sensor insertion tool to press the sensor into the port until you feel it dock with the connector at the bottom. When properly inserted a small gap (width of the sensor removal tool) remains between the widest part of the sensor and the instrument body, for ease of removal.





7. Turn the sensor "on" and condition it, as described next.

CONDITION A NEWLY INSTALLED SENSOR

Condition a new sensor, or one with a new membrane, as follows:

1. Fill and install the sensor as described above.
2. Connect the MP TROLL 9500 to a PC and establish a connection in Win-Situ 4 or Pocket-Situ 4.
3. Select the MP TROLL 9500 in the Navigation tree. All installed sensors will be displayed.

   Powering of the D.O. sensor begins as soon as the software recognizes the D.O. sensor and displays it in the Navigation tree. This starts the conditioning process.

***TIP:** If you plan to calibrate 100% D.O. in air, condition the sensor in a moist environment at ambient pressure—the loosely attached Cal Cup with a small amount of clean water is ideal.*

If you will be calibrating 100% D.O. in water, condition the sensor dry.

We recommend that you allow the sensor to condition for 2-10 hours before calibrating. Testing has shown that 10 hours of conditioning yields very stable long-term performance.

***TIP:** It is not necessary to maintain the computer connection; conditioning continues as long as the sensor is installed.*

CALIBRATION

OVERVIEW

Several options are available for calibrating a polarographic sensor.

- **Quick Cal:** Calibrates all Basic sensors (pH, ORP, polarographic D.O., conductivity) at the same time with one convenient solution. This is a 1-point 100% D.O. calibration in air at ambient pressure.
- **Traditional calibration–1 point:** 100% D.O. may be calibrated either in air (saturated with water) at ambient pressure, or in water (saturated with air—for example, using a bubbler). The water method is generally more accurate, as it better represents actual field D.O. measurement conditions.
- **Traditional calibration–2 point:** 100% D.O. may be calibrated either in air or in water. 0% D.O. is calibrated in an oxygen-

depleted solution such as sodium sulfite or nitrogen-saturated water. A 2-point calibration is recommended

- when you expect to measure very low D.O. values (< 5 mg/L),
- when required by Standard Operating Procedures.

Nominal vs. Stable

To shorten the calibration time, you have the option to accept the calibration when "Nominal" stability is achieved. If the early value is accepted, the calibration point will be designated "USER SET" in the calibration report. If the calibration report indicates that calibration was performed through to stability then the instrument will operate as intended by In-Situ's quality standards.

CALIBRATION SOLUTIONS & EQUIPMENT

100% D.O. calibrations may be performed in water saturated with air, or in air saturated with water. Deionized water is available from In-Situ Inc., but any clean water may be used. In-Situ's bubbler calibration kit is designed for an efficient water calibration.

An oxygen-depleted solution is used to calibrate the 0% D.O. Sodium sulfite is available from In-Situ Inc. For a cleaner calibration, nitrogen-saturated water may be used.

RECOMMENDED CALIBRATION FREQUENCY

Your own experience is the best guide to how often the polarographic D.O. sensor will benefit from recalibration under conditions of normal usage. Refer to the general guidelines under "How Often to Calibrate" in Section 10, and the tech note on "Instrument Calibration."

Until a new polarographic sensor has been thoroughly conditioned, it may require more frequent calibration. In the absence of other indications, a calibration should be performed every 2-4 weeks.

In addition, the polarographic D.O. sensor should be conditioned for 2-4 hours and recalibrated in the following circumstances:

- after cleaning the sensor,
- after replacing the membrane module,
- when taking measurements at an elevation different from that at which the sensor was last calibrated.

> **Q:** ***I did a Quick Cal. Why should I recalibrate D.O.?***
>
> **A:** *The D.O. Quick Cal, especially if done through to stability, can provide accurate measurement results. However, some procedures require a look-up table for the stimulus at a given temperature and pressure. This can be done in the traditional D.O. calibration. Also, better measurement results will be obtained when the 100% calibration is done in water saturated with air. This procedure is not provided for in Quick Cal. In addition, the traditional calibration provides for a 0% (0 ppm, 0 mg/L) calibration, which is recommended when measuring very low D.O. values.*

DISSOLVED OXYGEN CALIBRATION TIPS

The following discussion may help you to obtain the best results from the polarographic D.O. calibration.

- **Air or Water?** The software provides two options for conducting a 100% D.O. calibration:
  - **in air** (saturated with water). This is the condition during a Quick Cal in the inverted Cal Cup with the sensor membrane exposed to air, temperature sensor submerged, and Cal Cup vented to the atmosphere.
  - **in water** (saturated with air). In-Situ's bubbler calibration kit provides everything needed to create a vigorous bubbling action to insure air-saturated water. The Cal Cup is not used.

  Since dissolved oxygen measurements are typically made in water, calibrating in water will often yield better results. When calibrated in air, the membrane's behavior in water must be estimated.

- The D.O. calibration procedure is very sensitive to changes in temperature. Ideally, it should be done in an area protected from direct sunlight and away from ventilation ducts.
- The nature of the sensor membrane influences the response. Be sure to note the membrane thickness before starting the calibration. (If no thickness is indicated, the membrane is 1-mil Teflon.) Membrane thickness is more important with a 100% calibration in air.

DISSOLVED OXYGEN QUICK CAL

The procedure to Quick Cal the polarographic D.O. sensor, along with other Basic sensors, is in Section 3, Getting Started. This is a single-point 100% calibration in air (saturated with water).

The following traditional calibration is recommended for use when

- the user is required to enter a specific stimulus at the calibration temperature and pressure,
- calibration in water is preferred,
- a 0% calibration point is needed.

TRADITIONAL DISSOLVED OXYGEN CALIBRATION PROCEDURE

You may select a 1-point or a 2-point calibration. The first point (100% saturation) may be taken in air or in water.

Prepare the MP TROLL 9500 for water or air calibration as described in Steps 1-6 on the following page.

Preparation for 100% D.O. Calibration in Water

The bubbler cal kit for the Polarographic D.O. sensor comes with (1) Battery-powered air pump and 2 alkaline D-cells, (2) Bubbler cup with aquarium stone, tubing, check valve and pinch valve, (3) Grey PVC adapter to support the TROLL 9500 in the top of the bubbler cup.

1. Install the batteries in the portable air pump as shown in the diagram on the inside of the lid.
2. Fill the bubbler container almost to the top with clean water. The optimum amount depends on the volume of the sensors installed in the MP TROLL 9500.

   TIP: *Tap water is fine, unless it is high in salinity. It is easier to achieve 100% oxygen saturation in low-salinity water. Distilled water is readily available and works well.*

3. About 10 minutes before calibration, turn on the bubbler. Regulate bubbling with the pinch valve. For best results, run at the full flow rate to achieve saturation; after 10 minutes you can use the control valve to match the water turbulence conditions expected in the field.
4. Before beginning the calibration procedure, note the membrane thickness stamped on the membrane module.
5. With the D.O. sensor installed and plugs or sensors in the other sensor ports, rinse the front end of the MP TROLL 9500 thoroughly in clean water to remove contaminants and traces of fluids used for earlier calibrations.
6. When ready to calibrate, place the adapter securely in the top of the bubbler housing and insert the front (sensor) end of the MP TROLL 9500 into the adapter.
   - Insure the D.O. sensor is not in the aeration path. Rotate as necessary to prevent air bubbles from collecting on the membrane surface.
   - Insure the temperature sensor is submerged at least 0.5” (12 mm) in the aerated water.

Allow a few minutes for the temperature to stabilize, especially if you plan to enter a temperature dependent value from a look-up table.

Preparation for 100% D.O. Calibration in Air

TIP: *Before beginning the calibration procedure, check the side of the membrane module for the membrane thickness.*

1. With the D.O. sensor installed and plugs or sensors in the other sensor ports, rinse the front end of the MP TROLL 9500 thoroughly in clean water to remove contaminants and traces of fluids used for earlier calibrations.
2. Dry the D.O. sensor membrane by shaking the probe and/or gently wiping with a soft swab or the corner of a tissue.
3. Rinse the empty Cal Cup and attach it to the MP TROLL 9500. Thread the Cal Cup onto the body until it is seated against the o-ring, then back off slightly to avoid overtightening.
4. Invert the TROLL with Cal Cup attached and remove the black end cap from the Cal Cup.
5. Gently fill the Cal Cup with clean water until the temperature sensor is completely covered and the membrane at the tip of the D.O. sensor is in air. If any water splashes onto the membrane, ***gently*** blot the center of the membrane with a clean cotton swab or the corner of a soft lint-free tissue.
6. Loosely attach the end cap to the Cal Cup. For proper venting, a small hole in the threads of the cap should be at least partly visible to achieve ambient pressure conditions.

   You may wish to use a clamp or other support to maintain the TROLL 9500 in this inverted position.

Allow a few minutes for the temperature to stabilize, especially if you plan to enter a temperature dependent value from a look-up table.

7. If not already connected, connect the MP TROLL 9500 to a PC, launch the software, and "find" the device. Win-Situ screens are illustrated here. The Pocket-Situ interface is similar, with the Navigation tree at the top and the Information pane below it.

8. Select the MP TROLL 9500 in the Navigation tree.

   The software will automatically detect and display the installed sensors.

9. Select Dissolved Oxygen in the Parameters list.

   The sensor serial number (SN) and recent calibration information is displayed, as shown in the screen below.

10. Select **Calibrate**.

11. Before the DO Calibration Wizard starts, you will be asked how you want to handle barometric pressure. See the box below.

After dealing with barometric pressure the D.O. Calibration Wizard displays a screen like the one below:

12. Select the number of calibration points.
    1 point—100% D.O.
    2 points—100% and 0% D.O.

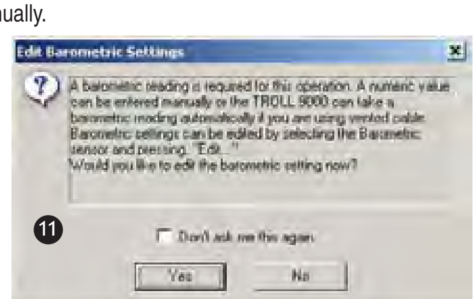
13. Select the membrane type (stamped on membrane module, if not, it's 1-mil Teflon). If calibrating in water, the membrane thickness is not crucial. When calibrating in air, be sure the correct membrane type is selected.

14. Select Air or Water as the medium for the first calibration point.

15. Select the stimulus at saturation:

    - Default—This value is calculated by the software at the current temperature and barometric pressure.
    - User Set—Enter a value from a look-up table if required.

Barometric pressure is important in converting measurement of D.O. concentration to percent saturation, and a value is required for accurate calibration. If the TROLL 9500 cable is vented, an accurate barometric pressure value can be read from the onboard barometric pressure sensor. If the TROLL cable is non-vented, then a barometric pressure value should be entered manually.



Do one of the following:

- If the TROLL 9500 is on **vented** cable now and will take measurements using **vented** cable, click No — and you may want to check the "Don't ask me this again" box.
- If the device is on **vented** cable now but will take measurements using **non-vented** cable, click Yes. In the Edit Barometric Channel screen, check the box indicating non-vented cable for measurements but vented cable for calibration/programming.
- If the device is on **non-vented** cable now and will take measurements on **non-vented** cable, click Yes. In the Edit Barometric Channel screen, check the box indicating non-vented cable for measurements and enter a barometric pressure value. For help in supplying information if the cable is not vented, see Section 9, Monitoring Barometric Pressure.

16. Click **Next** to continue. A screen like this will be displayed:

17. Select **Run** to begin stabilization for the first calibration point.

 The display will continuously update as readings are taken and compared against the stabilization criteria.

- Status indicators:

 NOT TESTED is displayed until you begin the calibration by selecting Run.

 UNSTABLE indicates the sensor response does not meet the criteria for a valid calibration point.

 NOMINAL indicates the sensor deviation meets early stabilization criteria.

 The **Accept** button becomes available when nominal stability is achieved. You may accept the early value, or wait for complete stability. If you accept the early value, the status will be designated “USER SET” in the calibration report. (For more on calibration reports, see “Calibration History” in Section 10.)

 STABLE is displayed when the readings have stabilized sufficiently to take a valid calibration point. The calibration proceeds automatically to the next screen.

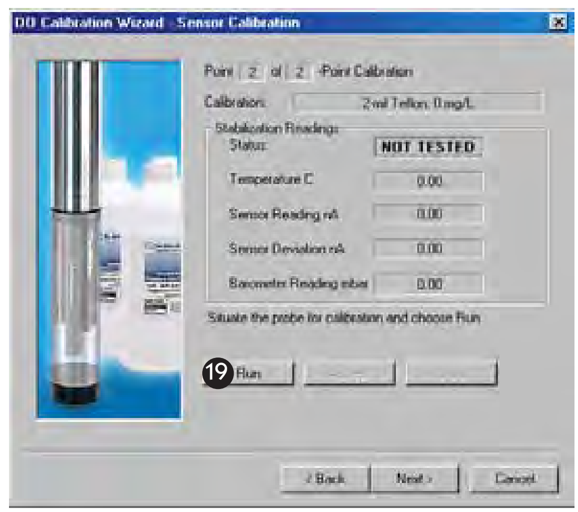
- Sensor Reading: The current sensor response in nanoAmps.
- Sensor Deviation: Change in response between the last 2 readings. This enables you to follow the progress of the stabilization, but the deviation from the previous reading is not necessarily the best indicator of stability as the software is looking at longer-term trends.
- Current temperature and barometric pressure are shown; these values are used to calculate the stimulus.

 TIP: *If the calibration stimulus was entered from a look-up table at step 15 and the temperature is not as expected, you may select Stop, then Back to retrieve the Setup page and re-enter the User Set stimulus.*

18. When readings have stabilized (or you click to **Accept** the Nominal result), the calibration will advance automatically.

 If doing a 1-point calibration, go to step 20.

 For a 2-point calibration, the Wizard displays a screen similar to the one shown below and waits for you to situate the sensor in oxygen-depleted medium—either the Cal Cup filled with sodium sulfite solution, or a nitrogen-saturated water bath.This time, the D.O. sensor membrane should be completely immersed in solution, as well as the temperature sensor.

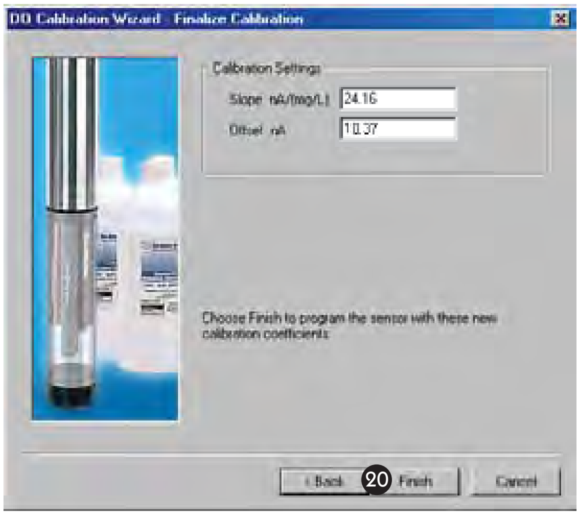


 Allow about 15 minutes for the sensor to stabilize in the medium.

19. Select **Run** to begin the stabilization for the 0% calibration point. Controls and status indicators are the same as for the first calibration point (step 17).

 In true 0% conditions, the sensor reading will be 10 nA or less. If the sensor needs maintenance or there is oxygen in the medium, readings will be higher than 10 nA and complete stability will never be reached. If an accurate 0% calibration is important to your application, do not accept Nominal. Cancel the calibration, perform sensor maintenance and/or check the conditions, and repeat the calibration.

20. When readings have stabilized (or you **Accept** the Nominal value), the final screen is displayed. The calculated sensor slope and offset are shown.



21. Select **Finish** to program the sensor with the new calibration coefficients. The values will be written to the sensor and you will be asked if you want to see the calibration report.

TIP: *You can look at the calibration report right after calibrating, or at any time. See "Calibration History" in Section 10 for details.*

Rinse the sensor and front end of the instrument **very** thoroughly after calibrating in sodium sulfite solution. A good way to do this is to fill the Cal Cup with water, attach to instrument, and shake vigorously. This may need to be done a couple of times.

TIP: *The calibration solution may be flushed down the drain with running water, or saved in a separate container and used to rinse the sensors the next time you calibrate with the same solution.*

After everything is thoroughly rinsed, the D.O. sensor is ready se.

Why does it take so long for the D.O. 100% to stabilize in air?

Paying attention to several factors can assure the shortest stabilization times possible within the stability algorithm:

- *The sensor membrane is perfectly dry.*
- *The ambient temperature is stable.*
- *The temperature sensor is submerged.*
- *The sensor has been fully conditioned.*

If these conditions are met, the sensor response should stabilize in 6-15 minutes.

Options for storing the sensor:

We recommend you leave the D.O. sensor installed in the instrument; this will assure you are able to take fast D.O. measurements on demand. A little water (distilled, deionized, or tap) or a damp sponge in the Cal Cup will keep the sensor membrane moist.

Remember that, as long as the D.O. sensor is installed, it is being conditioned.

If the sensor is removed from the instrument and then re-installed, conditioning will begin as soon as the sensor is detected by the instrument and displayed in the software.

SENSOR SLOPE AND OFFSET

The slope of a properly functioning sensor as calculated during the calibration process will typically be in the following ranges, depending on the membrane thickness:

1-mil membrane: between 30 and 67 nA/(mg/L)
2-mil membrane: between 15 and 34 nA/(mg/L)

If the calculated slope is much outside the stated range, the sensor may need maintenance. Refer to "Sensor Care and Handling" below.

The default offset for Quick Cal and 1-point calibrations is 2 nA. Offsets for 2-point calibrations should fall under 10 nA.

UNITS AND CALCULATED MEASUREMENTS

Four units are available for dissolved oxygen:

TIP: *To change unit preferences: In Win-Situ, select Preferences on the Options menu. In Pocket-Situ, select the Home site, then tap Setup in the command bar.*

- Oxygen concentration in milligrams of oxygen per liter of water (mg/L). Since a liter of pure water weighs 1000 grams, and a milligram is 1/1000 of a gram, this is equivalent to ppm (parts per million).
- Oxygen concentration in micrograms of oxygen per liter of water (µg/L).
- Oxygen concentration in microMolar (µmol/L), = mg/L x 31.25
- Oxygen saturation in % —100% D.O. being the maximum amount of oxygen that can be dissolved in water at a given atmospheric pressure, water temperature, and salinity. % saturation output is automatically corrected using the TROLL 9500's temperature, conductivity, and barometric pressure values (from a baro sensor on vented cable or from a user-entered input). If no conductivity sensor is present, salinity is assumed to be zero.

USAGE RECOMMENDATIONS AND CAUTIONS

The amount of oxygen that can be dissolved in water decreases at higher temperatures and decreases with increasing altitude (i.e., as barometric pressure drops) and salinity. In other words, as water becomes warmer and saltier, it can hold less and less dissolved oxygen.

During tests that include the D.O. channel, the MP TROLL 9500 automatically measures barometric pressure and temperature for compensation of D.O. readings.

The barometric pressure value at the time of calibration is stored in the sensor and will be used to correct D.O. readings for weather-induced pressure fluctuations taken at the same relative barometric pressure as the calibration. However, the large changes in barometric pressure due to changes in elevation are best accommodated by performing a recalibration. If you calibrate at sea level, for example, and use the instrument in the mountains, you should perform a recalibration at the new altitude.

Be sure to supply a barometric pressure value to correctly calculate dissolved oxygen measurements if the sensor will be attached to suspension wire or non-vented cable. This can be done during calibration or prior to setting up a test.

To assure you are able to take fast D.O. measurements on demand, it is best to leave the D.O. sensor installed in the MP TROLL. This takes full advantage of the conditioning and polarization that was accomplished during calibration. After replacing the TROLL 9500 batteries, be sure to power the sensor for an hour or two before use, especially if the batteries were out for a while.

During the first day, some drift is to be expected. After 24 hours or so, the D.O. values can be expected to stabilize.

The D.O. sensor, like the other water-quality sensors, has been tested to 350 psi pressure (246 m, 807 ft). We recommend gradual submersion and retrieval—no faster than 4 ft per second.

STIRRING

Polarographic D.O. measurements drop in very stagnant water due to depletion of oxygen next to the membrane. A slight perturbation to the system will cause the D.O. measurements to return to normal.

Stirring is not necessary for a hand-held instrument, an instrument attached to a boat or floating object, or in any other situation where the water is moving.

Stirring is recommended if the instrument is anchored to a fixed structure in stagnant conditions—for example, attached to a pier in a calm lake that has no underwater currents. If the wind is blowing and waves are slightly moving the cable, then stirring is probably not necessary.

Q: *When do I need to stir and when can I skip it?*

A: *Use a stirrer for best results when measuring D.O. in still or stagnant water.*

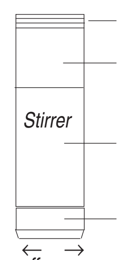
If the water (or the person holding the instrument) is moving at all, you can probably safely skip the stirring. Any water movement, as for example when the instrument is hand-held, eliminates the need for the stirrer.

Attaching the Stirrer

Install the stirrer accessory on the MP TROLL 9000 as follows:

1. Remove the nose cone from the MP TROLL 9500 and set it aside.
2. Screw the top of the stirrer (propeller end) to the stainless steel restrictor in place of the nose cone.

Starting the Stirrer



The stirrer is powered by two alkaline D-cells (installed). To start the motor, tighten the end cap.

The magnetic stir bar in the propeller compartment will start to spin. The stir bar is protected by a guard plate that may be removed for cleaning if necessary.

***TIP:** If the stir bar does not start spinning, try giving it a gentle nudge by sliding a narrow tool such as a screwdriver or key between the protective bars of the guard plate.*

To turn the stirrer off, back off the end cap until the stir bar stops spinning.

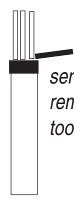
SENSOR CARE AND HANDLING

The D.O. sensor kit includes the following items for routine maintenance of the D.O. sensor:

- extra membrane module
- electrode filling solution (KCl electrolyte)
- cleaning solution and brush
- polishing strips (for cathode)
- storage bottle
- o-ring lubricant

SENSOR REMOVAL

Position the yoke of the sensor removal tool at the point where the sensor meets the sensor block and pry the sensor upward.



Always handle the sensor by the sides. Avoid touching the membrane at the sensor tip.

MAINTENANCE/INSPECTION

Inspect the sensor and membrane if readings begin to drift.

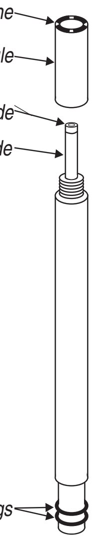
- Check for discoloration of the electrodes due to silver chloride (AgCl) deposition.
- Inspect the membrane for integrity of the surface, for the presence of algal growth or other contaminants, for crystallization that may indicate a leak in the membrane, and to ensure no air bubbles are trapped under the membrane.

CLEANING THE ELECTRODES

Remove the membrane module and clean the electrodes as follows:

Cathode. Use a polishing strip to buff the platinum cathode until it is shiny. This removes any deposits, increasing the chemically active surface of the electrode for a stronger D.O. signal.

Anode. If the sensor appears to be excessively discolored from its original matte grey color, clean the anode with ammonia and a soft brush. Extreme discoloration may be removed by soaking for a half-hour in ammonia before cleaning with a brush. The surface of the anode should appear uniform, but not necessarily mirror-like.



Polarographic Dissolved Oxygen Sensor

Regular cleaning will prevent pitting of the anode surface, caused by accumulated silver chloride deposition. Severe pitting cannot be removed; the sole remedy is to replace the sensor.

After cleaning, rinse thoroughly and shake to dry. Then fill and attach a new membrane module as follows.

REPLACING THE MEMBRANE MODULE

The D.O. sensor performs best in clean water. In environments with high organic content, the membrane can become fouled. Rips, tears and other damage will also affect membrane performance. For best results, replace the membrane when the slope and offset calculated during calibration change dramatically.

The current applied is so small that the electrolyte solution can be expected to last longer than the membrane in most applications

To replace a membrane module:

1. Make sure the area around port 2 is free of dirt and moisture, then remove the sensor. Remove and discard the used membrane module.
2. Inspect and clean the sensor as needed (see above).
3. Fill a new membrane cap with electrolyte and attach it to the sensor. Refer to "Fill the Membrane Module" earlier in this section.
4. Install and condition the sensor. Refer to "Condition a Newly Installed Sensor" earlier in this section.

Remember to condition the sensor for at least 2 hours, preferably 10 hours, before recalibrating with a new membrane. Even with all visible air bubbles removed, a certain amount of gas will be trapped under the membrane. The conditioning period will remove this excess oxygen.

SENSOR LIFE

The sensor body may be expected to last indefinitely so long as the silver coating is not rubbed off the anode during cleaning. The membrane module should be inspected regularly and replaced when it shows wear or damage and when the slope and offset calculated during calibration change dramatically.

STORAGE

Short-Term Storage (up to a two weeks)

Store assembled with membrane immersed in water. A suitable storage bottle is included in the sensor box.

Long-Term Storage

Remove the membrane module, rinse with deionized water, cap and store dry.

REFERENCES

Eaton, A.D., L.S. Clesceri, E.W. Rice, and A.E. Greenberg, eds., *Standard Methods for the Examination of Water and Wastewater,* 21st edition, Washington, D.C.: American Public Health Association, American Water Works Association, and Water Environment Federation, 2005. Section 4500-O G, Oxygen (Dissolved), Membrane Electrode Method.

EPA, Methods for Chemical Analysis of Water and Wastes, EPA/600/4-79-020, revised March 1983. Method 360.1, Oxygen, Dissolved, Membrane Electrode. Approved at 40 CFR Part 136.

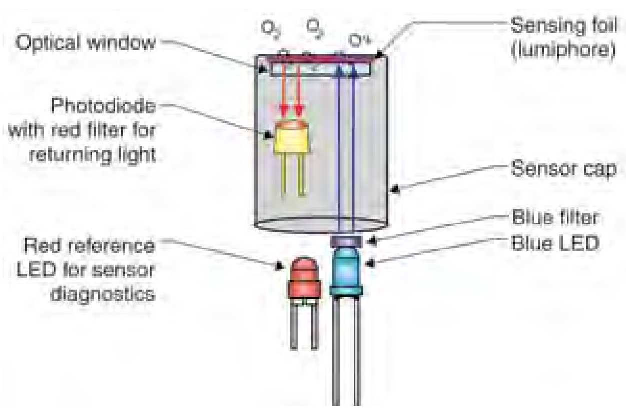
OPTICAL MEASUREMENT OF DISSOLVED OXYGEN

THE RDO OPTICAL DISSOLVED OXYGEN SENSOR

The In-Situ RDO® optical dissolved oxygen sensor measures dissolved oxygen using the principle of "dynamic luminescence quenching." Certain molecules, called "lumiphores," fluoresce when excited by light of a specific wavelength. Oxygen molecules act to quench this fluorescence. The lumiphores in the sensor are embedded in a gas-permeable sensing foil in a replaceable cap.

The sensor optics include a lens, blue LED and filter, red LED and filter, and a photodetector. When the blue LED emits light, the sensing foil emits red photons; the presence of oxygen in the foil causes a reduction in red light detected by the photodiode. The phase difference between the blue excitation light and the returned red light is measured, and the result is used to compute dissolved oxygen.

This method measures the "phase" (or delay) of the returned signal, and is thus based on the "lifetime" rather than the "intensity" of the luminescence.



COMPARISON TO POLAROGRAPHIC D.O. SENSOR

The RDO optical dissolved oxygen sensor offers several advantages over the more traditional electrochemical cell. Its solid-state design does not use membranes, filling solution, or other consumables. The sensor does not consume oxygen, thus it does not require flow past the sensor for measurement of DO. It does not require conditioning before use. It exhibits very little drift, therefore it does not require frequent calibration. In the absence of biofouling, it does not need frequent routine maintenance.

The RDO Sensor and Salinity

Unlike an electrochemical cell, the RDO sensor does not respond to changes in salinity. Since the absolute solubility of oxygen is lower in saline water, it is advantageous to compensate DO concentration readings (µg/L, mg/L, µmol/L) to ensure that the sensor accurately reports the concentration of dissolved oxygen in the presence of significant salinity. This can be accomplished by storing a salinity value in the sensor before taking measurements. The compensation algorithm is applied internally before concentration is reported. The degree of compensation is minimal at very low salinities, and several percent of reading at oceanic salinity levels.

The software prompts for a salinity value when you add a test. The value can be changed at any time by selecting the RDO sensor in the Navigation tree and clicking **Edit**, then "Edit RDO Salinity Value."

SENSOR INSTALLATION

You will need—

- TROLL 9500 water quality instrument
- Alkaline batteries

> ⚠ *Alternatively use Saft LSH-20 3.6V lithium D cells. Use of any other lithium battery will void the warranty of the RDO sensor and the TROLL 9500.*

- Latest version of TROLL 9500 firmware—this comes loaded in a new instrument, or is available with the download of new software at www.in-situ.com
- RDO sensor package, with
- Latest version of Win-Situ 4/ Pocket-Situ 4 software—this is shipped on a CD with a new TROLL 9500 instrument, or is available at www.in-situ.com.
- TROLL Com communication cable
- Desktop/laptop PC or RuggedReader® handheld PC

UNPACK THE RDO CABLE CONNECT SENSOR

The RDO cable connect sensor arrives installed in a 3-part adapter/restrictor/nose cone assembly. Remove the black restrictor and nose cone from the sensor and adapter assembly.

The soft Cal Cup insert enables calibration of the basic sensors when the RDO sensor is installed. It contains

- An extra screw for the adapter plate
- A sponge to create a moist environment for temporary storage of installed sensors that need to be kept wet

UNPACK THE RDO DIRECT CONNECT SENSOR

The RDO direct connect sensor ships in a box as shown below:

INSTALLING THE RDO SENSOR CAP

1. Remove the red protective dust cap from the sensor and **save it for later use**.

2. Use the supplied lens wipe to clean the lens of the sensor, if necessary.
3. Remove the RDO sensor cap from its shipping sleeve.
4. Align the arrow on the cap with the index mark on the sensor and firmly press the cap onto the sensor, without twisting, until it seals over the probe body.

Keep the cap in its sealed packaging until ready to install it.

Make sure that the o-ring is not pinched or rolled inside the cap.

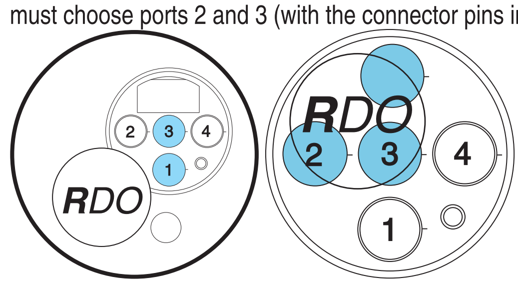
The cap's lifetime is 1 year after the first reading has been taken. Install by the date printed on the packaging.

INSTALLING THE RDO SENSOR

1. If necessary, install batteries in the TROLL 9500 instrument.

Please exercise great care in handling, installing, and shipping lithium batteries. Refer to the instructions, cautions and MSDS packed with the batteries.

2. Remove the standard restrictor or Cal Cup from the TROLL 9500 instrument (if attached). This allows access to the sensor block.
3. Determine the installation port(s) for the RDO sensor. For the cable connect, choose port 1 or 3. For the direct connect, you must choose ports 2 and 3 (with the connector pins in port 3).



Cable Connect **Direct Connect**

4. Use the Sensor Removal tool to remove the plug or existing sensor from the appropriate port. Port 1 is normally easier to access.

TIP: If installing in port 3, you may wish to remove the port 2 sensor temporarily (if installed).

5. Attach the RDO Sensor to the TROLL 9500:
   a. Remove the soft cap from the connector end of the direct connect RDO sensor. Attach the direct connect sensor and any other remaining sensors (in ports 1 and 4), if applicable. Proceed to step 6.
   b. For the cable connect sensor, insert the front end of the TROLL 9500 instrument through the large hole in the adapter, alongside the RDO sensor.

c. Press until the instrument's sensor block surface is flush with the adapter plate surface. Align the RDO sensor between sensor ports 1 and 2. Align the open hole for the RDO sensor cable beside port 1. Refer to the drawing below.

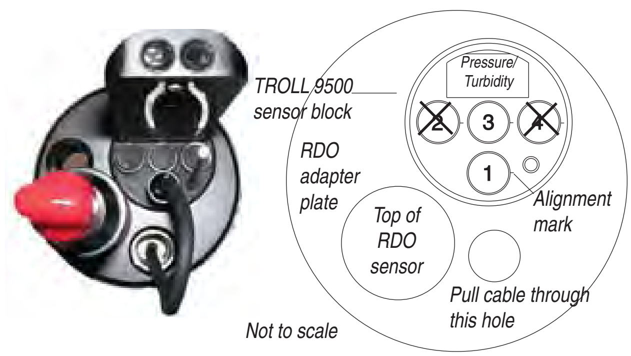
d. Tighten the adapter screw with a Phillips head screwdriver, not overly tight.

e. Feed the short black cable up through the open hole, so it is on the same side of the adapter plate as the TROLL 9500 sensor block (refer to the drawing below).

f. Remove the soft cap from the connector end of the RDO sensor cable harness. Align the mark on the side of the sensor with the alignment mark on the selected port (1 or 3). Or just visually align the 3-pin connector on the cable harness with the connector in the selected port.

g. Press the cable harness into the port until you feel it dock with the connector. When properly inserted a small gap (width of the sensor removal tool) remains between the instrument body and the widest part of the cable harness, for ease of removal.

Connected to the TROLL 9500, the RDO sensor looks like this:



> **Q:** *Why is there no Quick Cal option for the RDO sensor?*
>
> **A:** *Quick Cal solution is used to calibrate sensors that are known to drift and otherwise lose measurement accuracy on a time scale shorter than desired for field use. Thus a Quick Cal provides a simple and potentially less accurate means to calibrate the sensor but will improve the sensor accuracy as compared to the state to which it may have drifted. It is less accurate but also less costly than removing the instrument to a laboratory setting to perform traditional multi-point calibrations.*
>
> *Since the RDO sensor does not drift appreciably in media void of biofouling, there is nothing to be gained from a Quick Cal. A traditional 2-point laboratory calibration after cleaning or changing the sensor cap is adequate. If biofouling is detected, more frequent cleaning and subsequent calibration may be needed.*

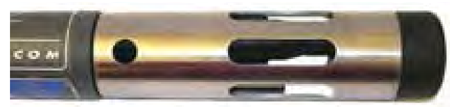
6. Remove the RDO sensor cap from its shipping/storage sleeve. Align the arrow with the index mark and firmly press the cap onto the sensor, without twisting, until it seals over the probe body. Make sure that the o-rings are not pinched or rolled between the cap and the sensor.

   Avoid allowing moisture, including atmospheric humidity, inside the cap. Keep the cap in its sealed packaging until you are ready to install it. Install promptly. Make sure that o-ring grooves are dry and the o-ring is not rolled or pinched inside the cap.

   The cap's lifetime is 1 year after the first reading has been taken with the TROLL 9500 instrument. Install by the date printed on the packaging.

7. Perform a 2-point calibration on the sensor, as described below.
8. Attach the restrictor and nose cone. (If a turbidity sensor or turbidity wiper are installed on the cable connect model, pull the slack in the adapter cable up against the probe so that it does not interfere with wiper movement or turbidity readings.)

Cable connect



Direct connect

9. If using the cable connect sensor, pull the slack in the adapter cable up against the probe so that it does not interfere with wiper movement or turbidity readings.

CALIBRATION

OVERVIEW

Nominal vs. Stable

To shorten the calibration time, you have the option to accept the calibration when "Nominal" stability is achieved. If the early value is accepted, the calibration point will be designated "USER SET" in the calibration report. If the calibration report indicates that calibration was performed through to stability then the instrument will operate as intended by In-Situ Inc.'s quality standards. For more on calibration reports, see Section 10 of this manual.

TIP: *During calibration, salinity is set to 0 PSU. A salinity value stored in the sensor is restored after calibration is complete. For more information on storing a fixed salinity value in the sensor, see The RDO Sensor and Salinity earlier in this chapter.*

CALIBRATION SOLUTIONS

100% DO calibration is performed in water saturated with air. For best results, use the In-Situ RDO Bubbler Cal kit (Cat. No. 0048580).

0% DO calibration is performed in an oxygen-depleted solution. Sodium sulfite (Na_2SO_3, Catalog No. 0017670) is available from In-Situ Inc. Bubbled nitrogen may be used; in this case allow plenty of time for the oxygen to be completely purged from the water.

RECOMMENDED CALIBRATION FREQUENCY

Calibration frequency is more predictable than with electrochemical DO sensors, since the sensor does not drift appreciably. If the foil is not mechanically damaged or removed, calibration can last three months or more.

***TIP:** For best results, check the RDO sensor several times per year in 100% air-saturated water.*

TRADITIONAL 2-POINT CALIBRATION

Ideally, the RDO sensor should be calibrated under stable and controlled conditions, like those found in a laboratory setting. However, field calibration can also be performed. Calibration solutions should be close in temperature to the sample matrix.

One or two calibration points can be taken. If only one point is taken, the software uses the results of a previous calibration for the other point.

A 2-point calibration (100% and 0%) is recommended

- When you expect to measure very low DO values (< 5 mg/L),
- When required by Standard Operating Procedures,
- After replacing the sensor capl

OXYGEN SATURATION POINT

1. Submerge the RDO sensor in a container of clean water aerated with the In-Situ bubbler. Ensure that the sensor is completely submerged and the sensor cap is not directly in the bubble stream.

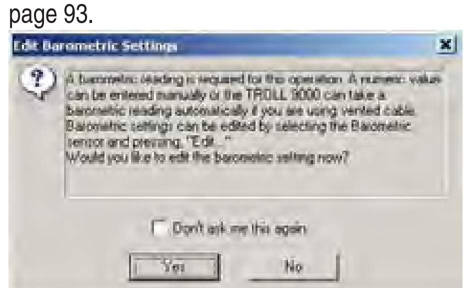
   Allow 5-10 minutes for temperature and oxygen equilibration.

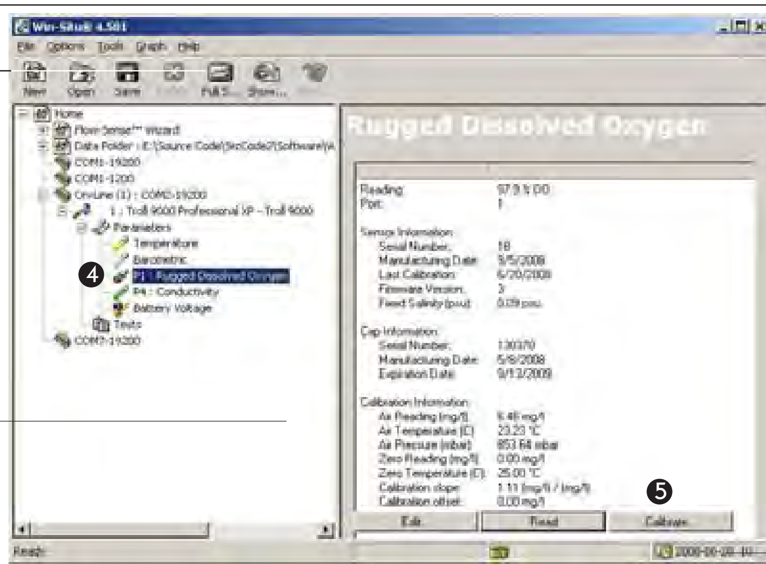
   ***TIP:** The equilibration time depends on the condition of the water with respect to temperature and exposure to air.*

2. Connect the TROLL 9500 to a PC and establish a connection in Win-Situ 4 or Pocket-Situ 4. Win-Situ screens are illustrated here. The Pocket-Situ interface is similar, with the Navigation tree at the top and the Information pane below it.
3. Select the TROLL 9500 in the Navigation tree. The software will automatically detect and display the installed sensors.
4. Select Rugged Dissolved Oxygen in the Parameters list.

   Information on the RDO sensor is shown, including its serial number (SN), the foil batch number, and recent calibration information, as shown in the large screen at the bottom of the page.

5. Select **Calibrate**.
6. Before the RDO Calibration Wizard starts, you will be asked how you want to handle barometric pressure. See the sidebar on page 93.





***TIP:** To see all of the information pane, you can click the "Full Screen" button on the Win-Situ toolbar.*

Barometric Pressure Options

Cable venting is essential to obtain accurate measurements, and the software cannot tell if the cable is vented, so please take a moment to supply this information. Do one of the following:

- If the TROLL 9500 is on vented cable now and will be deployed on ented cable, click **No** — and you may want to check the "Don't ask me this again" box.
- If the device is on vented cable now but will be deployed on non-vented cable, click **Yes**. In the next screen, check the box indicating non-vented cable for deployment but vented cable for calibration/programming.
- If the device is on non-vented cable now and will be deployed on non-vented cable, click **Yes**. In the next screen, check the box indicating non-vented cable for deployment and enter a barometric pressure value.

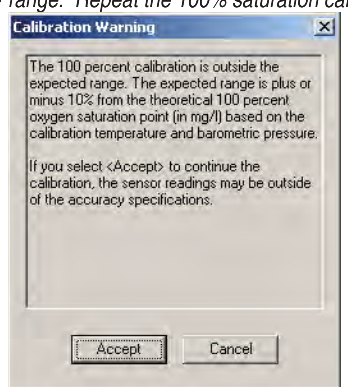
For help, see Section 9, Monitoring Barometric Pressure.

7. Three calibration options appear. Select the first or second option:
   - Calibrate: Starting from values stored in the sensor (user-set or factory defaults) for the 0% and 100% calibration, this allows the user to redo one or both calibration points
   - Restore defaults, then calibrate: Restores factory defaults for both 0% and 100%, then allows the user to redo one or both calibration points.
   - Restore defaults, don't calibrate: Restores factory defaults for both 0% and 100% saturation and closes the Calibration Wizard.
8. Follow the instructions for 100% oxygen calibration.
9. After allowing 5 to 10 minutes for temperature stabilization, click the **Run** button. The display will continuously update as readings are taken and compared against the stabilization criteria.

10. When readings have stabilized, the screen will appear similar to the one below, and you have several choices:

- Select **Next** to display the Zero Oxygen Point screen. Continue with step 11 to calibrate at 0%.
- Select **Next**, then **Next** again to finalize the calibration if you are performing a one-point calibration. Go to step 14.
- Select **Run** to run the oxygen saturation point again if you believe the sensor values are incorrect. Go back to step 9.

TIP: *The warning box below will appear if the slope is out of range. Repeat the 100% saturation calibration point.*



ZERO OXYGEN POINT

11. Immerse the RDO sensor in an oxygen-depleted medium:
   - Sodium sulfite (Na_2SO_3) solution is generally reliable, if somewhat messy. Use a laboratory beaker or In-Situ's special zero-point cal cup. Be sure the small well in front of the sensing foil is filled with solution.
   - Nitrogen bubbling requires considerable time for oxygen to be completely purged from the water.
   - Submerge the sensor completely, and check to be sure that there are no air bubbles on the sensing foil.
   - Allow up to 15 minutes for temperature equilibration.

12. When you are ready to take the calibration point, click or tap **Run** in the Zero Oxygen Point screen.

The display will continuously update as readings are taken and compared against the stabilization criteria. Controls and status indicators are the same as for the 100% calibration point.

13. When readings have stabilized, the screen will appear similar to the one shown in step 10, and you have two choices:

- Select **Next** to finalize the calibration. Continue with step 14.
- Select **Back** to calibrate the Oxygen Saturation point (step 9).

> ***TIP:*** *Sodium sulfite consumes oxygen aggressively. If performing the oxygen saturation point next, be sure to rinse the TROLL 9500 and RDO sensor* ***thoroughly*** *to avoid cross-contamination.*

- Select **Run** to run the oxygen saturation point again if you believe the sensor values are incorrect. Go back to step 12.

> ***TIP:*** *A warning box will appear if the slope is out of range (normal range is 0.9 to 1.1 with an offset of ±0.1). Repeat the zero point.*

FINALIZE THE CALIBRATION

14. The final calibration screen for a 1-point calibration at saturation was performed. To finalize the calibration, click **Finish**.

Status indicators:

NOT TESTED appears until you begin the calibration by selecting Run.

UNSTABLE indicates the sensor response does not meet the criteria for a valid calibration point.

NOMINAL indicates the deviation meets early stabilization criteria.

The **Accept** button becomes available when nominal stability is achieved. You may accept the early value, or wait for complete stability. If you accept the early value, the status will be designated "USER SET" in the calibration report. (For more on calibration reports and the difference between Nominal and Stable, see Section 10 of this manual.)

STABLE is displayed when the readings have stabilized sufficiently to take a valid calibration point.

- Reading: The temperature sensor response is shown in degrees C, and RDO sensor response is shown in mg/L. Win-Situ automatically detects stability in both parameters.
- Deviation: Change in response between the last 2 readings. This enables you to follow the progress of the stabilization, but deviation from the previous reading is not necessarily the best indicator of stability as the software is looking at longer-term trends.
- Current barometric pressure in your selected unit.

The values will be written to the sensor and you will be asked if you want to see the calibration report.

TIP: *For more on Calibration Reports, see Section 10 of this manual.*

The RDO sensor is now calibrated and ready to take readings. To confirm this, take a reading by selecting the RDO sensor in the Navigation tree and clicking the **Read** button.

TIP: *If the units for the reading are not what you expect, it is easy to change the units selection: In Win-Situ, select Preferences on the Options menu. In Pocket-Situ, select the Home site, then tap Setup in the command bar.*

Clean-up

Rinse the sensor and front end of the instrument very thoroughly after calibrating in sodium sulfite solution to avoid cross-contamination. For best results, always use fresh calibration solutions.

UNITS AND CALCULATED MEASUREMENTS

Four units are available for dissolved oxygen:

TIP: *To change unit preferences: In Win-Situ, select Preferences on the Options menu. In Pocket-Situ, select the Home site, then tap Setup in the command bar.*

- Oxygen concentration in milligrams of oxygen per liter of water (mg/L). Since a liter of pure water weighs 1000 grams, and a milligram is 1/1000 of a gram, this is equivalent to ppm (parts per million).
- Oxygen concentration in micrograms of oxygen per liter of water (µg/L). This is equivalent to parts per billion (ppb).
- Oxygen concentration in microMolar (µmol/L) = mg/L x 31.25
- Oxygen saturation in % —100% DO being the maximum amount of oxygen that can be dissolved in water at a given atmospheric pressure, water temperature, and salinity. The percent saturation output is automatically corrected using the TROLL 9500 instrument's temperature, conductivity, and barometric pressure values (from a baro sensor on vented cable or from a user-entered input). If no conductivity sensor is present, salinity is assumed to be zero.

USAGE RECOMMENDATIONS AND CAUTIONS

The amount of oxygen that can be dissolved in water decreases at higher temperatures and with increasing altitude (i.e., as barometric pressure drops) and salinity. In other words, as water becomes warmer and saltier, it can hold less dissolved oxygen.

During tests that include the RDO channel, the TROLL 9500 instrument automatically measures barometric pressure and temperature for compensation of DO readings.

The barometric pressure value at the time of calibration is stored in the sensor and will be used to correct DO readings for weather-induced pressure fluctuations taken at the same relative barometric pressure as the calibration. However, the large changes in barometric pressure due to changes in elevation are best accommodated by performing a recalibration. If you calibrate at sea level, for example, and deploy the instrument in the mountains, you should perform a recalibration at the new altitude.

Exposure to direct sunlight can bleach the sensing foil over time but this effect is minimized with the protection provided by the opaque optical isolation layer. However, the frequent application of strong blue light (blue LED during readings) will eventually have a bleaching effect on the foil. In-Situ recommends sampling intervals of greater than 1 minute for long-term deployments.

Salinity

Since the absolute solubility of oxygen is lower in saline waters, it is advantageous to compensate DO concentration readings (µg/L, mg/L, µmol/L) to ensure that the sensor accurately reports the concentration of dissolved oxygen in the presence of significant salinity. This can be accomplished by storing a salinity value in the sensor before taking measurements. The compensation algorithm is applied internally before the concentration is reported. The degree of compensation is minimal at very low salinities, and but may affect readings by several percent at higher levels.

To store a salinity value in the RDO sensor, connect in Win-Situ 4 or Pocket-Situ 4, select RDO in the Navigation tree, click Edit and in the next screen select "Edit RDO Salinity Value."

SENSOR CARE AND HANDLING

BIOFOULING

Organisms that produce or consume oxygen, if attached to the area of the sensing foil, may artificially influence the sensor's measurement of the oxygen in the surrounding water. In addition, the sensor's response time may be increased.

To avoid this the sensor should be cleaned at regular intervals depending on the required accuracy and the fouling condition at the site.

MAINTENANCE AND STORAGE

Cleaning the Sensor Cap

1. Leave the cap on the sensor!
2. Rinse the sensor with clean water from a squirt bottle or spray bottle.
3. Gently wipe with a soft cloth or brush if biofouling is present.
4. If extensive fouling or mineral build-up is present, soak the cap end in vinegar for 15 minutes, then soak in deionized water for 15 minutes.

Do not use organic solvents—they will damage the foil. Do not remove the cap from the sensor prior to brushing.

After cleaning the sensor, perform a 2-point user calibration.

Cleaning the Optical Window (Perform only if changing the cap)

Remove the cap and gently wipe the window with the supplied lens wipe.

Caution: Do not wet the lens area with water or any solution.

Cleaning the Sensor Body

With the sensor cap installed on sensor, gently scrub sensor body with a soft brush. Soak in vinegar and DI water to remove mineral deposits or extensive fouling as in step 4, above.

Storage

Prior to installation: Store in factory supplied container.

Installed: The RDO sensor can be stored wet or dry. When installed with other sensors, it may be useful to store all sensors in a moist environment. In-Situ supplies recyclable plastic calibration and storage sleeves, as well as calibration and storage vessels for this purpose.

Replacing the Sensor Cap

The sensor cap has a 1-year life after the TROLL 9500 instrument takes its first RDO sensor reading. Replacement caps are available from In-Situ Inc. or your authorized In-Situ distributor.

1. Pull the used sensor cap off of the sensor, without twisting.
2. Remove the existing o-rings from the sensor.
3. Use a lint-free cloth to remove any moisture from the sensor body.

Note: Ensure that there is no moisture in the o-ring grooves. Avoid touching or cleaning the lens with anything other than the supplied lens wipe.

RDO Sensor Summary

- When a **turbidity wiper** is installed, be sure to pull the slack in the RDO adapter cable back against the TROLL 9500 body so it will not interfere with the wiper's rotation.
- To calibrate the **Basic sensors** with RDO installed, fill the soft plastic cal insert (it has an orange base) with calibration solution, slide it up around the sensors, including the RDO cable, and use the RDO restrictor as a support during calibration.
- The RDO sensor will work properly only in **port 1 or 3** of the TROLL 9500. Remember that a combination pH/ORP sensor will operate properly only in port 1, and a turbidity wiper accessory only in port 3.
- Basic **sensors that require hydration** (pH and pH/ORP) may be stored in the calibration and storage sleeve for short periods of time. For long-term storage, remove the RDO sensor—it is not necessary to remove it from the adapter—with restrictor and nose cone. Attach the standard TROLL 9500 Cal Cup with a moist sponge in the bottom.
- The RDO sensor and all TROLL 9500 materials are suitable for monitoring in low flow, groundwater, and surface water sites.

4. Use your finger to apply a layer of lubricant around the o-ring grooves. Place the o-rings on the sensor. Apply another thin layer of lubricant to the o-rings and grooves.

Note: Do not transfer grease to the lens or sensor pins.

5. Clean the lens on the sensor with the wipe provided in the kit and allow to dry thoroughly. Inspect for scratches or dirt.
6. Remove the new cap from its sealed packaging and attach it to the sensor, being careful to press firmly, without twisting, until it seals over the probe body. Make sure that the o-rings are not pinched or rolled between the cap and sensor.
7. Perform a 2-point calibration. No conditioning is required prior to use.

14 OXIDATION-REDUCTION POTENTIAL

WHAT IS ORP?

Oxidation Reduction Potential (ORP) is a measure of a water system's capacity to either release or gain electrons in chemical reactions. The process of oxidation involves losing electrons while reduction involves gaining electrons. Oxidation and reduction (redox) reactions control the behavior of many chemical constituents in drinking water, wastewater, and aquatic environments. The reactivity and solubility of critical elements in living systems is strongly dependent on redox conditions. ORP values are used much like pH values to determine water quality. While pH values characterize the relative state of a system for receiving or donating hydrogen ions (acting as a base or an acid), ORP values characterize the relative state of a system for gaining or losing electrons. ORP values are affected by all oxidizing and reducing agents, not just acids and bases.

WHY MEASURE ORP?

The effect that potable water has on plumbing is directly related to its ORP value. Unfavorable values can cause excessive corrosion, leading to expensive repairs. ORP is one parameter that can be monitored during the disinfecting process for drinking water, swimming pool water, and spa water.

The life expectancy of bacteria in water is related to ORP. In fact, studies have shown that the life span of bacteria in water is more dependent on the ORP value than on the chlorine concentration. For swimming pools at a normal pH value between 7.2 and 7.6, the ORP value must be kept above 700 mV to kill unwanted organisms. Hypochlorite or other oxidizing agents must be added when the ORP falls below 700 mV. In contrast, natural waters need a much lower ORP value in order to support life. Generally ORP values above 400 mV are harmful to aquatic life. Ideally the ORP value in salt water aquariums should be kept between 350 and 390 mV. ORP levels below 300 mV are to be avoided. An oxidizing environment is needed to convert any ammonia (NH_3) to nitrites (NO_2^-) and nitrates (NO_3^-). Ammonia levels as low as 0.002 mg/l can be harmful to some fish species.

Typical ORP values

Fluid	ORP (mV)
Salt water aquarium	~ 350
Harmful to aquatic life	> 400
Properly chlorinated swimming pool	> 700

The determination of ORP is particularly worthwhile in water that contains a relatively high concentration of a redox-active species, e.g., the salts of many metals (Fe_2^+, Fe_3^+) and strong oxidizing (chlorine) and reducing (sulfite ion) agents. Thus, ORP can sometimes be utilized to track the metallic pollution of ground- or surface water, or to determine the chlorine content of wastewater effluent. However, ORP is a nonspecific measurement—that is, the measured potential is reflective of a combination of the effects of all the dissolved species in the medium. Because of this factor, the measurement of ORP in relatively clean environmental water (ground, surface, estuarine, and marine) has only limited utility unless a predominant redox-active species is known to be present. Care is required not to "over-interpret" ORP data unless specific information about the site is known.

THE pH/ORP SENSOR

The single-junction, three-electrode sensor uses a potentiometric method to measure pH and ORP in a test solution. The pH electrode consists of a pH-sensitive glass whose voltage is proportional to the hydrogen ion concentration. The ORP electrode serves as an electron donor or acceptor depending upon the test solution. The reference electrode supplies a constant stable output for comparison. Electrical contact is made with the test solution using a saturated potassium chloride (KCl) solution. The electrode behavior is described by the Nernst equation:

$$E_m = E_o - (RT/nF)\ \ln \{[ox] / [red]\}$$

where

E_m is the potential from the ORP electrode,

E_o is related to the potential of the reference electrode,

R is the Gas Law constant,

F is Faraday's constant,

T is the temperature in Kelvin,

n is the number of electrons,

[ox] is the oxidant concentration in moles/L, and

[red] is the reductant concentration in moles/L.

Most natural waters contain many species that are involved in the redox process so that it is not possible to calculate the ORP using the Nernst equation. All redox species do however reach equilibrium. A Standard solution of known redox potential for a particular ORP electrode is used to calibrate ORP. The sensor then gives a calibrated response in mV when placed in a sample.

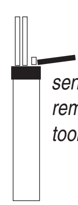
SENSOR INSTALLATION

The MP TROLL 9500 may be shipped with a pH/ORP sensor installed. If installation is necessary, unpack and install the sensor in port 1 of the MP TROLL 9500 as follows.

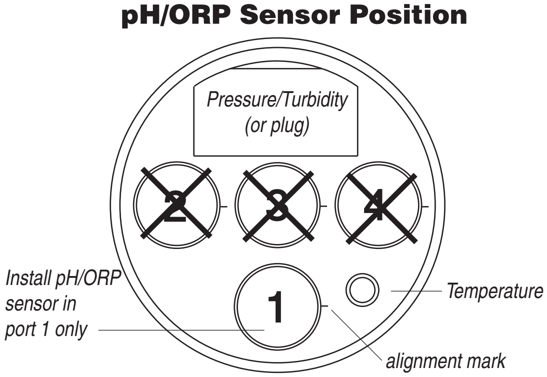
The combination pH/ORP sensor will work properly only in port 1.

TIP: *To ensure optimum response for a new or previously stored sensor, rinse off the soaking solution, then soak the sensor in clean water for at least 15 minutes before calibrating.*

1. Remove the restrictor or Cal Cup from the front end of the TROLL 9500. This allows access to the sensor block shown below.
2. Remove the sensor hydration bottle and set aside for future use.
3. Rinse the sensor in clean water to remove the soaking solution. Soak the sensor in clean water for at least 15 minutes before calibrating.
4. Remove any moisture or dirt from the area around port 1, then use the sensor removal tool to remove the plug from the port. Retain the plug for future use.



pH/ORP Sensor Position



5. Remove any moisture or dirt from the port connector with a clean swab or tissue.
6. Remove the cap from the sensor connector. Check lubrication of the o-rings. If they appear dry, apply a silicone lubricant.
7. Visually align the sensor connector pins with the port connector pins.
8. Press the sensor firmly into the port until you feel it dock with the port connector. When properly inserted a small gap (the width of the sensor removal tool) remains between the widest part of the sensor and the instrument body, for ease of removal.

CALIBRATION

OVERVIEW

A one-point calibration in a solution with a known potential at a given temperature is sufficient to calibrate ORP. Software options:

- **Quick Cal:** Calibrates ORP (and optionally pH, polarographic D.O., and conductivity) at one time with one solution.
- **Traditional calibration:** A one-point calibration in a solution specifically formulated for calibrating ORP. Results in calculation of sensor offset.
- **Default coefficients:** Resets the sensor's factory defaults. No solutions are required.

Nominal vs. Stable

To shorten the calibration time, you have the option to accept the calibration when "Nominal" stability conditions are achieved. If the early value is accepted, the calibration point will be designated "USER SET" in the calibration report. If the calibration was performed through to stability ("STABLE" in the calibration report), the sensor will operate as intended by In-Situ's quality standards.

CALIBRATION SOLUTIONS

Only one solution is required for ORP calibration. Quick Cal and ZoBell's solution are available from In-Situ Inc. A custom solution may be used in a Traditional calibration if its milliVolt value at the calibration temperature is known.

Please note that a pH/ORP sensor requires separate calibrations for pH and ORP. The Quick Cal procedure produces excellent results for ORP so long as the solution is stored as recommended and used before its expiration date. After performing a Quick Cal for ORP, we recommend a 2- or 3-point Traditional calibration for pH, as described in Section 11 of this manual.

RECOMMENDED CALIBRATION ORDER FOR pH AND ORP

The pH/ORP sensor requires separate calibrations for pH and ORP. A suggested calibration scenario is as follows:

A. First, Quick-Cal ORP (plus, optionally, other installed Basic sensors). For the procedure, see Section 3, Getting Started.

B. Then, perform a 2- or 3-point Traditional pH calibration as described in Section 11 of this manual.

TRADITIONAL ORP CALIBRATION PROCEDURE

If you wish to perform a traditional calibration with a dedicated ORP calibration solution, use the following procedure.

1. With a pH/ORP sensor installed and plugs or sensors in the other ports, rinse the front end of the MP TROLL 9500 in clean water. For best results, rinse again in a portion of the calibration solution.
2. Fill the Cal Cup with ZoBell's or other custom ORP calibration solution.
3. Attach the Cal Cup to the MP TROLL 9500. Thread the Cal Cup onto the body until seated against the o-ring, then back off slightly to avoid overtightening.
4. Connect the MP TROLL 9500 to a PC and establish a connection in Win-Situ 4 or Pocket-Situ 4.

5. Select the MP TROLL 9500 in the Navigation tree. The software will automatically detect and display the installed sensors. (This can take a moment.)
6. Select ORP in the Parameters list. The sensor serial number (SN) and recent calibration information is displayed.

7. Select **Calibrate** to launch the ORP Calibration Wizard.
8. In the ORP Calibration Wizard, select the solution the sensor is soaking in. For ZoBell's, the reference milliVolt value is available in the software. For a custom solution, select "Other" and enter the mV of the solution at the calibration temperature.

9. Select **Next** to continue.
10. In the next screen, select **Run** to begin the stabilization.

The display will continuously update as readings are taken and compared against the stabilization criteria.

Indicators during Calibration

- **Status:**

  NOT TESTED is displayed until you begin the calibration by selecting Run.

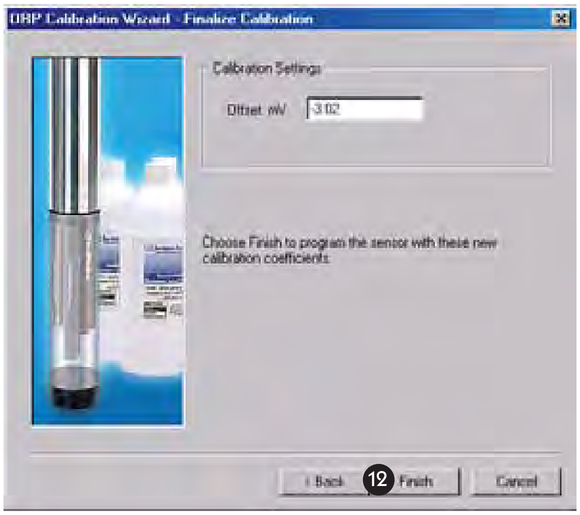
  UNSTABLE indicates the sensor response does not meet the criteria for a valid calibration point.

  NOMINAL indicates the sensor deviation meets early stabilization criteria.

  The **Accept** button becomes available when nominal stability is achieved. You may accept the early value, or wait for complete stability. If you accept the early value, the calibration point will be designated "USER SET" in the calibration report. (For more on calibration reports, see "Calibration History" in Section 10.)

  STABLE is displayed when the readings have stabilized sufficiently to take a valid calibration point. The calibration proceeds automatically to the next screen.
- **Temperature** is displayed for your information.
- **Sensor Reading:** The current sensor response in milliVolts.
- **Sensor Deviation:** Change in sensor response between the last two readings. This enables you to follow the progress of the stabilization, but deviation from the previous reading is not necessarily the best indicator of stability as the software is looking at longer-term trends.

11. The final screen shows the calculated sensor offset. This value should be 0 mV ± 20 mV.



12. Select **Finish** to write this value to the sensor.

The ORP sensor is now calibrated and ready to use.

TIP: *You can look at the calibration report right after calibrating, or at any time. See "Calibration History" in Section 10 for details.*

TIP: *The calibration solution may be flushed down the drain with running water, or saved in a separate container and used to rinse the next time you calibrate with the same solution.*

Options for storing sensors:

- If the instrument will be used in a day or so, leave the sensors installed. Remove the Cal Cup and rinse it and the sensors. Add 50-100 mL of tap water to the Cal Cup. Return the probe to the Cal Cup for transport to the field site.
- For longer storage, see the section on Sensor Care and Handling later in this chapter.

RESETTING DEFAULT COEFFICIENTS

The sensor's calibration may be reset back to factory defaults at any time. This is a good option if the results of a recent calibration are suspect because the cal solution has been exposed to air or has otherwise deteriorated

1. With a pH/ORP sensor installed, establish a connection to the instrument in Win-Situ 4 or Pocket-Situ 4.
2. Select ORP in the Parameters list and click **Calibrate**.
3. In the first screen, select Use Default Coefficients, then **Next**.
4. In the final screen, click **Finish** to send the values to the sensor.

SENSOR OFFSET

The offset for ORP is a traditional "zero offset," and is typically 0 ± 20 mV. If the offset calculated during calibration is outside this range, inspect the sensor. If it is clean, then the fault was probably with the cal solution (aging, exposure to air, etc.). In this case, resetting the factory defaults for ORP can often restore the sensor performance.

UNITS AND CALCULATED MEASUREMENTS

ORP readings may be displayed in Volts or milliVolts. No calculated measurements are available.

RECOMMENDED CALIBRATION FREQUENCY

Calibration frequency will depend on the nature of the sample and the degree of accuracy required. In clean water samples, the sensor could retain its accuracy for 2-6 weeks. Recalibrate the sensor—

- after replacing the reference junction and/or the filling solution,
- during routine, scheduled maintenance,
- every 2-6 weeks in the absence of other indications.

NORMALIZATION TO STANDARD HYDROGEN ELECTRODE VALUES

ORP values are dependent on solution composition, temperature, and sensor type. ORP (Eh) values reported in the literature are often normalized to the standard hydrogen electrode as a standard reference electrode. Since the standard hydrogen electrode is extremely fragile, it is impractical to use in the field. In-Situ's sensor uses a silver/silver-chloride reference electrode in place of the standard hydrogen electrode.

The following equation may be used to normalize the readings reported by our sensor calibrated with our solution to standard hydrogen electrode values (±50 mV).

$$ORP_{SHE} = ORP_{observed} + \{215.81 - T_C * [0.77942 + T_C * 0.001934]\}$$

where ORP_{SHE} is the sample potential relative to the standard hydrogen electrode

$ORP_{observed}$ is the sample potential relative to the In-Situ reference electrode

T_C is the sample temperature in °C

ORP measured by a sensor immersed in a solution should not be equated with thermodynamic Eh. Differences may occur due to lack of chemical equilibrium, presence of multiple redox couples, sensor poisoning, and other factors.

In addition, like all platinum ORP electrodes, In-Situ's pH/ORP sensor may give unstable readings in solutions containing chromous, vanadous, titanous, and other ions that are stronger reducing agents than hydrogen or platinum.

USAGE RECOMMENDATIONS AND CAUTIONS

- ORP readings vary slightly with temperature, but are not easily corrected because, unlike pH, the ORP value depends on the activity of many ions in solution. pH values are more easily corrected because they are due to the activity of one ion, H^+.

SENSOR CARE AND HANDLING

sensor removal tool

SENSOR REMOVAL

Use the sensor removal tool to pop the sensor out.

MAINTENANCE/INSPECTION/CLEANING

If the platinum ORP sensor appears dull or fouled, it may be cleaned with a swab dipped in alcohol. Rub gently until the platinum appears shiny. Rinse in clean water.

If a film develops on the glass electrode, or if the sensing glass or junction become dehydrated, the response may be sluggish or erratic, or the sensor may fail to calibrate. In these cases, rinse the sensor in 90% isopropyl alcohol, then soak in storage solution (Catalog No. 0065370) for at least an hour, overnight if needed. If this does not restore the response, try soaking in 0.1 M HCl solution for 5-10 minutes, followed by a thorough rinse in clean water. If the response has still not improved, replace the filling solution, or the junction.

Note: The following maintenance instructions apply to In-Situ's newest pH/ORP sensor (cat. no. 0059520). Older sensors (cat. no. 0032010 & 0032020, now discontinued) are not user-serviceable.

REPLACING THE FILLING SOLUTION

Replace the filling solution every 5-6 months, or when:

- The sensor fails to calibrate with reasonable slope and offset
- Readings drift
- Readings during calibration at pH 7 are outside the range 0±20 mV

1. Unscrew the reference junction as shown.

2. Holding the sensor at an angle, shake out the old filling solution.
3. Protect the connector end of the sensor with the soft cap it shipped with, or wrap the sensor in a paper towel to prevent solution from entering the connector.
4. Using the dispenser cap on the filling solution bottle, insert the tube into the bottom of the empty reservoir. Squeeze a steady stream of solution into the reservoir until it overflows and no bubbles are observed.

   Continue to add solution while withdrawing the tube.

5. Screw in the reference junction, and hand-tighten until snug. Some filling solution will overflow. Wipe the excess off the sensor body.
6. Soak the sensor in tap water for at least 15 minutes.
7. Recalibrate the sensor.

If necessary, thoroughly clean the electrical connector to remove filling solution: Using a disposable pipette, fill the connector with isopropyl alcohol (70% to 100%). Shake to dry. Repeat 3 times. Dry overnight. When thoroughly dry, recalibrate.

REPLACING THE JUNCTION

Replace the junction when the sensor fails to calibrate, even after replacing the filling solution.

1. Unscrew the reference junction and discard.

2. Replace the filling solution and screw in a new reference junction as described above.
3. Soak for 15 minutes in tap water, then recalibrate the sensor.

TIP: *Keep the junction damp at all times to avoid a lengthy rewetting process.*

STORAGE

Short-Term Storage (several days)

Store in the Cal Cup in tap water.

Long-Term Storage (up to several weeks)

Remove the sensor and store in the electrode storage bottle with 10-20 mL of storage solution (Catalog No. 0065370). Tighten the cap to prevent drying. Prior to use, condition the sensor by rinsing with deionized or tap water and soaking for 15 minutes.

REFERENCES

Eaton, A.D., L.S. Clesceri, E.W. Rice, and A.E. Greenberg, eds., *Standard Methods for the Examination of Water and Wastewater,* 21st edition, Washington, D.C.: American Public Health Association, American Water Works Association, and Water Environment Federation, 2005. Section 2580, Oxidation-Reduction Potential.

15 AMMONIUM

WHAT IS AMMONIUM ?

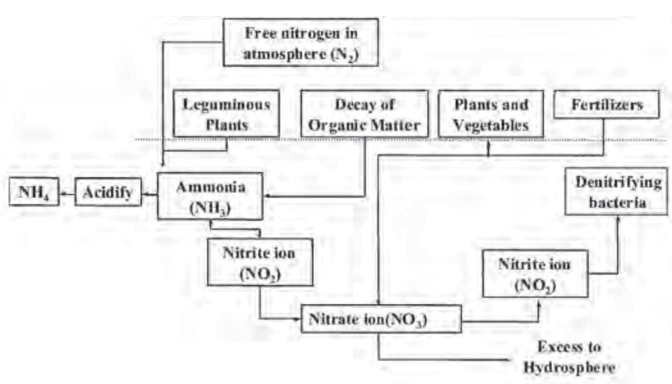
Ammonium (NH_4^+) is the ionized form of ammonia (NH_3). Ammonia and ammonium are naturally occurring forms of nitrogen, part of the nitrogen cycle. In natural waters they exist in two forms: Dissolved ammonia gas (NH_3) is highly toxic to aquatic life, while ammonium, the ionized form (NH_4^+), is not. Both may be grouped together as "total ammonia."

The ammonia/ammonium equilibrium in water is closely related to pH levels. At a pH of 6.5 almost all ammonia is in the form of ammonium. However, as the pH increases (becomes more basic), ammonium is changed into harmful ammonia. Ammonium ions are the predominant species in most unpolluted natural water systems where the pH is typically less than 9. Even a small amount of ammonia is detrimental to fish while a moderate amount of ammonium is tolerated. The lethal dose of ammonia for trout is only 0.2 mg/L.

WHY MEASURE AMMONIUM?

Major sources of ammonium are wastewater from sewage treatment plants, and nitrogen in fertilizers which is transformed to ammonium in soil by microorganisms. Ammonia/ammonium can be a key parameter in the assessment of water and wastewater quality. Measurement of ammonium can yield information on the composition and movement of pollutants in groundwater and surface water, landfill leachate, runoff from agricultural activities, waste concentrations in fisheries, and nutrient levels in natural water bodies.

THE NITROGEN CYCLE



THE AMMONIUM SENSOR

The In-Situ sensor is an ion-selective electrode (ISE) that is selective for the ammonium ion (NH_4^+). It is a double-junction combination ISE with a silver/silver-chloride reference half-cell, PVC sensing membrane, and reference electrolyte gel. It measures the concentration in parts per million of ammonium ion in solution (calculated as nitrogen, ppm as N).

SENSOR PREPARATION

To ensure optimum membrane response, the ammonium sensor should be thoroughly hydrated in an appropriate solution before calibration. A good way to do this is to allow the sensor to soak in the solution you plan to use for the first calibration point (lowest concentration) for at least 15 minutes and up to several days before calibration and use.

- 1.4 ppm N for calibration in the lower range (concentrations less than 14 ppm N)
- 140 ppm N for calibration in the upper range (concentrations of 14 ppm N and up)

The sensor kit includes an empty bottle for this purpose.

SENSOR INSTALLATION

Unpack the ammonium sensor, hydrate it as above, and install in port 1, 2, or 3 in the sensor block at the front end of the MP TROLL 9500 as follows.

TIP: *Remember that a polarographic D.O. sensor (if present) will operate properly only in port 2 and a turbidity wiper accessory only in port 3.*

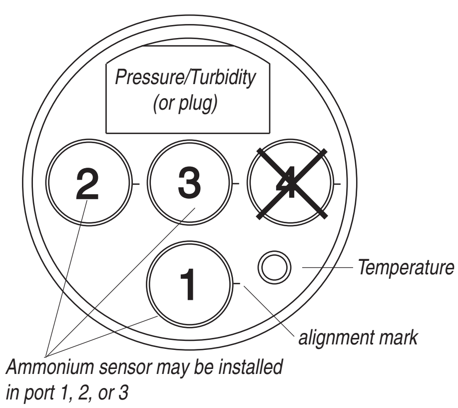
1. Remove the restrictor from the front end of the MP TROLL 9500. This allows access to the sensor block depicted in the drawing below.
2. Remove the sensor's protective cap or storage bottle and set aside for future storage of the sensor. If the connector end is covered with a cap, remove it also.
3. Remove any moisture or dirt from the area around the port where you will install the sensor, then use the sensor removal tool to remove the plug from the port where you will install the sensor.

4. Remove any moisture or dirt from the port connector with a clean swab or tissue.
5. Check lubrication of the sensor o-rings.

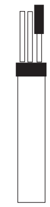
TIP: *The sensor o-rings require generous lubrication before installation. New sensors will be lubricated at the factory. If the o-rings appear dry, apply apply a silicone lubricant before installation.*

6. Handling the sensor by the sides, not the tip, align the mark on the side of the sensor with the mark on the port.

Avoid touching the membrane at the tip of the sensor. Contaminants on the membrane can change its properties and affect measurements.



7. Use the sensor insertion tool to firmly press the sensor into the port until you feel it dock with the connector at the bottom. When properly inserted a small gap (width of the sensor removal tool) remains between the widest part of the sensor and the instrument body, for ease of removal.



CALIBRATION

OVERVIEW

The software offers several options for ammonium calibration.

- **Three-point bithermal** ("two-temperature") calibration. The first two calibration points are taken in solutions of different concentrations at the same temperature. The third point uses one of these solutions at a temperature that is at least 10° higher or lower depending on anticipated field conditions. This type of calibration allows determination of the sensor's "isopotential point"—the ion concentration at which changes in temperature do not cause a change in sensor response (voltage). A three-point bithermal calibration is recommended before the first use of the sensor, and regularly thereafter, to insure accurate readings at all potential temperatures.
- **Two-point isothermal** ("same temperature") calibration using solutions of two different concentrations. A two-point isothermal calibration calculates the sensor's slope and offset but cannot compute the isopotential point. For best results this type of calibration should be carried out as close as possible to the temperature at which the sensor will be used. Or, It may be performed after a previous three-point bithermal calibration to recalculate the slope and offset of an aging sensor while retaining the previously calculated isopotential point.
- **Single-point** calibration. After the initial three-point bithermal calibration has established the sensor slope, offset, and isopotential point, a single-point calibration may be used with good results to adjust the offset on a daily basis.

CALIBRATION SOLUTIONS

Ammonium chloride (NH_4Cl) solutions certified to N.I.S.T. standards are supplied in the In-Situ Ammonium Calibration Kits:

14.0 ppm as N
140 ppm as N
1400 ppm as N

Specialized calibration kits are available for calibrating the ammonium sensor for low-range and high-range measurements:

Low range: two quarts each 14 ppm and 140 ppm
High range: two quarts each 140 ppm and 1400 ppm

RECOMMENDED CALIBRATION FREQUENCY

Ion-selective electrodes are inherently unstable and drift is quite normal. To achieve the most accurate sensor response, we recommend a complete three-point bithermal calibration once a week, with a single-point calibration daily or after 4-6 hours of use.

PREPARING TO CALIBRATE

You will need:

- MP TROLL 9500 with the hydrated ammonium sensor installed and sensors or plugs in the other sensor ports
- Cal Cup
- One, two, or three ammonium calibration solutions, selected for the range you expect to measure. When performing a multi-point calibration, begin with the lowest-concentration solution.
- For a three-point bithermal calibration: a temperature bath, or container of ice large enough to hold the Cal Cup (and stirrer, if used).
- Stirrer: Use a stirrer during calibration if it will also be used in the field—for example, in stagnant or very slowly moving water. The more closely calibration conditions reflect field conditions, the more successful the calibration. For more information on the stirrer, see “Stirring” in Section 10.

AMMONIUM CALIBRATION PROCEDURE

1. Rinse the Cal Cup and front end of the MP TROLL 9500 in clean water. Shake to dry.

   For best results, follow this with a rinse in a portion of the selected calibration solution. Discard the rinse solution.

2. Insure the black PVC base (or the stirrer) is attached to the Cal Cup, and fill the Cal Cup to the fill line with the selected calibration solution.
   - Begin with the lowest concentration when performing a multi-point calibration.
   - With a full complement of sensors installed, use the lower line as a guide.
   - With 1 or 2 removable sensors installed, fill to the upper line.

3. Insert the front end of the MP TROLL 9500 into the open end of the Cal Cup. Thread the Cal Cup onto the body until seated against the o-ring, then back off slightly to avoid overtightening.

   To stabilize the instrument, you may wish to use a calibration stand or other support.

Cal Cup

3

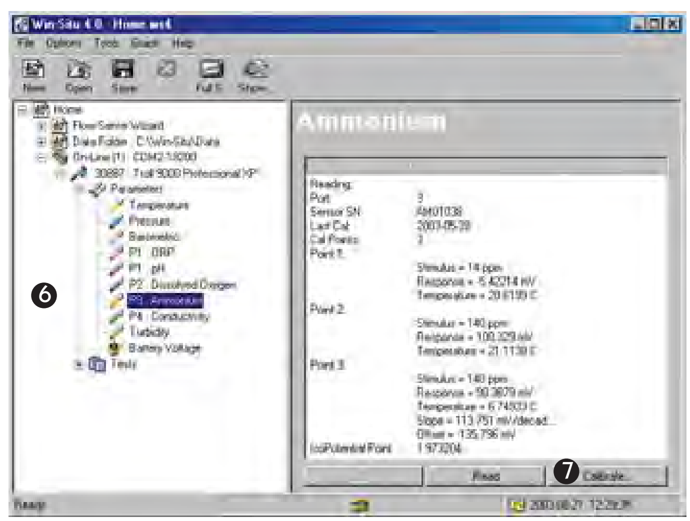
Stirrer (optional)

4. Connect the MP TROLL 9500 to a PC and establish a connection in Win-Situ 4 or Pocket-Situ 4. Win-Situ screens are illustrated here. The Pocket-Situ interface is similar, with the Navigation tree at the top of the screen and the Information pane below it.

5. Select the MP TROLL 9500 in the Navigation tree.

   The software will automatically detect and display the installed sensors. If one or more sensors is installed in the wrong port, an error message will be displayed. Simply remove the sensor and install it in the correct position, then “refresh” the device before continuing.

6. Select Ammonium in the Parameters list. The sensor serial number (SN) and recent calibration information is displayed.



7. Select **Calibrate**.

The Ammonium Calibration Wizard starts. A screen like this is displayed.

8. Select the number of calibration points for this calibration, and the concentration (ppm) of the calibration solution for each point.

   Cal point 1 is the solution the sensor is soaking in now, the lowest concentration for a multi-point calibration. If doing a three-point bithermal cal, choose cal point 3 to be the same as either cal point 1 or cal point 2.

9. Select **Next** to continue.

10. In the next screen, select **Run** to begin the stabilization.

   The display will continuously update as readings are taken and compared against the stabilization criteria.

- Status indicators:

  NOT TESTED is displayed until you begin the calibration by selecting Run.

  UNSTABLE indicates the sensor response does not meet the criteria for a valid calibration point.

  NOMINAL indicates the sensor deviation meets early stabilization criteria.

  The **Accept** button becomes available when nominal stability is achieved. You may accept the early value, or wait for complete stability. If you accept the early value, the calibration point will be designated "USER SET" in the calibration report. (For more on calibration reports, see "Calibration History" in Section 10.)

  STABLE is displayed when the readings have stabilized sufficiently to take a valid calibration point. The calibration proceeds automatically to the next screen.

- Sensor Reading: The current sensor response in milliVolts.
- Deviation: Change in sensor response between the last two readings.
- Current temperature is also displayed.

11. If doing a single-point calibration, go to step 16.

    For a multi-point calibration, the Wizard returns to the screen shown at step 10 and waits for you to situate the probe in the next calibration solution and click Run.

12. Remove the Cal Cup, discard the first solution, rinse the Cal Cup and the front end of the instrument with clean water, followed by a rinse in the next calibration solution, refill the Cal Cup with the second solution, and attach it to the instrument.

    TIP: *The used calibration solution may be flushed down the drain with running water, or saved in a separate container and used as a rinse the next time you calibrate with the same solution.*

13. Select **Run** to begin the stabilization for cal point 2. Status indicators and controls are the same as for cal point 1 (step 10).

    Again wait for Stable status (or click Accept when Nominal is indicated).

    If doing a two-point calibration, go to step 16.

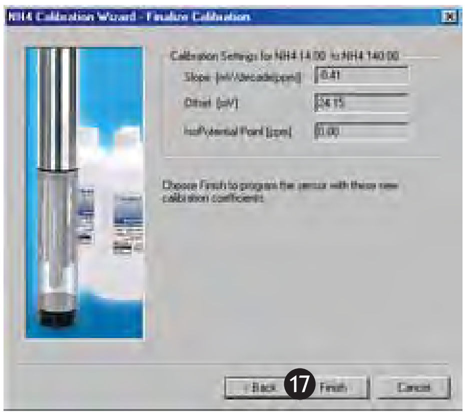
14. For the third calibration point, use the cal point 1 or cal point 2 solution (as specified in step 8) but change the temperature by at least 10°C. A convenient way to do this is to move the probe—Cal Cup and all—into a temperature-controlled bath or container of ice. Allow time for the sensor to reach thermal equilibration with the solution temperature. With stirring or agitation, this should take about 10 minutes, perhaps up to 30 minutes if left undisturbed.

15. When the temperature is stable, select **Run** for cal point 3.

    When Nominal is accepted or Stable is indicated for cal point 3, the final screen is displayed.

16. The final screen of the Calibration Wizard shows the sensor slope and offset calculated during the calibration process. For a three-point bithermal calibration, the calculated isopotential point is shown. If a single-point calibration has been performed, the isopotential point is the one calculated during the last three-point bithermal calibration.

17. Select **Finish** to program the sensor with the newly calculated calibration coefficients.



The ammonium sensor is now calibrated and ready to use.

> ***TIP:*** *You can look at the calibration report right after calibrating, or at any time. See "Calibration History" in Section 10 for details.*

Options for storing sensors:

The ammonium sensor should calibrated immediately before use. If storage is necessary, remove the sensor from the instrument and immerse in 14 ppm N solution, for later use in the low ammonium range, or 140 ppm N solution, for use in the high range.

SENSOR SLOPE AND OFFSET

The expected slope for a new sensor is about 56 (± 2) mV per decade of concentration (ppm). The calibration curve begins to deviate from linear at about 1 ppm. The sensor's zero offset is recalculated with each single-point calibration.

UNITS AND CALCULATED MEASUREMENTS

Ammonium ion concentration is reported in ppm (equivalent to mg/L). No calculated measurements are currently available.

USAGE RECOMMENDATIONS AND CAUTIONS

Ammonium Sensor	
Operating Temperature	-5°C to 40°C (23°F to104°F) continuous temperature; can tolerate up to 50°C (122°F) intermittently
Pressure Rating	20 psi (14 m, 46 ft)
pH range	up to 8.5

> *Do not submerge the ammonium sensor deeper than 46 ft (14 m). Do not use in the basic pH range (8.5 or higher).*

pH

The sensor's pH range is that range over which a change in pH will not cause a significant change in the measured voltage. It is the plateau on a graph of pH against mV at constant concentration of the detected ion. Outside this range, a change in pH may cause a significant change in the measured mV.

TEMPERATURE

The higher the temperature, the shorter the lifetime of the electrode. 1°C difference in temperature causes a 2% error at 10 ppm, unless a bithermal calibration is performed.

CONDUCTIVITY

In saline waters (conductivities of 1,000 µS/cm or higher), the presence of interfering ions such as sodium or potassium may limit the usability of the ammonium sensor.

POTENTIAL INTERFERENCES

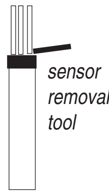
The following table lists concentrations of possible interfering ions that cause 10% error at various levels of NH_4^+.

Ion	100 ppm NH_4^+	10 ppm NH_4^+	1 ppm NH_4^+
Cs^+	100	10	1
K^+	270	27	2.7
Tl^+	3100	310	31
H^+	pH 1.6	pH 2.6	pH 3.6
Ag^+	270,000	27,000	2700
Li^+	35,000	3500	350
Na^+	11,100	1,100	110

SENSOR CARE AND HANDLING

SENSOR REMOVAL

Position the yoke of the sensor removal tool at the point where the sensor meets the sensor block and pry the sensor upward.



Avoid touching the membrane at the tip of the sensor. Contaminants on the membrane can change its properties and affect measurements.

MAINTENANCE/INSPECTION/CLEANING

As long as extreme pH and high organic solvent content is avoided, the sensor should last for several months at room temperature. Eventually some of the components will leach out, and this will affect the response (detection limit and scope), but this can be compensated through calibration.

If film buildup is visible on the membrane, rinse under a gentle stream of clean water, or swish gently in a mild detergent solution, rinse well with clean water, and shake to dry.

To avoid depletion of the reference solution, do not allow the sensor to soak in pure water for more than a few minutes at a time.

The electrode is not customer-refillable.

STORAGE

Store the sensor immersed in 14 or 140 ppm N solution, depending on usage requirements, rather than dry or in DI water.

REFERENCES

Eaton, A.D., L.S. Clesceri, E.W. Rice, and A.E. Greenberg, eds., *Standard Methods for the Examination of Water and Wastewater,* 21st edition, Washington, D.C.: American Public Health Association, American Water Works Association, and Water Environment Federation, 2005. Section 4500-NH_3 Nitrogen (Ammonia). D. Ammonia-Selective Electrode Method.

EPA, Methods for Chemical Analysis of Water and Wastes, EPA/600/4-79-020, revised March 1983. Method 350.3, Nitrogen, Ammonia, Potentiometric, Ion Selective Electrode. Approved at 40 CFR Part 136.

Rundle, Chris C., A Beginners Guide to Ion-Selective Electrode Measurements. Nico2000 Ltd., London, UK. On the web at www.nico2000.net

U.S. Geological Survey, Office of Water Quality Technical Memorandum 93.12: Water Resources Division Nomenclature Conventions for Reporting Concentrations of Ammonium Ions and Ammonia in Natural Waters. August 26, 1993.

16 CHLORIDE

WHAT IS CHLORIDE?

Chloride (Cl^-) is a highly soluble ion in water and can potentially be present in high concentrations. Chloride enters the water supply when runoff from rain or irrigation dissolves a variety of chloride-containing salts in rock and soil. Freshwater sources, streams, lakes, and underground aquifers typically have less than 10 ppm Cl^-. Some waters with as little as 250 ppm Cl^- will taste salty to sensitive individuals, especially if the sodium cation (Na^+) is also present. Wastewater from sewage or industrial facilities will normally contain higher amounts of chloride. Chloride is naturally present in higher concentrations near coastal areas where it can infiltrate canals and sewers.

WHY MEASURE CHLORIDE?

Chloride ions are not toxic to humans. However, a high chloride content may harm some structures, especially those made of metal. Chloride can increase the rate of corrosion on metals in the presence of water. Vegetation is also sensitive to the amount of chloride in the soil. Agriculturally productive soils can be turned into unproductive wastelands over a period of time by irrigating with water containing high amounts of chloride. The WHO (World Health Organization) has established 100 ppm Cl^- as a maximum for water used for irrigation, while 250 ppm Cl^- is the maximum for drinking water.

THE CHLORIDE SENSOR

The In-Situ sensor is an ion-selective electrode (ISE) that is selective for the chloride ion (Cl^-). It is a double-junction combination ISE with a silver/silver-chloride reference half-cell, solid-state sensing electrode, and reference electrolyte gel. It measures the concentration in parts per million of chloride ion in solution (ppm Cl^-).

Typical Chloride values

Fresh water	< 10 ppm Cl^-
Sea water	20,000 ppm Cl^-
Irrigation water standard (WHO)	100 ppm Cl^-
Drinking water standard (WHO)	250 ppm Cl^-

SENSOR PREPARATION

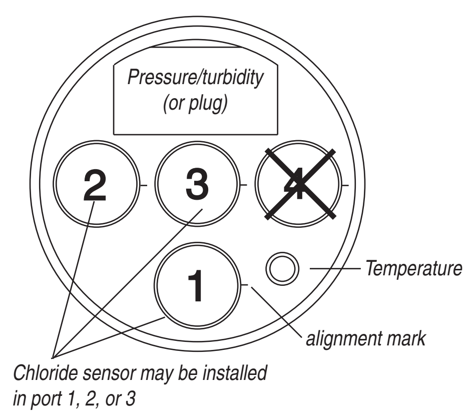
To insure the chloride sensor is thoroughly hydrated, soak it in distilled water for about 15 minutes before installation. The sensor kit includes an empty bottle for this purpose. Unlike the ammonium and nitrate sensors, the solid-state chloride sensor does not require soaking in a solution of specific concentration.

SENSOR INSTALLATION

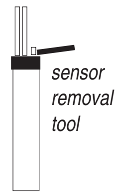
Unpack the chloride sensor, hydrate it as described above, and install in port 1, 2, or 3 in the sensor block at the front end of the MP TROLL 9500 as follows.

***TIP:** Remember that a polarographic D.O. sensor (if present) will operate properly only in port 2, and a turbidity wiper accessory only in port 3 .*

1. Remove the restrictor from the front end of the MP TROLL 9500. This allows access to the sensor block depicted in the drawing below.



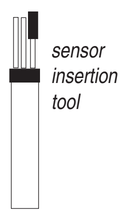
2. Remove the sensor's protective cap or storage bottle and set aside for future storage of the sensor.
3. Remove any moisture or dirt from the area around the port where you will install the sensor, then use the sensor removal tool to remove the plug from the port where you will install the sensor.



4. Remove any moisture or dirt from the port connector with a clean swab or tissue.
5. Check lubrication of the sensor o-rings.

TIP: *The sensor o-rings require generous lubrication before installation. New sensors will be lubricated at the factory. If the o-rings appear dry, apply apply a silicone lubricant before installation.*

6. Handling the sensor by the sides, not the tip, align the mark on the side of the sensor with the mark on the port.
7. Use the sensor insertion tool to firmly press the sensor into the port until you feel it dock with the connector at the bottom. When properly inserted a small gap (width of the sensor removal tool) remains between the widest part of the sensor and the instrument body, for ease of removal.



CALIBRATION

OVERVIEW

The software offers several options for chloride calibration.

- **Three-point bithermal** ("two-temperature") calibration. The first two calibration points are taken in solutions of different concentrations at the same temperature. The third point uses one of these solutions at a temperature that is at least 10° higher or lower depending on anticipated field conditions. This type of calibration allows determination of the sensor's "isopotential point"—the ion concentration at which changes in temperature do not cause a change in sensor response (voltage). A three-point bithermal calibration is recommended before the first use of the sensor, and regularly thereafter, to insure accurate readings at all potential temperatures.
- **Two-point isothermal** ("same temperature") calibration using solutions of two different concentrations. A two-point isothermal calibration calculates the sensor's slope and offset but cannot compute the isopotential point. For best results this type of calibration should be carried out as close as possible to the temperature at which the sensor will be used. Or, it may be performed after a previous three-point bithermal calibration to recalculate the slope and offset of an aging sensor while retaining the previously calculated isopotential point.
- **Single-point** calibration. After the initial three-point bithermal calibration has established the sensor slope, offset, and isopotential point, a single-point calibration may be used with good results to adjust the offset on a daily basis.

CALIBRATION SOLUTIONS

Sodium chloride (NaCl) solutions certified to N.I.S.T. standards are supplied in the In-Situ Chloride Calibration Kits:

35.5 ppm Cl^-
355 ppm Cl^-
3545 ppm Cl^-

Specialized calibration kits are available for calibrating the chloride sensor for low-range and high-range measurements:

Low range: two quarts each 35.5 ppm and 355 ppm
High range: two quarts each 355 ppm and 3545 ppm

RECOMMENDED CALIBRATION FREQUENCY

Ion-selective electrodes are inherently unstable and drift is quite normal. To achieve the most accurate sensor response, we recommend a complete three-point bithermal calibration once a week, with a single-point calibration daily or after 4-6 hours of use.

PREPARING TO CALIBRATE

You will need:

- MP TROLL 9500 with the hydrated chloride sensor installed and sensors or plugs in the other sensor ports
- Cal Cup
- One, two, or three chloride calibration solutions, selected for the range you expect to measure. When performing a multi-point calibration, begin with the lowest-concentration solution.
- For a three-point bithermal calibration: a temperature bath, or a container of ice large enough to hold the Cal Cup (and stirrer, if used).
- Stirrer: Use a stirrer during calibration if it will also be used in the field—for example, in stagnant or very slowly moving water. The more closely calibration conditions reflect field conditions, the more successful the calibration. For more information on the stirrer, see "Stirring" in Section 10.

CHLORIDE CALIBRATION PROCEDURE

1. Rinse the Cal Cup and front end of the MP TROLL 9500 in clean water. Rinse very thoroughly if the chloride sensor has recently been exposed to pH buffers during a pH calibration. Shake to dry.

   For best results, follow this with a rinse in a portion of the selected calibration solution. Discard the rinse solution.

2. Insure the black PVC base (or the stirrer) is attached to the Cal Cup, and fill the Cal Cup to the fill line with the selected calibration solution.

   - Begin with the lowest concentration when performing a multi-point calibration.
   - With a full complement of sensors installed, use the lower line as a guide.
   - With 1 or 2 removable sensors installed, fill to the upper line.

3. Insert the front end of the MP TROLL 9500 into the open end of the Cal Cup. Thread the Cal Cup onto the body until seated against the o-ring, then back off slightly to avoid overtightening.

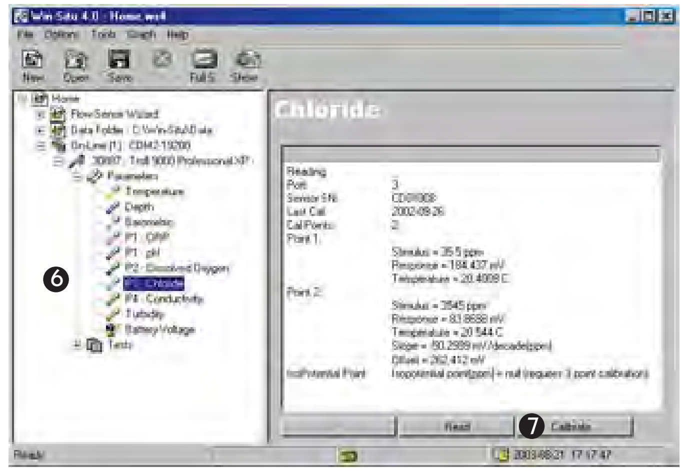
   To stabilize the instrument, you may wish to use a calibration stand or other support.

4. Connect the MP TROLL 9500 to a PC and establish a connection in Win-Situ 4 or Pocket-Situ 4. Win-Situ screens are illustrated here. The Pocket-Situ interface is similar, with the Navigation tree at the top of the screen and the Information pane below it.

5. Select the MP TROLL 9500 in the Navigation tree.

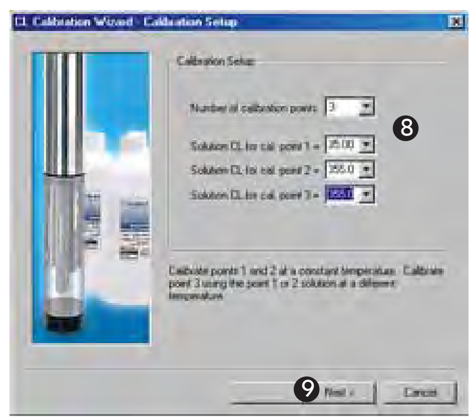
   The software will automatically detect and display the installed sensors. If one or more sensors is installed in the wrong port, an error message will be displayed. Simply remove the sensor and install it in the correct position, then "refresh" the device before continuing.

6. Select Chloride in the Parameters list. The sensor serial number (S/N) and recent calibration information is displayed.



7. Select **Calibrate**.

   The Chloride Calibration Wizard starts. A screen like this is displayed.

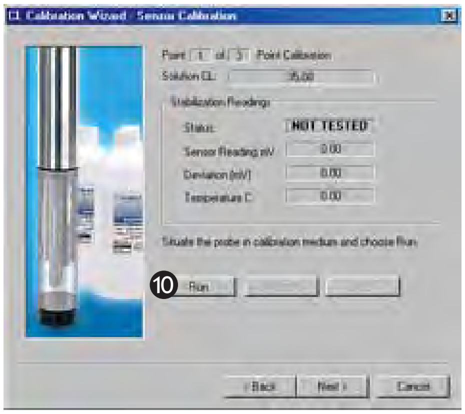


8. Select the number of calibration points for this calibration, and the concentration (ppm) of the calibration solution for each point.

   Cal point 1 is the solution the sensor is soaking in now, the lowest concentration for a multi-point calibration. If doing a three-point bithermal cal, choose cal point 3 to be the same as either cal point 1 or cal point 2.

9. Select **Next** to continue.

10. In the next screen, select **Run** to begin the stabilization.



The display will continuously update as readings are taken and compared against the stabilization criteria.

- Status indicators:

  NOT TESTED is displayed until you begin the calibration by selecting Run.

  UNSTABLE indicates the sensor response does not meet the criteria for a valid calibration point.

  NOMINAL indicates the sensor deviation meets early stabilization criteria.

  The **Accept** button becomes available when nominal stability is achieved. You may accept the early value, or wait for complete stability. If you accept the early value, the calibration point will be designated “USER SET” in the calibration report. (For more on calibration reports, see “Calibration History” in Section 10.)

  STABLE is displayed when the readings have stabilized sufficiently to take a valid calibration point. The calibration proceeds automatically to the next screen.

- Sensor Reading: The current sensor response in milliVolts.
- Deviation: Change in sensor response between the last two readings.
- Current temperature is also displayed.

11. If doing a a single-point calibration, go to step 16.

    For a multi-point calibration, the Wizard returns to the screen shown at step 10 and waits for you to situate the probe in the next calibration solution and click Run.

12. Remove the Cal Cup, discard the first solution, rinse the Cal Cup and the front end of the instrument in clean water, followed by a rinse in the next calibration solution, refill the Cal Cup with the second solution, and attach it to the instrument.

    TIP: *The used calibration solution may be flushed down the drain with running water, or saved in a separate container and used as a rinse the next time you calibrate with the same solution.*

13. Select **Run** to begin the stabilization for cal point 2. Status indicators and controls are the same as for cal point 1 (step 10).

    Again wait for Stable status (or click Accept when Nominal is indicated).

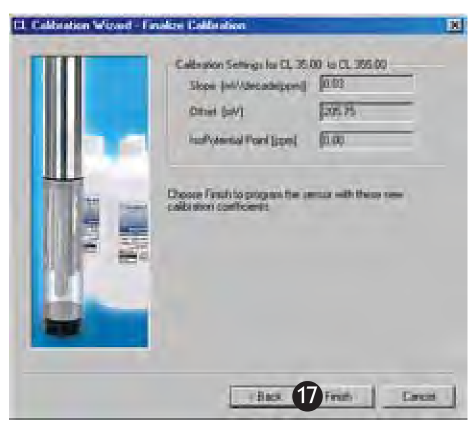
    If doing a two-point calibration, go to step 16.

14. For the third calibration point, use the cal point 1 or cal point 2 solution (as specified in step 8) but change the temperature by at least 10°C. A convenient way to do this is to move the probe—Cal Cup and all—into a temperature-controlled bath or container of ice. Allow time for the sensor to reach thermal equilibration with the solution temperature. With stirring or agitation, this should take about 10 minutes, perhaps up to 30 minutes if left undisturbed.

15. When the temperature is stable, select **Run** for cal point 3.

    When Nominal is accepted or Stable is indicated for cal point 3, the final screen is displayed.

16. The final screen of the Calibration Wizard shows the calculated sensor slope and offset. For a three-point bithermal calibration, the isopotential point is shown. If a single-point calibration has been performed, the isopotential point is the one calculated during the last three-point bithermal calibration.



17. Select **Finish** to program the sensor with the newly calculated calibration coefficients.

The chloride sensor is now calibrated and ready to use.

TIP: *You can look at the calibration report right after calibrating, or at any time. See "Calibration History" in Section 10 for details.*

Options for storing sensors:

The sensor should calibrated immediately before use. If storage is necessary, remove the sensor from the instrument and immerse in 35 ppm Cl solution, for later use in the low chloride range, or 355 ppm Cl solution, for use in the high range.

SENSOR SLOPE AND OFFSET

The expected slope for a new sensor is about 57 (± 2) mV per decade of concentration (ppm). The calibration curve begins to deviate from linear at about 10 ppm. The sensor's zero offset is recalculated with each single-point calibration.

UNITS AND CALCULATED MEASUREMENTS

Chloride ion concentration is reported in ppm (equivalent to mg/L). No calculated measurements are available.

USAGE RECOMMENDATIONS AND CAUTIONS

Chloride sensor	
Operating Temperature	-5°C to 50°C (23°F to 122°F) continuous temperature; can tolerate up to 60°C (140°F) intermittently
Pressure Rating	100 psi (70 m, 231 ft)
pH range	2 to 12

Do not submerge the chloride sensor deeper than 231 ft (70 m).

pH EFFECTS

The sensor's pH range is that range over which a change in pH will not cause a significant change in the measured voltage. It is the plateau on a graph of pH against mV at constant concentration of the detected ion. Outside this range, a change in pH may cause a significant change in the measured mV.

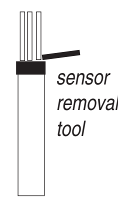
POTENTIAL INTERFERENCES

The table on this page lists possible interfering ions that cause 10% error at various levels of Cl^-.

Ion	100 ppm Cl^-	10 ppm Cl^-	1 ppm Cl^-
OH^-	8000	800	80
NH_3	12	1.2	0.12
$S_2O_3^{2-}$	1	0.1	0.01
Br^-	0.3	0.03	0.003
S^{2-}	10^{-4}	10^{-5}	10^{-6}
I^-	$5x10^{-5}$	$5x10^{-6}$	$5x10^{-7}$
CN^-	$2x10^{-5}$	$2x10^{-6}$	$2x10^{-7}$
Complexes with BI^{3+}, Cd^{2+}, Mn^{2+}, Pb^{2+}, Sn^{2+}, Tl^{3+} and reducing agents			

SENSOR CARE AND HANDLING

SENSOR REMOVAL



To remove the sensor, position the yoke of the sensor removal tool at the point where the sensor meets the sensor block and pry the sensor upward.

MAINTENANCE/INSPECTION/CLEANING

If a film should form on the top of the membrane, use a swab to remove it, followed by a rinse in deionized water and soaking for a few minutes in a solution of 35 ppm or 355 ppm Cl.

To avoid depletion of the reference solution, do not allow the sensor to soak in pure water for more than a few minutes at a time.

The electrode is not customer-refillable.

STORAGE

Store the sensor immersed in 35 or 355 ppm Cl solution, depending on usage requirements. For longer-term storage, it may be rinsed and stored dry to avoid depletion of the reference solution.

17 NITRATE

WHAT IS NITRATE ?

Nitrogen is an essential nutrient for plants and animals. It exists in the environment in many different forms, constantly being replenished as part of the nitrogen cycle. Nitrate (NO_3^-) is one form of nitrogen in the ecosystem that is very soluble in water. Nitrate enters the water system when runoff from rainfall or irrigation washes through soils that contain nitrate. The nitrate dissolves in the water and is carried to nearby streams and lakes. It also permeates downward into the soil where it may enter underground aquifers. The concentration of nitrogen in a body of water depends mostly upon the land cover and soil type. Highest concentrations are associated with shallow groundwater and agricultural use of the land. Agriculture is a large contributor to the pollution of surface water and groundwater because of the use of fertilizers that contain nitrate. Also, densely populated livestock produce large quantities of manure that can be changed into nitrate upon decay.

Nitrate remains in surface water until it is consumed as a nutrient by plants or other organisms. Surface streams have nitrate concentrations ranging from 0.1 to 20 ppm N. Levels as high as 30 ppm N are found in wastewater discharges and wastewater effluent plants while levels as low as 0.05 ppm N are found in unpolluted groundwater.

WHY MEASURE NITRATE?

High nitrate levels in drinking water are associated with health problems. Nitrate is reduced to nitrite in the digestive system, where it may then oxidize iron in the hemoglobin molecule of red blood cells to form methemoglobin. Methemoglobin lacks the capacity to bind and carry oxygen to tissues. As a result of this health risk, the EPA has established 10 ppm N as the maximum limit of nitrate in drinking water for the USA.

Typical Nitrate values

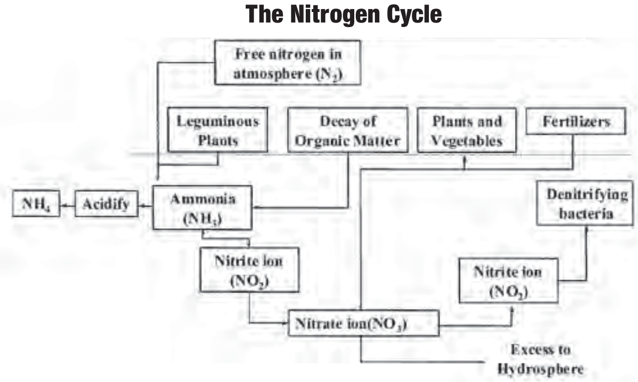
Unpolluted groundwater	0.05 ppm N
Surface water	0.1 to 20 ppm N
Waste water	~ 30 ppm N
Drinking water standard (EPA)	10 ppm N

High levels of nitrate in lakes can lead to a process called eutrophication. Nitrates are nutrients for aquatic plants and algae, causing overproduction when present in excessive levels. This accelerated growth or bloom can eventually lead to a number of negative impacts on the aquatic environment such as a reduction in dissolved oxygen, which can lead to the death of fish and other aquatic life. Reduction of sunlight to submerged aquatic vegetation due to increased coverage on the surface causes a corresponding reduction in photosynthesis and eventual death.

THE NITRATE SENSOR

The In-Situ sensor is an ion-selective electrode (ISE) that is selective for the nitrate ion (NO_3^-). It is a double-junction combination ISE with a silver/silver-chloride reference half-cell, PVC membrane, and reference electrolyte gel. It measures the concentration in parts per million of nitrate ion in solution (calculated as nitrogen, ppm as N).

The Nitrogen Cycle



SENSOR PREPARATION

To ensure optimum membrane response, the nitrate sensor should be thoroughly hydrated in an appropriate solution before calibration. A good way to do this is to allow the sensor to soak in the solution you plan to use for the first calibration point (lowest concentration) for at least 15 minutes and up to several days before calibration and use.

- 1.4 ppm N for calibration in the lower range (concentrations less than 14 ppm N)
- 140 ppm N for calibration in the upper range (concentrations of 14 ppm N and up)

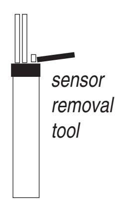
The sensor kit includes an empty bottle for this purpose.

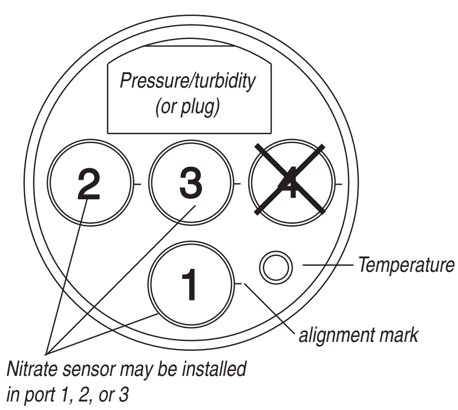
SENSOR INSTALLATION

Unpack the nitrate sensor, hydrate it as above, and install in port 1, 2, or 3 in the sensor block at the front end of the MP TROLL 9500 as follows.

TIP: *Remember that a polarographic D.O. sensor (if present) will operate properly only in port 2 and a turbidity wiper accessory only in port 3.*

1. Remove the restrictor from the front end of the MP TROLL 9500. This allows access to the sensor block depicted in the drawing below.
2. Remove the sensor's protective cap or storage bottle and set aside for future storage of the sensor. If the connector end is covered with a cap, remove it also.
3. Remove any moisture or dirt from the area around the port where you will install the sensor, then use the sensor removal tool to remove the plug from the port where you will install the sensor.





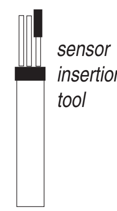
4. Remove any moisture or dirt from the port connector with a clean swab or tissue.
5. Check lubrication of the sensor o-rings.

TIP: *The sensor o-rings require generous lubrication before installation. New sensors will be lubricated at the factory. If the o-rings appear dry, apply apply a silicone lubricant before installation.*

6. Handling the sensor by the sides, not the tip, align the mark on the side of the sensor with the mark on the port.

Avoid touching the membrane at the tip of the sensor. Contaminants on the membrane can change its properties and affect measurements.

7. Use the sensor insertion tool to firmly press the sensor into the port until you feel it dock with the connector at the bottom. When properly inserted a small gap (width of the sensor removal tool) remains between the widest part of the sensor and the instrument body, for ease of removal.



CALIBRATION

OVERVIEW

The software offers several options for nitrate calibration.

- **Three-point bithermal** ("two-temperature") calibration. The first two calibration points are taken in solutions of different concentrations at the same temperature. The third point uses one of these solutions at a temperature that is at least 10° higher or lower depending on anticipated fieldconditions. This type of calibration allows determination of the sensor's "isopotential point"—the ion concentration at which changes in temperature do not cause a change in sensor response (voltage). A three-point bithermal calibration is recommended before the first use of the sensor, and regularly thereafter, to insure accurate readings at all potential temperatures.
- **Two-point isothermal** ("same temperature") calibration using solutions of two different concentrations. A two-point isothermal calibration calculates the sensor's slope and offset but cannot compute the isopotential point. For best results this type of calibration should be carried out as close as possible to the temperature at which the sensor will be used. Or, It may be performed after a previous three-point bithermal calibration to recalculate the slope and offset of an aging sensor while retaining the previously calculated isopotential point.

- **Single-point** calibration. After the initial three-point bithermal calibration has established the sensor slope, offset, and isopotential point, a single-point calibration may be used with good results to adjust the offset on a daily basis.

CALIBRATION SOLUTIONS

Potassium nitrate (KNO_3) solutions certified to N.I.S.T. standards are supplied in the In-Situ Nitrate Calibration Kits:

14.0 ppm as N
140 ppm as N
1400 ppm as N

Specialized calibration kits are available for calibrating the nitrate sensor for low-range and high-range measurements:

Low range: two quarts each 14.0 ppm and 140 ppm
High range: two quarts each 140 ppm and 1400 ppm

RECOMMENDED CALIBRATION FREQUENCY

Ion-selective electrodes are inherently unstable and drift is quite normal. To achieve the most accurate sensor response, we recommend a complete three-point bithermal calibration once a week, with a single-point calibration daily or after 4-6 hours of use.

PREPARING TO CALIBRATE

You will need:

- MP TROLL 9500 with the hydrated nitrate sensor installed and sensors o0r plugs in the other sensor ports
- Cal Cup
- One, two, or three nitrate calibration solutions, selected for the range you expect to measure. When performing a multi-point calibration, begin with the lowest-concentration solution
- For a three-point bithermal calibration: a temperature bath, or a container of ice large enough to hold the Cal Cup (and stirrer, if used).
- Stirrer: Use a stirrer during calibration if it will also be used in the field—for example, in stagnant or very slowly moving water. The more closely calibration conditions reflect field conditions, the more successful the calibration. For more information on the stirrer, see “Stirring” in Section 10.

NITRATE CALIBRATION PROCEDURE

1. Rinse the Cal Cup and front end of the MP TROLL 9500 in clean water. Shake to dry.

   For best results, follow this with a rinse in a portion of the selected calibration solution. Discard the rinse solution.

2. Insure the black PVC base (or the stirrer) is attached to the Cal Cup, and fill the Cal Cup to the fill line with the selected calibration solution.
   - Begin with the lowest concentration when performing a multi-point calibration.
   - With a full complement of sensors installed, use the lower line as a guide.
   - With 1 or 2 removable sensors installed, fill to the upper line.

3. Insert the front end of the MP TROLL 9500 into the open end of the Cal Cup. Thread the Cal Cup onto the body until seated against the o-ring, then back off slightly to avoid overtightening.

   To stabilize the instrument, you may wish to use a calibration stand or other support.

4. Connect the MP TROLL 9500 to a PC and establish a connection in Win-Situ 4 or Pocket-Situ 4. Win-Situ screens are illustrated here. The Pocket-Situ interface is similar, with the Navigation tree at the top of the screen and the Information pane below it.

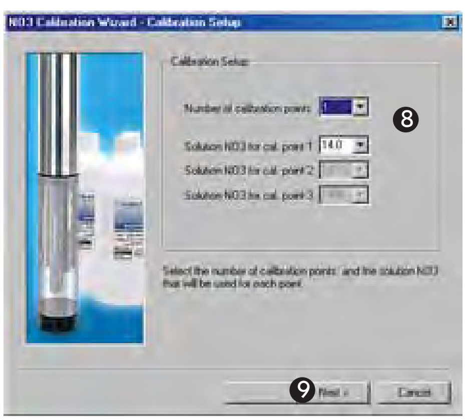
5. Select the MP TROLL 9500 in the Navigation tree.

   The software will automatically detect and display the installed sensors. If one or more sensors is installed in the wrong port, an error message will be displayed. Simply remove the sensor and install it in the correct position, then “refresh” the device before continuing.

6. Select Nitrate in the Parameters list. The sensor serial number (SN) and recent calibration information is displayed.

7. Select **Calibrate**.

   The Nitrate Calibration Wizard starts. A screen like this is displayed.

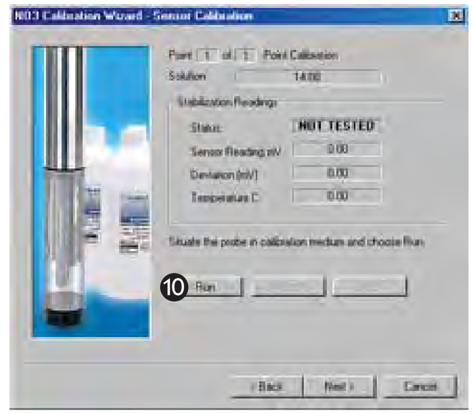


8. Select the number of calibration points for this calibration, and the concentration (ppm) of the calibration solution for each point.

   Cal point 1 is the solution the sensor is soaking in now, the lowest concentration for a multi-point calibration. If doing a three-point bithermal cal, choose cal point 3 to be the same as either cal point 1 or cal point 2.

9. Select **Next** to continue.

10. In the next screen, select **Run** to begin the stabilization.



The display will continuously update as readings are taken and compared against the stabilization criteria.

- Status indicators:

  NOT TESTED is displayed until you begin the calibration by selecting Run.

  UNSTABLE indicates the sensor response does not meet the criteria for a valid calibration point.

  NOMINAL indicates the sensor deviation meets early stabilization criteria.

  The **Accept** button becomes available when nominal stability is achieved. You may accept the early value, or wait for complete stability. If you accept the early value, the calibration point will be designated "USER SET" in the calibration report. (For more on calibration reports, see "Calibration History" in Section 10.)

  STABLE is displayed when the readings have stabilized sufficiently to take a valid calibration point. The calibration proceeds automatically to the next screen.

- Sensor Reading: The current sensor response in milliVolts.
- Deviation: Change in sensor response between the last two readings.
- Current temperature is also displayed

11. If doing a single-point calibration, go to step 16.

    For a multi-point calibration, the Wizard returns to the screen shown at step 10 and waits for you to situate the probe in the next calibration solution and click Run.

12. Remove the Cal Cup, discard the first solution, rinse the Cal Cup and the front end of the instrument with clean water, followed by a rinse in the next calibration solution, refill the Cal Cup with the second solution, and attach it to the instrument.

TIP: The used calibration solution may be flushed down the drain with running water, or saved in a separate container and used as a rinse the next time you calibrate with the same solution.

13. Select **Run** to begin the stabilization for cal point 2. Status indicators and controls are the same as for cal point 1 (step 10).

    Again wait for Stable status (or click Accept when Nominal is indicated).

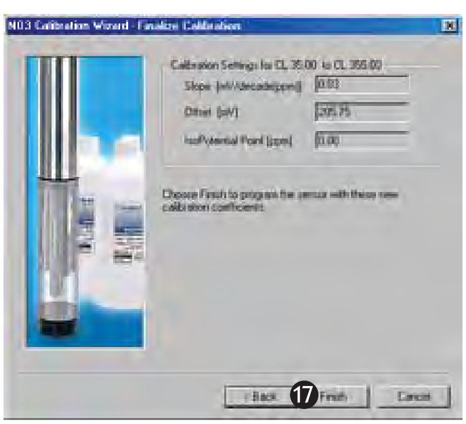
    If doing a two-point calibration, go to step 16.

14. For the third calibration point, use the cal point 1 or cal point 2 solution (as specified in step 8) but change the temperature by at least 10°C. A convenient way to do this is to move the probe—Cal Cup and all—into a temperature-controlled bath or container of ice. Allow time for the sensor to reach thermal equilibration with the solution temperature. With stirring or agitation, this should take about 10 minutes, perhaps up to 30 minutes if left undisturbed.

15. When the temperature is stable, select **Run** for cal point 3.

    When Nominal is accepted or Stable is indicated for cal point 3, the final screen is displayed.

16. The final screen of the Calibration Wizard shows the sensor slope and offset calculated during the calibration process. For a three-point bithermal calibration, the calculated isopotential point is shown. If a single-point calibration has been performed, the isopotential point is the one calculated during the last three-point bithermal calibration.



17. Select **Finish** to program the sensor with the newly calculated calibration coefficients.

The nitrate sensor is now calibrated and ready to use.

TIP: You can look at the calibration report right after calibrating, or at any time. See "Calibration History" in Section 10 for details.

Options for storing sensors:

The sensor should calibrated immediately before use. If storage is necessary, remove the sensor from the instrument and immerse in 14 ppm N solution, for later use in the low nitrate range, or 140 ppm N solution, for use in the high range.

SENSOR SLOPE AND OFFSET

The expected slope for a new sensor is about 57 (± 2) mV per decade of concentration (ppm). The calibration curve begins to deviate from linear at about 10 ppm. The sensor's zero offset is recalculated with each single-point calibration.

UNITS AND CALCULATED MEASUREMENTS

Nitrate ion concentration is reported in ppm (equivalent to mg/L). No calculated measurements are available.

USAGE RECOMMENDATIONS AND CAUTIONS

Nitrate Sensor	
Operating Temperature	-5°C to 40°C (23°F to104°F) continuous temperature; can tolerate up to 50°C (122°F) intermittently
Pressure Rating	20 psi (14 m, 46 ft)
pH range	2.5 to 11

Do not submerge the nitrate sensor deeper than 46 ft (14 m).

TEMPERATURE

The higher the temperature, the shorter the lifetime of the electrode. 1°C difference in temperature causes a 2% error at 10 ppm, unless a bithermal calibration is performed.

POTENTIAL INTERFERENCES

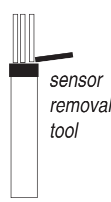
The following table shows concentrations of possible interfering ions that cause 10% error at various levels of NO_3^-.

Ion	100 ppm NO_3^-	10 ppm NO_3^-	1 ppm NO_3^-
ClO_4^-	0.01	0.001	0.0001
I^-	0.5	0.05	0.005
ClO_3^-	5	0.5	0.05
CN^-	10	1	0.1
Br^-	70	7	0.7
NO_2^-	70	7	0.7
HS^-	100	10	1
HCO_3^-	1000	100	10
CO_3^{2-}	2000	200	20
Cl^-	3000	300	30
$H_2PO_4^-$	5000	500	50
HPO_4^{2-}	5000	500	50
PO_4^{3-}	5000	500	50
AcO^-	20,000	2000	200
F^-	60,000	6000	600
SO_4^{2-}	100,000	10,000	1000

SENSOR CARE AND HANDLING

SENSOR REMOVAL

Position the yoke of the sensor removal tool at the point where the sensor meets the sensor block and pry the sensor upward.



Avoid touching the membrane at the tip of the sensor. Contaminants on the membrane can change its properties and affect measurements.

MAINTENANCE/INSPECTION/CLEANING

As long as extreme pH and high organic solvent content is avoided, the sensor should last for several months at room temperature. Eventually some of the components will leach out, and this will affect the response (detection limit and scope), but this can be compensated through calibration.

If film buildup is visible on the membrane, rinse under a gentle stream of clean water, or swish gently in a mild detergent solution, rinse well with clean water, and shake to dry.

To avoid depletion of the reference solution, do not allow the sensor to soak in pure water for more than a few minutes at a time.

The electrode is not customer-refillable.

STORAGE

Store the sensor immersed in 14 or 140 ppm N solution, depending on usage requirements, rather than dry or in DI water.

REFERENCES

Eaton, A.D., L.S. Clesceri, E.W. Rice, and A.E. Greenberg, eds., *Standard Methods for the Examination of Water and Wastewater,* 21st edition, Washington, D.C.: American Public Health Association, American Water Works Association, and Water Environment Federation, 2005. Section 4500-NO_3^- D. Nitrate Electrode Method.

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18 TURBIDITY

WHAT IS TURBIDITY?

Turbidity is an indirect measure of the clarity or transparency of water, and thus an important indicator of its condition and productivity. Created by suspended matter and microscopic organisms, turbidity causes light to be scattered and absorbed rather than transmitted directly through water. Turbidity is the physical characteristic of the solution that causes light scattering. Turbidity is the opposite of clarity.

The APHA reference work *Standard Methods* (Eaton and others, 2005) defines turbidity as “an expression of the optical property that causes light to be scattered and absorbed rather than transmitted with no change in direction or flux level through the sample.”

Turbidity is not . . .

- a direct measure of clarity.
- a measure of color.
- a measure of suspended solids; it is a measure of their light-scattering abilities.

The In-Situ Turbidity sensor* is in conformance with the ISO 7027 turbidity standard which specifies 90° scattered light.

WHY MEASURE TURBIDITY?

Turbidity measurements

- can provide a reasonable estimate of the *total suspended solids* or sediments (TSS) concentration in water.
- can tell us something about the health of a natural water body. Clear water lets light penetrate more deeply into a lake or stream than does murky water. This light allows photosynthesis to occur and oxygen to be produced.

Typical turbidity values

EPA drinking water	0.3 - 0.5 NTU
Treated water	0 - 1 NTU
Fresh water, >21.5” visibility	< 10 NTU
Fresh water, 2.5” visibility	240 NTU
Short-term stress to aquatic life	> 10 NTU
Unsafe level for most aquatic life	> 100 NTU

- can be a useful indicator of runoff into surface water systems.
- in flow-cell or in-line applications, when pumping water at very low rates, can provide a good indication of true formation water.

Higher turbidity levels make it more costly to treat surface water for use as drinking water. Controlling turbidity may be an effective way to protect against pathogens in drinking water.

Aesthetic considerations also play a role in our desire to quantify turbidity: Most people would rather look at, drink, or swim in clear water than in water that appears cloudy, and closely associate appearance with the health of the body of water.

HOW IS TURBIDITY MEASURED?

Historical methods for measuring turbidity relied on subjective estimates that depended largely on the eye of the beholder.

In the Jackson Candle method, for example, a candle flame is observed through the length of a glass tube into which a fluid sample is poured until the rays of transmitted and scattered light appear equal and the flame essentially disappears. Among several drawbacks to this method, the reproducibility of standards formulated from natural sediments was difficult to control.

The Secchi disk method used in limnological studies involves submerging a weighted, black-and-white painted metal plate until the pattern can no longer be detected. The plate is then pulled up until it is visible again. The average of the two depths provides an estimate of water clarity or transparency.

Modern turbidimeters measure the loss in intensity of a light beam as it passes through a solution containing suspended and dissolved particles that are large enough to scatter the light. The method is based upon a comparison of the intensity of light scattered by the sample with the intensity of light scattered by a standard reference suspension. The *nephelometer* is a particular type of turbidimeter that measures the intensity of light scattered at right angles (90°) to the incident light. This lessens the difficulty of differentiating small changes against a large background. Standards for turbidity-measurement instruments specify the light source, angle, wavelength, beam width, and sample suspensions, among other factors. Many of today's commonly accepted procedures (e.g., Standard Methods, EPA, and ISO) apply to laboratory bench-top instruments.

THE TURBIDITY SENSOR

The optional turbidity sensor of the Multi-Parameter TROLL 9500 is permanently-installed and factory-calibrated. It may be a turbidity sensor alone or a pressure/turbidity sensor combination. If your MP TROLL 9500 was ordered without a turbidity sensor or a pressure sensor, there will be a permanently installed plug in the pressure/turbidity sensor slot. A turbidity sensor or combination pressure/turbidity sensor can be added at the factory.

The In-Situ turbidity sensor is comprised of a matched solid-state detector-emitter pair positioned at right angles. The light source is an infrared LED, optimized for operation at 870 nanometers (nm). The optical windows of the detector (photodiode) and emitter (LED) are scratch-resistant sapphire. ISO 7027 has set a detection angle of 90° and the light wavelength at 860 nm. The sensor uses active modulation for ambient light rejection.

The In-Situ sensor is an electronic nephelometer which compares the intensity of light scattered by the environmental fluid with intensity of light scattered by a standard reference suspension. The higher the intensity of scattered light, as measured in NTU's, the higher the turbidity. This measurement generally provides a very good correlation with the concentration of particles in the water that affect clarity. However, measurements of scattered light cannot be directly related to a gravimetric equivalent, such as suspended sediment load, unless a working curve for the specific sample is created.

THE TURBIDITY WIPER

The optional wiper accessory helps to keep the turbidity sensor optics free of bubbles and fouling.

The wiper installs in port 3 of the MP TROLL 9500 like other removeable sensors. A positional brace aligns it with respect to the turbidity sensor and keeps it stable in moving waters.

The wiper pad is adhesive-free, low-abrasion cotton material. The pad is easily replaced when it becomes too soiled to clean the sensor optics effectively.

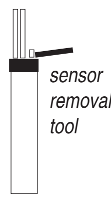
Use of the wiper will significantly impact battery life. Lithium batteries are recommended.

WIPER INSTALLATION

The MP TROLL 9500 may be shipped with the optional wiper already installed in port 3, as shown on the drawing below. If installation is necessary, unpack and install the wiper in port 3 as follows.

The turbidity wiper will function properly only when installed in ***port 3***.

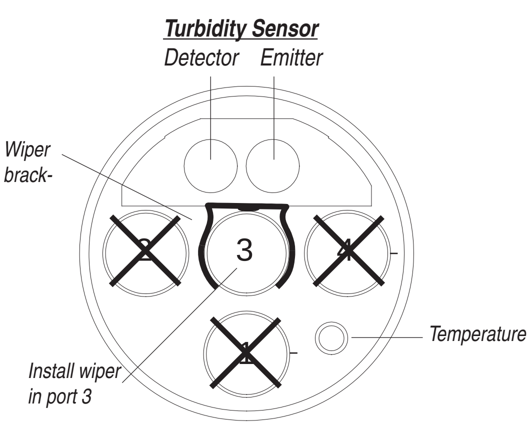
1. Remove the restrictor from the front end of the MP TROLL 9500. This allows access to the sensor block depicted in the drawing below.
2. Use the sensor removal tool to remove the sensor or plug from port 3. Retain the plug for future use. For best access to port 3, you may need to remove sensors or plugs from other ports as well.



3. Check lubrication of the o-rings on the connector end of the wiper.

TIP: *The wiper o-rings require generous lubrication before installation. New wipers will be lubricated at the factory. If the o-rings appear dry, apply apply a silicone lubricant before installation.*

4. Visually align the connector on the wiper with the connector at the bottom of port 3.
5. Press firmly until you feel the wiper dock with the port connector. When properly inserted a small gap (width of the sensor removal tool) remains between the wiper body and the instrument body.
6. Press the wiper into the bracket attached to the turbidity sensor.
7. After installing a new wiper, we recommend you access wiper control in the software while you can clearly see the wiper movement. Connect in software, select the wiper, and click **Wipe** to ensure the wiper passes over the turbidity sensor optics properly.



What does the wiper do, and when is wiping necessary?

The wiper helps keep the optical windows of the turbidity sensor clear of bubbles and debris during measurements. When the sensor is off, the wiper is parked in its “home” position over sensor port 4. When a turbidity measurement is called for—a manual reading, a scheduled reading during a test, while calibrating or profiling—the wiper makes a full 360 degree sweep to clean the optics.

Wiping is not needed when the instrument is hand-held for short periods (Profiling). Gently swishing the MP TROLL in the water should serve to dispel air bubbles.

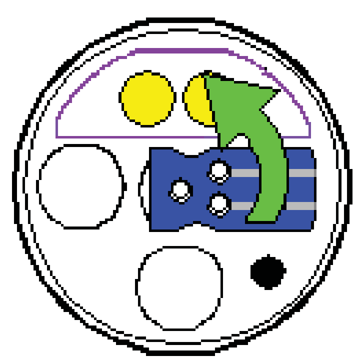
WIPER MOVEMENT

When the turbidity sensor is off—not taking a measurement—the wiper head is “parked” over port 4. When a turbidity measurement is requested, the wiper head passes over the optics, sweeping them clean, and returns to its parking place. One “wipe” consists of a 360° counter-clockwise sweep (viewed from the sensor end), as shown in the drawing below. Wiping occurs automatically before turbidity readings—manual reads, profiling, calibration, and tests—that are more than 15 seconds apart. If readings are less than 15 seconds apart, the wiper will wipe once, before the first reading.

A single wipe may be initiated in the software when the instrument is idle to clear the turbidity optics of bubbles or debris. The wiper’s movements are entirely software-controlled.

TIP: *15 seconds are alotted for a wipe cycle. This time is generous to allow for slower wiper movement at very low temperatures.*

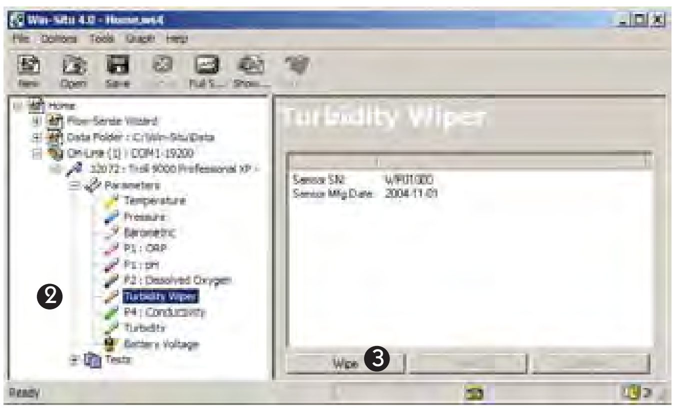
If readings—test, calibration, profiling—are more than 15 seconds apart, the turbidity sensor will be wiped automatically before each reading. If readings are less than 15 seconds apart, the wiper will wipe the windows just once, before the first reading.



MANUAL WIPE

To wipe the turbidity sensor optics manually:

1. With the wiper installed in port 3, connect the MP TROLL 9500 to a PC and establish a connection in Win-Situ 4 or Pocket-Situ 4.
2. Select the Wiper in the Navigation tree.



3. Click **Wipe**. The wiper will pass once over the turbidity sensor optics and return to its home position.

WIPER GUIDELINES AND PRECAUTIONS

- If a wiper is installed during a Quick Cal of the Basic sensors (see Section 3, Getting Started), steps should be taken to insure the wiper pad material does not absorb the Quick Cal solution. There are two ways to do this.
  - Remove the wiper head before doing the Quick Cal. Refer to Wiper Maintenance guidelines later in this section for instructions on removing the wiper head.
  - Alternatively, soak the front end of the instrument in plain water before calibrating to allow the wiping pad to absorb sufficient water to prevent its absorbing any Quick Cal solution.
- **Do not attempt to move the wiper head by hand.** Wiper movement is software-controlled.
- The wiper pressure may be adjusted if necessary so that the pad is effectively cleaning the sapphire windows of the turbidity sensor during movement. Refer to Wiper Maintenance guidelines later in this section.
- The wiper pad or head may be replaced as needed. Refer to Wiper Maintenance guidelines later in this section.
- When an RDO optical dissolved oxygen sensor is installed, check to see that the RDO adapter cable is out of the way of wiper movement.

CALIBRATION

FACTORY CALIBRATION

The turbidity sensor has been factory-calibrated to achieve a sensor accuracy of ± 5% or 2 NTU (whichever is greater). The sensor is calibrated over its full range, 0 to 2000 NTU, using polymer standards. The resulting calibration coefficients are written to the sensor memory, where they are stored permanently. They may be overlaid by performing a field calibration as described below, or may be recalled from the sensor memory at any time.

The MP TROLL 9500's turbidity sensor is ready to measure turbidity without any user intervention. It is advisable to take a turbidity reading first in your own calibration solution(s) as a check to ensure the accuracy is within your operational standards and requirements. If this result is satisfactory, a field calibration is not required.

FIELD CALIBRATION

Field calibration (or "user calibration") is an overlay function that is applied after the factory calibration math is done. The factory calibration applies across the entire range of NTU, and can be altered in the field with a 1 to 4 point calibration procedure as described below to compensate for effects of sensor fouling and other factors. You may wish to perform a field calibration with standards other than polymer (i.e., Formazin).

For best results, calibrate as close to field temperature as possible.

CALIBRATION SOLUTIONS

A nephelometer such as the In-Situ turbidity sensor should be calibrated using standard reference suspensions having reproducible light-scattering properties. The sensor has been factory-calibrated with polymer suspensions, and the resulting calibration coefficients take into account the light-scattering properties of the suspensions and the sensor optics.

Q: ***Why do I need to calibrate the turbidity sensor if it has been calibrated in the factory?***

A: *A new turbidity sensor is ready to measure turbidity with reference to suspended polymer standards. If you prefer to reference turbidity measurements to Formazin rather than polymer, a field calibration with Formazin should be performed.*

After cleaning the sensor, readings should be checked with standards and a field calibration performed if necessary.

Polymer-based standards are submicron, non-surface charged, solid spheres in matrixes of ultrapure water in homogeneous suspension; this homogeneity allows linear dilutions. EPA approved the polymer suspensions in 1984 as a calibration standard for turbidimeters. Polymer suspensions are very stable, can withstand temperature extremes, and have excellent lot-to-lot precision. A range of polymer suspensions are available individually from In-Situ Inc. for calibrating any expected turbidity range. They can be diluted with turbidity-free water to achieve other NTU values (but see the cautions below).

Avoid vigorous mixing or agitation, which will create air bubbles and lower the accuracy of the standards. It is advantageous to calibrate a nephelometric turbidimeter with a standard that most closely matches the size of the particulates you will be measuring.

Calibrating with Other Solutions

Formazin: If you wish to recalibrate with Formazin, keep these points in mind.

- Requires very careful handling.
- Must be shaken gently and allowed to settle for at least 5 minutes before use.
- Should not be diluted.

Diluting Polymer Suspensions: If you dilute polymer suspensions, keep these points in mind:

- Do not dilute more than 10:1. Use good laboratory techniques.
- Store carefully. PVC bottles are recommended.
- Diluting polymer suspensions takes them out of the category of “primary standards”, they become “secondary standards.”
- If not handled carefully, the dilutions can become unstable; the suspension of particles may be lost.

RECOMMENDED CALIBRATION FREQUENCY

Your own experience is the best guide to how often the turbidity sensor will benefit from recalibration. The need for recalibration depends on the condition of the optical windows, which in turn depends on the environment. In a biologically active environment, cleaning and calibration will be required more often. Periodic checks in calibration solutions of known turbidity can be beneficial in indicating how well the sensor is holding its calibration.

A field calibration is recommended

- if you wish to reference turbidity measurements to a standard other than polymer.
- after cleaning the sensor windows of contamination.
- when readings appear to drift, or show unexpectedly high or low results.

* if algal or other growth on the front end of the MP TROLL 9500 changes the reflective properties of the device.

TURBIDITY CALIBRATION PROCEDURE

You will need:

- MP TROLL 9500 with turbidity sensor (wiper optional), plugs in any unused sensor ports.
- The restrictor, nose cone, and removable sensors (if any) that will be installed when turbidity is measured.
- A laboratory beaker large enough to hold the instrument and calibration solution.
- One or more calibration standards for the region in which you wish to calibrate. Several ranges from Very Low to Full are suggested in the Calibration Wizard.

__TIP:__ A 1-point to 4-point field calibration may be carried out in any range. When performing a multi-point calibration, begin with 0 NTU solution. For best measurement precision the highest NTU value should exceed the readings you expect in the field.

1. Rinse the front end of the MP TROLL 9500 with clean water. Shake well to remove the rinse water; dry external surfaces (not the optical windows) with a clean tissue.
2. Pour the selected calibration standard into the beaker and insert the MP TROLL 9500 into the solution.

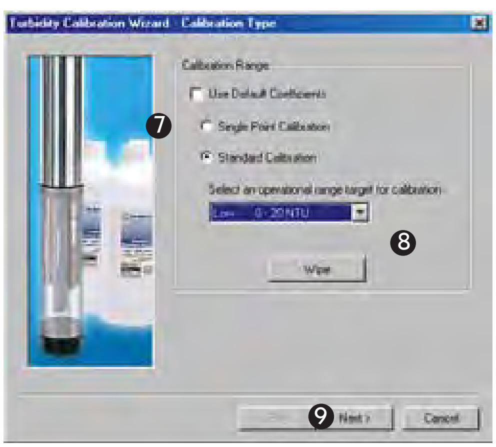
   The windows of the turbidity sensor should be immersed at least ¼” (a quarter of an inch) deep in the solution. If no wiper is present, gently agitate the instrument to dispel any air bubbles.

3. Connect the MP TROLL 9500 to a PC and establish a connection in Win-Situ 4 or Pocket-Situ 4. Win-Situ screens are illustrated here. The Pocket-Situ interface is similar, with the Navigation tree at the top of the screen and the Information pane below it.
4. Select the MP TROLL 9500 in the Navigation tree.

   The installed sensors will be displayed—including the turbidity wiper, if installed in port P3.
5. Click to select Turbidity in the Parameters list. The sensor serial number (S/N) and recent calibration information is displayed.

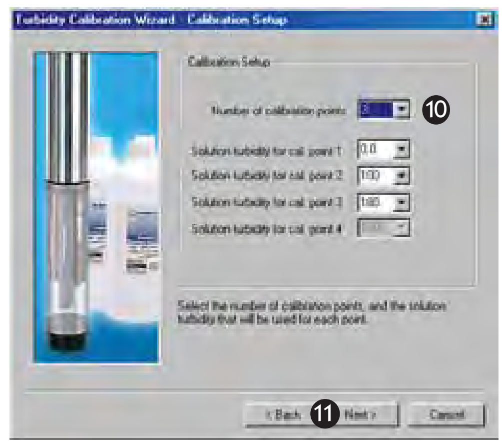
6. Select **Calibrate**.

   The Turbidity Calibration Wizard starts. A screen like the one below is displayed.



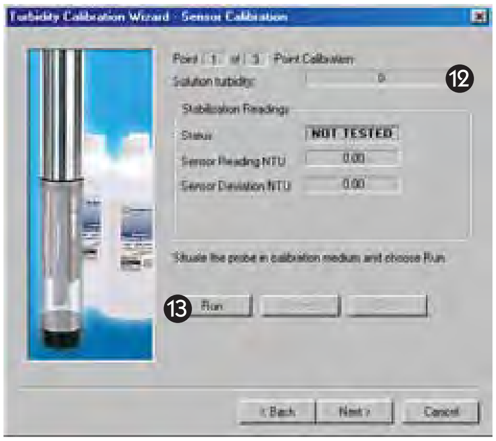
7. Select the type of calibration you wish to do:
   - Use Default Coefficients resets the factory defaults. If you select this option, click **Next** and proceed to step 17.
   - Single-Point Calibration. Click **Next** and go to step 12.
   - Standard Calibration (default).
8. If you selected a Standard Calibration, select an operational range target. The ranges are suggestions only; a 1- to 4-point calibration may be performed in any range, using any standards

   Note: If the software detects a turbidity wiper accessory, pressing the **Wipe** button will result in one complete wipe cycle of the turbidity sensor optics.
9. Select **Next** to continue.
10. In the next screen, select the number of calibration points for this calibration, and the turbidity value (in NTU) of the calibration solution for each point. One to four points (solutions) may be selected for any operational range target selected in the previous screen.



    When performing a multi-point calibration, cal point 1 must be taken in a standard with a value of 0 NTU. Use clear water for this. Purchased distilled or deionized water will generally measure less than 0.5 NTU. Filtered water will have a lower NTU value.
11. Select **Next** to continue.

A screen similar to the one shown below is displayed.



12. If you are performing performing a single-point calibration, enter the value of the calibration standard (NTU). For a multi-point calibration, the value of the first solution will be displayed.

13. When the sensor is situated in the calibration medium, select **Run** to begin the stabilization.

    The display will continuously update as readings are taken and compared against the stabilization criteria.

- Status indicators:

    NOT TESTED is displayed until you begin the calibration by selecting Run.

    UNSTABLE indicates the sensor response does not meet the criteria for a valid calibration point.

    NOMINAL indicates the sensor deviation meets early stabilization criteria.

    The **Accept** button becomes available when nominal stability is achieved. You may accept the early value, or wait for complete stability. If you accept the early value, the calibration point will be designated "USER SET" in the calibration report. (For more on calibration reports, see "Calibration History" in Section 10.)

    STABLE is displayed when the readings have stabilized sufficiently to take a valid calibration point. The calibration proceeds automatically to the next screen.

- Sensor Reading: The current sensor response in NTU
- Sensor Deviation: Change in sensor response between the last two readings.
- Temperature

14. If doing a one-point calibration, go to step 17.

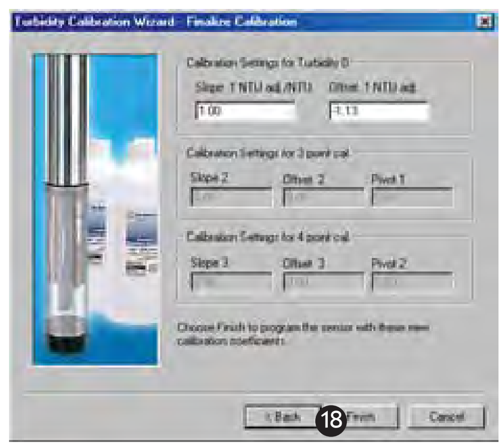
    For a multi-point calibration, the Wizard returns to the screen shown at step 13 and waits for you to situate the probe in the next calibration solution and click Run.

15. Discard the first solution, rinse the beaker and the front end of the instrument thoroughly, wipe off excess water, refill the beaker with the second solution, and insert the MP TROLL 9500 as before.

16. Select **Run** to begin the stabilization for the second calibration point. Status indicators and controls are the same as for the first calibration point (step 13).

    Again wait for stabilization, dump, rinse, dry, refill, Run, as many times as necessary to collect a stable calibration point in each solution.

17. The final screen shows the sensor slope and offset calculated during the calibration process (or the default settings if you selected that option at step 7). A slope and offset will be shown for each calibration point.



"Pivot" designates the point at which the slope characteristics change with a multi-point calibration. The correct slope for the turbidity values being monitored will automatically be applied.

18. Select **Finish** to program the sensor with the newly calculated calibration coefficients.

    TIP: *You can look at the calibration report right after calibrating, or at any time. See "Calibration History" in Section 10 for details.*

RESETTING DEFAULT COEFFICIENTS

The sensor's calibration may be reset back to factory defaults at any time. As long as there is no contamination on the optical windows, this will restore the factory accuracy (± 5% or 2 NTU).

1. Establish a connection to the instrument in Win-Situ 4 or Pocket-Situ 4.
2. Select Turbidity in the Parameters list and click **Calibrate**.
3. In the first screen, select Use Default Coefficients, then **Next**.
4. In the final screen, click **Finish** to restore the sensor's factory calibration coefficients.

SENSOR SLOPE AND OFFSET

The offset is factory-set at 0 NTU. The zero offset may be recalculated for any appropriate value by performing a single-point calibration using a calibration standard of the desired NTU value. The sensor response is very linear up to 200 NTU.

UNITS AND CALCULATED MEASUREMENTS

Two units are available for readings from the turbidity channel:

- NTUs—Nephelometric Turbidity Units. Select NTU when the sensor has been calibrated with polymer suspensions.
- FNUs—Formazin Turbidity Units. Select FNU when the sensor has been calibrated with Formazin.

USAGE RECOMMENDATIONS AND CAUTIONS

The operational pressure rating of the turbidit y sensor is 150 psi. Do not submerge it deeper than 346 ft (105 m).

Avoid use of the stirrer accessory (recommended for monitoring dissolved oxygen in stagnant water) when measuring turbidity.

When used without a wiper, dirty sensor optics can be compensated for to some extent by changing the offset.

Optical absorbancy ("color") will lessen the turbidity signal.

Turbidity readings are temperature-commpensated.

The optics need 5 seconds warm-up time to take the first reading later. Subsequent readings can be returned instantaneously.

COMMON INTERFERENCES

Light scattering depends upon the size, shape, refractive index, and other characteristics of the particles and the wavelength of the light. Optically black particles, such as those of activated carbon, may absorb light and effectively decrease turbidity measurements. Nephelometers are relatively unaffected by small changes in design parameters and therefore are specified as the standard instrument for measurement of low turbidities. Nonstandard turbidimeters, such as forward-scattering devices, are more sensitive than nephelometers to the presence of larger particles and are useful for process monitoring. Reported turbidities are heavily dependent on the particulate matter contained in the suspensions that are used to prepare instrument calibration curves.

Due to current technological limitations, field turbidity measurement is "a snapshot of averages," Field measurements can be an excellent indicator of in-situ turbidity; final determination for reporting purposes should be conducted in a laboratory.

PROFILING TURBIDITY

The turbidity sensor's 5-second warmup will result in a slight delay before the first Profiler reading for all parameters. Subsequent readings can be taken within the Profiler's 2-second cycling.

If a turbidity wiper accessory is installed, it performs an initial wipe of the sensor optics—this takes about 15 seconds—then displays the first turbidity reading. If the profiling rate is longer than 15 seconds, this 15 second wipe will happen before each reading. To avoid this delay, set the profiling rate to less than 15 seconds. See Customizing the Profiler in Section 5 for details.

LOGGING TURBIDITY DATA

The wiper is activated automatically before turbidity readings during tests, so long as the readings are 15 seconds or more apart. To prolong battery life when running a wiper, we recommend the use of external power or two internal lithium D-cells installed in the MP TROLL 9500.

SENSOR CARE

INSPECTION/MAINTENANCE/CLEANING

The optical windows of the sensor are made of scratch-resistant sapphire. The optical components are not user-serviceable. Serious mechanical and temperature shock are about the only things that can damage the LED. If you feel the instrument has suffered such damage, contact In-Situ Technical Support.

However, the windows may need frequent cleaning, especially if used in a biologically active environment. A wiper accessory can help to prevent the accumulation of foreign material.

Cleaning may be necessary if the optical windows of the sensor become visibly contaminated by the gradual accumulation of foreign material. Because the sensor is not removable, we recommend gentle swabbing of the windows with a circular motion using plain water. Solvents are not recommended, although an ammonia solution (e.g., grocery-store ammonia) may be used with good effect to remove particularly stubborn materials.

A calibration check should be performed after cleaning, using calibration standards.

WIPER MAINTENANCE

The cotton wiper pad will require replacement periodically to maintain its effectiveness in cleaning the turbidity sensor optics. The entire head may be replaced, or just the pad. In either case, the wiper head will need to be removed. A hex wrench is supplied for this purpose. You do not need to remove the entire wiper; leave the wiper body installed in port 3.

Replacement pads and wiper heads are available from In-Situ Inc. or your distributor.

To remove the wiper head, use the supplied hex wrench to loosen the set screw

Removing the Wiper Head

With the wiper parked over port 4, loosen the set screw on the wiper head until you can grasp the wiper head and gently pull it out.

Replacing the Wiper Pad

1. Remove the wiper head as above. Remove and discard the used pad.
2. Insert a new pad into the slots with the smooth side facing out, and pull to eliminate slack. Excess material may be trimmed close to the wiper head.
3. Position the head on the motor shaft with the pad facing down toward the sensors. The button at the top of the shaft should be flush with the wiper head surface. Tighten the set screw against the flat of the motor shaft. ***Be very careful not to move the wiper head in a lateral direction by hand after tightening.***
4. If convenient, connect in software, select the wiper, and click **Wipe** to ensure the wiper passes over the turbidity sensor optics properly.

Adjusting Wiper Pressure

If necessary, loosen the set screw on the wiper head and gently pull the head up or press down lightly to ensure the pad just brushes the optical windows when it passes over the turbidity sensor. Then re-tighten the set screw. ***Be very careful not to move the wiper head in a lateral direction by hand when engaged with the motor shaft.***

TIP: *The wiper head is at the best height when it just brushes the optical windows of the turbidity sensor—too high and it will not clean effectively; too low and it may not be able to spin.*

If it is necessary to remove the entire wiper assembly, be sure to use the sensor removal tool and grasp the body of the wiper. Do not attempt to pull the wiper out by the head.

Wiper Replacement Parts	Catalog No.
Replacement wiper head	0044520
Wiper pad replacement kit	0044530

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19 SDI-12 OPERATION

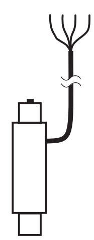
SDI-12 is a serial digital interface that operates at 1200 baud. In-Situ's SDI-12 Adapter enables processing of the MP TROLL 9500's sensor measurements by a standard SDI-12 data recorder.

SDI-12 REQUIREMENTS

- MP TROLL 9500 (firmware 1.54 or later)
- SDI-12 Adapter (for proper power management)
- SDI-12 data recorder (customer-supplied)

WIRING

Connect the stripped and tinned wires from the SDI-12 Adapter to the terminal block of an SDI-12 data recorder (or to an SDI-12 network) as follows.



- WHITE - serial data line
- BLACK - ground line
- RED - 12-volt supply line
- GREEN - shield

The data recorder or an external power supply may provide power (9.6 - 16 V) to the 12V line. The shield should be terminated (grounded) at the data recorder.

Minimum voltage supplied per the SDI-12 specification (9.6V) is sufficient to power a TROLL 9500 on 170 ft (52 m) of RuggedCable. Cables as long as 300 ft (91 m) may be used, depending on power supplied. Before using cables longer than 170 ft (52 m) we recommend that you measure the voltage at the Adapter. The table lists power requirements for specific submersible cable lengths.

CONNECTIONS

Attach the Twist-Lock Connector on the MP TROLL's RuggedCable to the matching connector on the SDI-12 Adapter.

The Adapter is weather-resistant but not completely waterproof. It is not designed to be exposed to the elements. Provide a weather-resistant enclosure for optimum operation.

Table 19-1. Cable length & power supply requirements

Cable length		Power supply
feet	meters	requirement
170	52	9.6 V
180	55	9.8 V
190	58	9.9 V
200	61	10.1 V
210	64	10.3 V
220	67	10.4 V
230	70	10.6 V
240	73	10.8 V
250	76	10.9 V
260	79	11.1 V
270	82	11.3 V
280	85	11.4 V
290	88	11.6 V
300	91	11.8 V

SDI-12 SUPPORT

The MP TROLL 9500 supports the SDI-12 Version 1.3 commands. Data loggers that support SDI-12 Version 1.3 can usually send the Version 1.3 commands to an SDI-12 "sensor" like the MP TROLL automatically. These commands are listed later in this section. Additional information may be found in an SDI-12 reference, such as that listed at the end of this section. Or consult your SDI-12 data logger documentation for more specific information.

Insure SDI-12 is ***enabled*** *(factory default) on the 9500. In Win-Situ 4 or Pocket-Situ 4, select the TROLL, click* ***Edit...*** *select SDI-12 Mode Preferences.*

Calibration of the water-quality sensors will need to be done through Win-Situ 4 or Pocket-Situ 4 as SDI-12 protocols do not support calibration.

SENSOR IDENTIFICATION

In response to the “send identification” command, the MP TROLL 9500 will respond as follows:

The default sensor address is 0. The device supports software-changeable addresses.

```
013IN-SITU WQP100154030452 <CR><LF>
```

- *Serial number*
- *Firmware version*
- *Sensor (MP TROLL 9500) model*
- *Manufacturer (In-Situ Inc.)*
- *SDI-12 compatability (version 1.3)*
- *Sensor address*

SENSOR VERIFICATION

In response to the Verification command, the MP TROLL 9500 will respond as follows:

```
0+030452+30+1.54+3.0+5+3.0+4.5 <CR><LF>
```

- *External power voltage*
- *Battery voltage*
- *Battery type (0=none, 5=alkaline, 6=lithium)*
- *Hardware version (1 decimal place)*
- *Firmware version (2 decimal places)*
- *2-digit entity code*
- *Serial number*
- *Sensor address*

MAKING SDI-12 MEASUREMENTS

When measurements are made they will be taken on all sensors installed in the MP TROLL 9500. “Derived” or calculated measurements, available in Win-Situ, are reported in SDI-12 for D.O. and conductivity. For example, the D.O. sensors can report oxygen concentration in milligrams per liter and saturation in percent. Specific conductance is reported as well as conductivity.

TIP: *SDI-12 protocols use the term “sensor” for a single SDI-12 device with an address. In this usage, the MP TROLL 9500 is a “sensor,” even though it includes up to 11 installed “sensors” in the In-Situ usage. The “sensors” in the In-Situ usage cannot be addressed individually using SDI-12 protocols.*

The default order in which parameters are reported, and the units for each parameter, are listed in Table 19-2.

TIP: *You can change the default order of parameters reported in Win-Situ or Pocket-Situ like this:*

1. Select the MP TROLL in the Navigation tree
2. Select Edit
3. In the dialog box, select “SDI-12 mode preferences”

According to the SDI-12 specification the Start Measurement command “aM!” can take up to 9 measurements. Since the MP TROLL 9500 can potentially report more than 9 measurements there are two approaches to measuring all sensors:

- Use the Start Concurrent Measurement command (“aC!”). This command supports up to 20 measurements.
- Use the Start Additional Measurement commands (“aMn!”). The logger would first issue an “aM!” command. If the command responds with 9 measurements then the logger will send an “aM1!” command (after reading the initial measurements with the “aD0!” command), and read the measurements with the “aD0!” command. This process is repeated, progressing through the value of “n”, until the “aMn!” command responds with less than 9 measurements.

When parameters are read back over the SDI-12 bus via one of the “aDn!” commands they will be reported in a fixed order (Table 19-2). If a unit has duplicate transducers, only one will be reported under this fixed-order reporting, by order of the port it is plugged into. For example, if two pH sensors are plugged into ports 1 and 3, the sensor in port 1 will be reported.

Note that the fixed reporting order can be changed as as described in the tip ✔ on this page.

A measurement is returned for all possible MP TROLL parameters.

Table 19-2. SDI-12 Parameter Reporting (Default Order)

Order	Parameter	Unit
1	Pressure	PSI
2	Temperature	degrees Celsius
3	Barometric Pressure	PSI
4	Turbidity	NTU
5	pH	pH
6	ORP	milliVolts
7	Conductivity (Actual)	μS/cm
8	D.O. (Polarographic)	mg/L
9	Battery Voltage	volts
10	Nitrate	ppm
11	Ammonium	ppm
12	Chloride	ppm
13	RDO (Optical D.O.)	mg/L
14	Conductivity (Specific)	μS/cm
15	Salinity	PSU
16	D.O. (Polarographic)	% saturation
17	RDO (Optical D.O.)	% saturation
18	Ammonia	ppm
19	Total Dissolved Solids	g/L
20	Resistivity	kOhm-cm

- If a sensor port is empty, the unit will report readings with values of 0.0.
- If you edit the device to set SDI-12 mode preferences, as described in the tip ✔ above, only the parameters you select will be reported.
- If a sensor is reading out of its range, a value of -999999.9 will be reported.

REDUNDANT LOGGING (WIN-SITU 4 AND SDI-12)

If your MP TROLL 9500 supports internal logging, the instrument is capable of running tests (programmed in Win-Situ) while participating in an SDI-12 network; however Win-Situ cannot communicate with the MP TROLL 9500 while it is transmitting SDI-12 data, and conversely, the instrument cannot receive or respond to SDI-12 commands while connected to a PC serial port.

This “redundant logging” feature means

- if the SDI-12 recorder somehow “loses” data, the MP TROLL 9500 data can be retrieved using Win-Situ.

* if the SDI-12 recorder ceases to function due to power loss, the MP TROLL 9500 will continue to collect new data using its own internal batteries and clock.

TIP: *Depending on the SDI-12 data recorder used, rapid sample schedules during a test may result in SDI-12 “retries.”*

EXTENDED (ISCO) COMMANDS

Extended commands allow the data sampler to identify both the data channels and channel units that correspond to the ASCII formatted floating point data being returned. In response to the “aXPR0!” command, the response will be in the form: “aIxIxIx...<CR><LF>” where ‘a’ is the address, each ‘I’ is a parameter identifier, and each ‘x’ specifies the units for the preceding ‘I’.

The data sampler will first issue either a measure or a concurrent measure command. These commands return the number of channels that will be reported in a subsequent read command. This number will correspond with the number of pairs returned by the extended commands.

If the expected number of “Ix” pairs is not returned in response to the “aXPR0!” command, additional “aXPRx!” commands will be issued until all pairs are received.

REFERENCE

SDI-12, A Serial-Digital Interface Standard for Microprocessor-Based Sensors, version 1.3. SDI-12 Support Group, Logan, Utah, April 7, 2000. Available at www.sdi-12.org.

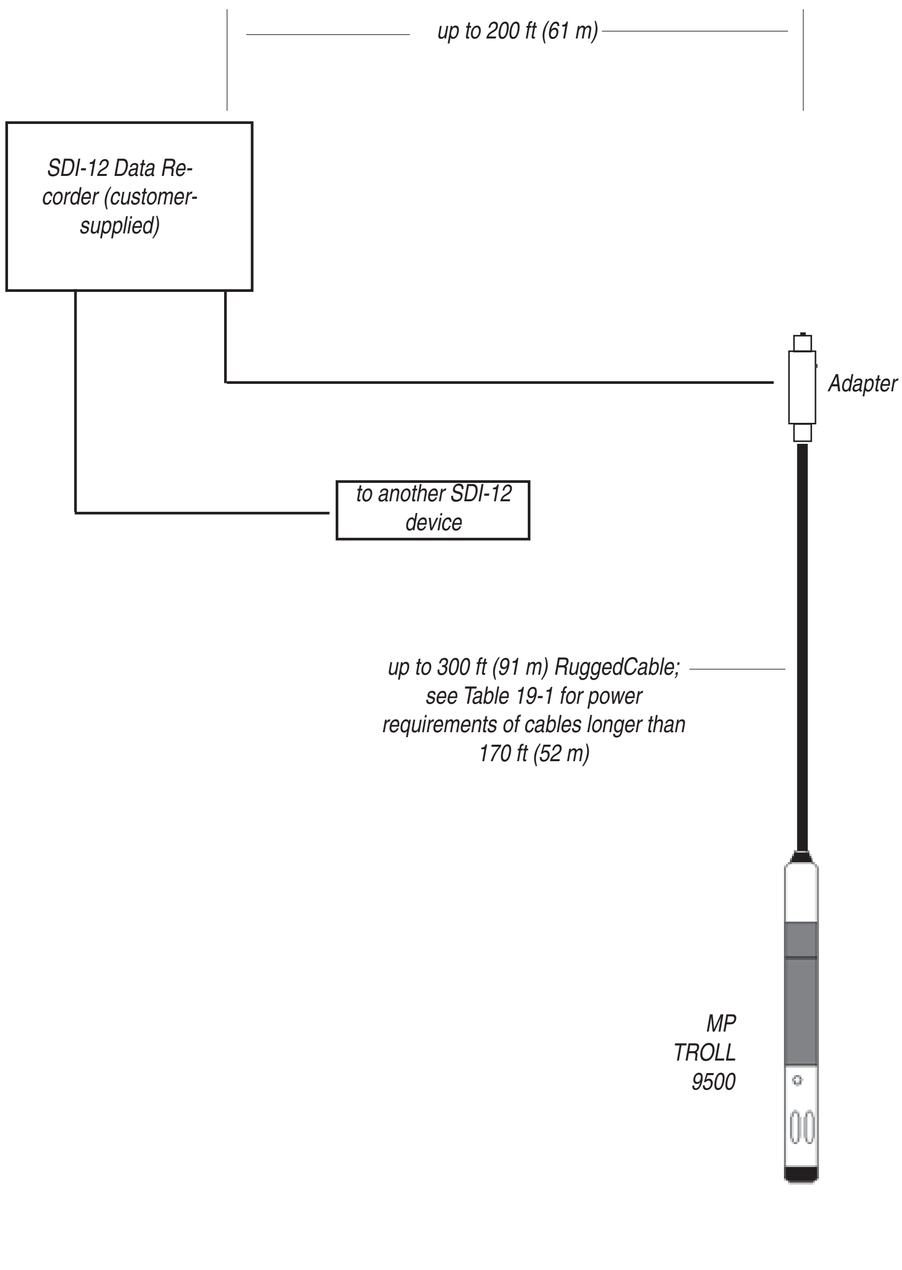
SDI-12 V 1.3 COMMAND SET

NAME	COMMAND	RESPONSE & COMMENTS
Address Query	?!	a<CR><LF> The wildcard address '?' character is supported only for the Address Query command. It is ignored as an invalid address for all other commands
Acknowledge Active	a!	a<CR><LF> Basic address characters in the range '0' to '9' and extended address characters in the ranges 'A' to 'Z' and 'a' to 'z' are supported. All other characters are ignored as an invalid address. The default address is '0'
Change Address	aAb!	b<CR><LF> Software changeable addresses and the Change Address command are supported
Send Identification	aI!	013IN-SITU WQP100vvvxxxxx<CR><LF> where vvv = device firmware * 100 (153 = 1.53) xxxxx = 5-digit device serial number
Start Verification*	aV!	00001<CR><LF> One result is available immediately for reading by the Send Data command
Send Data	aD0! . . . aD9!	0+030452+30+1.53+3.0+5+3.0+4.5 <CR><LF> Address + serial no. + 2-digit entity code + firmware version (2 decimal places) + hardware version (1 decimal place) + battery type (0=none, 5=internal alkaline, 6=internal lithium) + battery voltage (1 decimal place) + external power voltage (1 decimal place)
Start Measurement*	aM!	0001n<CR><LF>
Start Measurement with CRC	aMC!	n parameters will be available for reading by the Send Data command within 1 second. A service request (a<CR><LF>) will be sent when the parameters are ready. The number of parameters returned is determined by the SDI-12 defaults shown in Table 19-2 (or edit the SDI-12 mode preferences)
Send Data	aD0! . . . aD9!	a<values><CR><LF> or a<values><CRC><CR><LF>
Additional Measurements*	aM1! . . . aM9!	atttn<CR><LF>
Additional Measurements with CRC	aMC1! ... aMC9!	atttn<CR><LF>
Send Data	aD0! . . . aD9!	a<values><CR><LF> or a<values><CRC><CR><LF>
Start Concurrent Measurement	aC!	atttnn<CR><LF>
Start Concurrent Measurement with CRC	aCC!	atttnn<CR><LF>
Send Data	aD0! . . . aD9!	a<values><CR><LF> or a<values><CRC><CR><LF>
Additional Concurrent Measurements	aC1! . . .aC9!	atttnn<CR><LF>
Additional Concurrent Measurements with CRC	aCC1! ... aCC9!	atttnn<CR><LF>
Extended Commands		
ISCO Compatability	aXPR0! ... aXPR9!	aIxIxIxIx<CR><LF> where each Ix is a character pair identifying the parameter and units for each measurement. The number of Ix pairs equals the number of data values returned for the Start Measurement and Start Concurrent commands, limited to 19 per command. If the expected number of "Ix" pairs is not returned in response to the "aXPR0!" command, additional "aXPRx!" commands will be issued until all pairs are received

* This command may result in a service request.

a	Sensor address	!	Command terminator	<CR><LF>	Response terminator
ttt	Time (seconds) until measurement is ready	n, nn	Number of measurement values		

SDI-12 Schematic Installation Diagram



20 LOW-FLOW MONITORING

Groundwater that has sat in a well casing for a period of time may not adequately represent the formation water. Well purging can ensure that fresh formation water is drawn into the casing for representative measurement of water temperature, pH, conductivity, and other parameters. The well may be pumped to remove a predetermined number of volumes of stagnant water from the well.

A more cost- and time-effective method of purging involves pumping at very low flow rates with concurrent monitoring of water quality indicator parameters until it is determined that true formation water is being monitored. The Flow-Sense Wizard in Win-Situ 4 and Pocket-Situ 4 automates this process to help determine when a representative sample of formation water can be collected from a well for analysis. Based on user input, the software calculates the volume of the In-Situ flow cell and tubing, and the time to exchange one complete volume at the specified pumping rate. The frequency of measuring the water-quality indicator parameters is based on the time required to completely evacuate one volume of the flow cell and tubing. Meter and graphical views help to determine when the change in parameter readings falls within the specified target range.

Flow cell for sub-4" TROLL 9500

Flow cell for sub-2" TROLL 9500

PREPARATION

- Install Win-Situ 4 from the software CD or In-Situ website
- Install Pocket-Situ 4 to your desktop/laptop PC from the CD or website, connect the computers in ActiveSync®, launch the Win-Situ Software Manager, and follow the instructions to install Pocket-Situ 4 on the RuggedReader

  TIP: *When using the RDO sensor for low-flow monitoring, be sure to install the most recent version of Win-Situ 4 and Pocket-Situ 4, available at www.in-situ.com.*

- Calibrate the water-quality sensors
- Have the following site information ready to enter in the software when prompted by the Flow-Sense Wizard:
  - Well diameter and total depth
  - Screen length
  - Depth to water level, top of screen and placement of pump intake, referenced to a benchmark
  - Pump model & type
  - Tubing type
  - Tubing inner diameter
  - Tubing length

RDO SENSOR PREPARATION

Special preparation is in order if you plan to use the sub-4" RDO® optical dissolved oxygen sensor for low-flow monitoring. You will need:

RDO Optical Dissolved Oxygen sensor.................................0085070
Flow Cell for use with RDO sensor..0057600

The RDO-ready flow cell includes hardware fittings for setting up the flow cell and installing the RDO sensor.

PREPARE THE FLOW CELL

Connect valves and tubing to flow cell body. Attach spike or base plate. Insert the calibrated TROLL 9500 into the flow cell. Turn on the pump.

CONFIGURE THE FLOW-SENSE WIZARD IN THE OFFICE

Text entry on a PDA in the field can be tedius. To simplify the task, we suggest you run the Flow-Sense Wizard using Win-Situ 4 on a full-sized PC in the office to prime the software with representative values. Then use Win-Situ Sync to copy the “templates” created in this way to the PDA.

A Connect the TROLL 9500 you will use in the field to your desktop PC. The device can be in air since the sampled data are not important.

B For each well you need to sample, execute the Wizard as described on the following pages. The more information you can enter in advance, the less you will have to tap in later with a stylus outdoors.

C Estimate any values you do not yet know (e.g., tubing length, pumping rate, final drawdown).

D Let the stabilization phase run for at least one reading, then **Accept**.

E When the Wizard asks if you want to save the file, give each one a meaningful name, for example:

“Well A template.flo”
“Well B template.flo”

F On your next ActiveSync connection, In-Situ’s synchronization utility Win-Situ Sync will prompt you for Low Flow templates you wish to transfer to the PDA

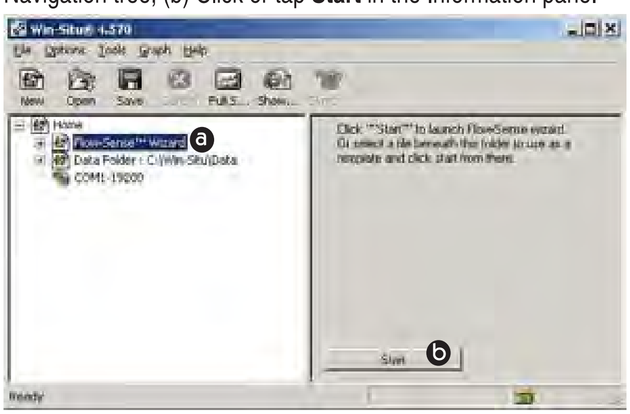
TIP: *If Win-Situ Sync does not launch automatically, select it from the In-Situ Inc. group in Programs on the Windows Start Menu. Be sure the option Transfer data files from Desktop to Field Unit is checked ☑. Click to transfer files..*

START THE SOFTWARE

Connect the TROLL 9500 to the PC or PDA. Launch Win-Situ 4 or Pocket-Situ 4. If you have not used the software before, take a moment to specify a connection type, COM port, and baud rate in the Connection Wizard.

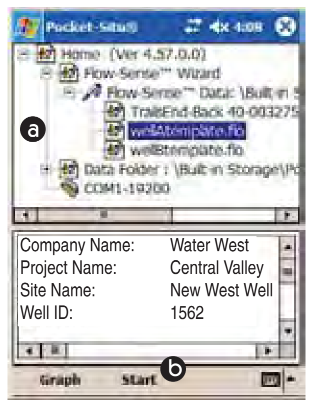
LAUNCH THE FLOW-SENSE WIZARD

1. Select one of the following ways to launch the Flow-Sense Wizard:
   - Tools Menu: Select the Flow-Sense Wizard (not available in Pocket-Situ)
   - Navigation Tree: (a) Select the Flow-Sense Wizard in the Navigation tree; (b) Click or tap **Start** in the Information pane.



   - If you’ve used the Flow-Sense Wizard before—or copied “template” files from a different PC—expand the Flow-Sense Wizard folder by clicking on the +, then expand the Flow-Sense Data folder. (a) Select a file or template. (b) Click or tap **Start**.

Input values from that file or template will be copied.



VERIFY UNIT PREFERENCES

Before the Flow-Sense Wizard starts, you may wish to verify the current unit selections. Length measurements in the Flow-Sense Wizard default to metric (meters, centimeters), but you can enter and display this data in English units (feet, inches) if you prefer. You may also wish to verify the units for Conductivity, Dissolved Oxygen, ORP, pH, Temperature, and Turbidity.

TIP: *Flow units in the Flow-Sense Wizard will always be in milliliters (mL). For best results, units should be consistent between the desktop application and the PDA application.*

To skip the settings verification, click Continue.

The Wizard will open the COM port and connect to the instrument. If you have used the Wizard before, or launched the Wizard from an existing .flo file, data entry values will be supplied.

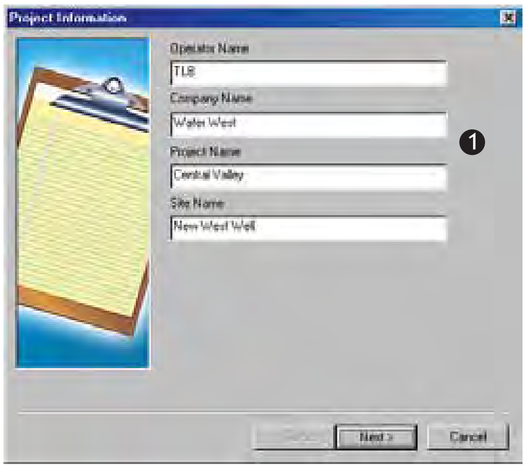
TIP: *The Wizard opens the COM port you used last (this is stored in the Wizards.ini file in the Config subfolder in the folder where Win-Situ is installed).*

If several connections have been used in the past, the Wizard uses the first “direct” connection it encounters in the tree.

If the Wizard is started without any connection information at all, it will attempt to connect using COM 1 at a baud rate of 19200.

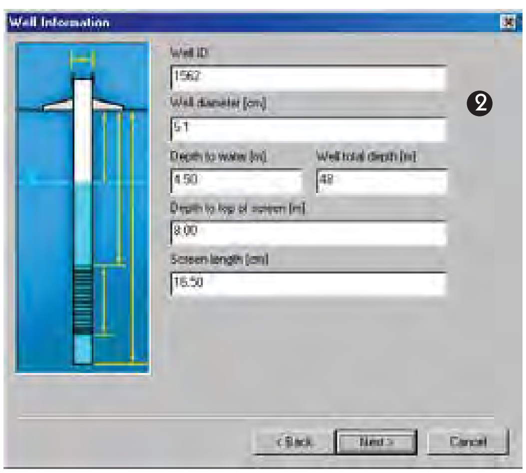
FLOW-SENSE WIZARD INPUT

1. The first input screen provides for entry of specific details about the project. This information will be included in the output report. The Project Name and Site Name will appear in the output file name.



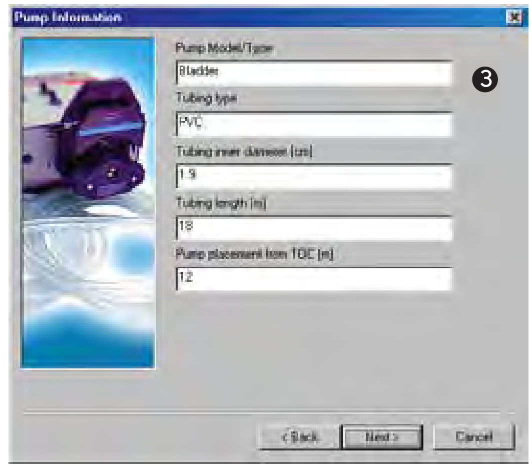
Click or tap **Next** to continue.

2. In the next screen, enter information about the well. This information will be included in the output report. The Well ID will appear in the output file name.



Click or tap **Next** to continue.

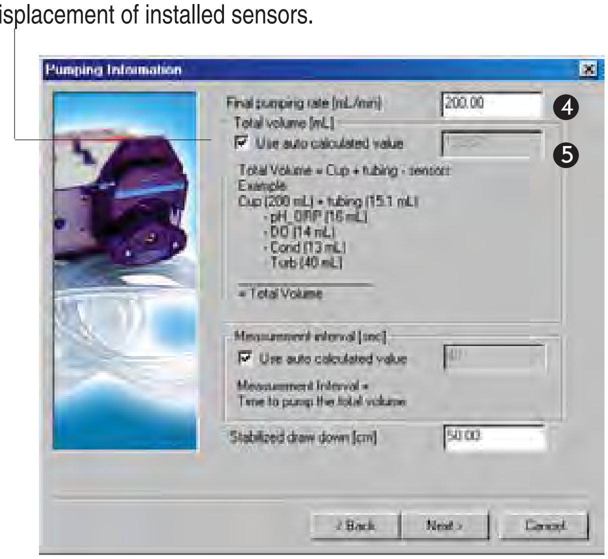
3. In the next screen, enter details about the pump and tubing (tubing information is used in later volume calculations). If creating a template, estimate the tubing length and pump placement.



Click or tap **Next** to continue.

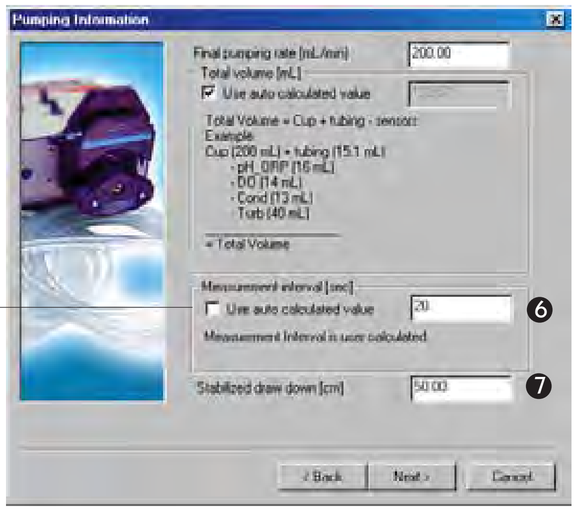
The next screen requests pumping information

4. **Final pumping rate:** Enter in milliliters per minute. If creating a template, accept the default or estimate the pumping rate.
5. **Total volume—Auto Calculated Value:** This is the software-calculated volume of the cup (flow cell) and tubing, less the displacement of installed sensors.



To specify a different volume, clear the "Auto" check box, and enter the new volume (mL).

6. **Measurement interval—Auto Calculated Value:** This is the software-calculated time (seconds) for one complete exchange of water in the calculated volume at the final pumping rate. In other words, this is the time required to completely evacuate one volume of the flow cell and tubing and draw in a new volume. Readings will be taken at this interval unless you specify a different interval.

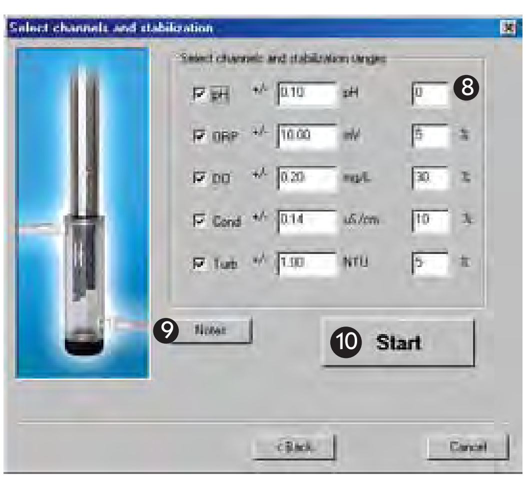


To specify a different interval, clear the "Auto" check box as shown above, and enter the desired measurement interval (seconds).

7. **Stabilized drawdown:** Final drawdown from the initial water level entered previously (measured with tape after pumping starts). If creating a template, estimate the final drawdown.

   Click or tap **Next** to continue.

8. The final screen displays the available parameters. Choose the parameters to monitor and the target stability range for each parameter. You can enter absolute values in parameter units or percentage values



> **TIP:** *If you want to enter percent values in the right column, enter "1" as a default value in the absolute (middle) column.*

The percentage range is calculated by the formula:

$$\frac{\text{max - min of last 3 readings}}{\text{last reading}} \times 100\%$$

9. If you wish to add comments, click the **Notes** button. They will be included in the output report.

10. Ensure the pump is on (unless you are creating a template), then click or tap **Start** to begin the stabilization readings.

    The sidebar on page 139 describes the stabilization readings screen that is shown next.

11. When the readings appear stable, you are ready to save the data and exit the software. Click or tap **Accept**.

    If creating a template, let the stabilization phase run for at least one reading, then click **Accept**.

SAVING THE LOW-FLOW DATA OR TEMPLATE

Click Save when a suggested output file name is displayed. You may change this name if you like. After it is saved, the file will be displayed in the Data Folder branch of the Navigation tree and will open in the Information pane, like other test files extracted in Win-Situ 4 or Pocket-Situ 4.

The file may be displayed in report format or as a graph in both Win-Situ 4 and Pocket-Situ 4. (If you can't see much on the PDA screen, try scrolling to the right.) The top of the file presents well, site, and project information. At the end of the file are the measurement data.

Additional functions are available through Win-Situ 4.

- Print (file menu)
- Graph (button in Information pane). However, note that better graphical report output is available if you export to Excel.
- Save as text file (file menu)
- Export to Excel (file menu)

OUTPUT

Low-Flow files are saved as files of type .flo in a folder named Flow-Sense Data under the Flow-Sense Wizard folder, and are accessible in the Navigation tree. By default they are named as shown below:

Flow-Sense Data \ Central Valley-New West Well-1562-6-10-2007.flo

Project name
Site name
Well ID
Date (m-dd-yyyy)
Low flow file designator

EXPORT TO EXCEL OPTION

To automatically create an output report in Microsoft® Excel® from Win-Situ 4:

1. In the Win-Situ Navigation tree, select a low-flow data file. If it opens in Graph view, select the Report button.
2. On the Win-Situ File Menu, select Export to Excel.
3. The report will open in an Excel spreadsheet.

USING A CUSTOM EXCEL TEMPLATE

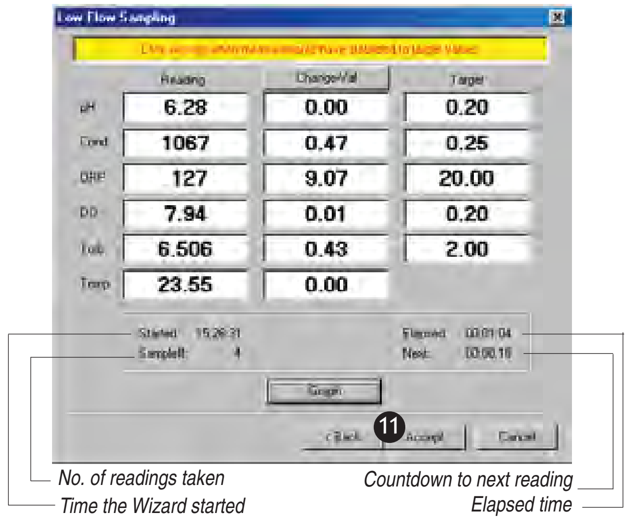
The Win-Situ 4 installation includes an Excel template for creating an output report (shown on the following page). This template is named InSituLowFlow.xlt, and is automatically installed to the Templates directory of the Microsoft operating system. Brief instructions for using this template are included in the spreadsheet that opens when you select Export to Excel.

To format an output report using the custom template,

1. After exporting a low flow data file to Excel, insert a new sheet based on a template by right-clicking the tab at the bottom of the screen in Excel.
2. Click Insert, then select the template InSituLowFlow.xlt.
3. When prompted by Excel, select "Enable Macros."

   An example of low flow data formatted in Excel using this template is shown on the following page.
4. If desired, save the report as an .xls file.

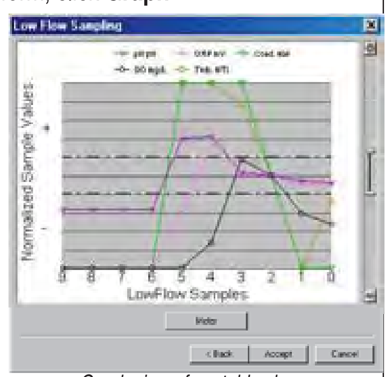
STABILIZATION READINGS—METER AND GRAPH



- **Reading:** the current reading
- **Change - Val:** difference between the maxium and minimum over the last 3 readings *OR*
- **Change - %:** difference between the current reading and the third reading back, expressed as a percentage
- **Target** specified earlier in the Wizard (shown for Values)

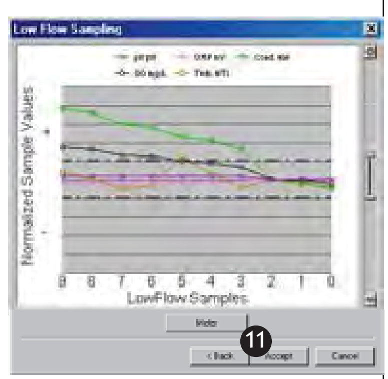
To view this data in graphical form, click **Graph**.

The graph shows the change and stabilization ranges of all parameters. The "change band," between the heavy dotted lines, represents a composite target of all specified stability ranges. You can drag the range finder up or down, or expand the stability region to zoom in.



Graph view of unstable change

The most recent readings are shown on the right, earlier readings on the left. 0 marks the latest reading. The change band is centered on the third point as a reference. The graph can show up to 10 sets of readings. Change is recalculated with each reading.



Graph view of stabilized change

In-Situ Inc.

Troll 9500	**Low-Flow System**
04/23/07	**ISI Low-Flow Log**

Project Information:		**Pump Information:**	
Operator Name	Scott Bennett	Pump Model/Type	Bladder P1101M
Company Name	In-Situ Consultants	Tubing Type	Polypropolyene
Project Name	MR0523	Tubing Diameter	0.1 [cm]
Site Name	Lakeside Road Landfill	Tubing Length	385.5 [m]
		Pump placement from TOC	396.98 [m]

Well Information:		**Pumping information:**	
Well Id	MW-6	Final pumping rate	300 [mL/min]
Well diameter	1.57 [cm]	Flowcell volume	1685.2 [mL]
Well total depth	429.79 [m]	Calculated Sample Rate	338 [sec]
Depth to top of screen	364.17 [m]	Sample rate	300 [sec]
Screen length	94.49 [cm]	Stabilized drawdown	14.17 [cm]
Depth to Water	108.92 [m]		

Low-Flow Sampling Stabilization Summary

	Time	Temp [F]	pH [pH]	Cond [µS/cm @25C]	Turb [NTU]	RDO [mg/L]	ORP [mV]
Stabilization Settings			+/-0.1	+/-1 +/-3 %	+/-1 +/-10 %	+/-1 +/-10 %	+/-10
Last 5 Readings	17:12:47	56.80	5.15	339.97	13.95	0.17	390.10
	17:16:51	56.51	5.16	339.03	46.17	0.17	417.08
	17:20:08	56.56	5.10	338.61	68.57	0.16	434.31
	17:22:34	56.51	5.10	338.16	64.85	0.16	445.60
	17:27:45	56.57	5.09	338.73	76.91	0.16	469.46
Variance in last 3 readings	17:20:08	0.04	-0.05	-0.42	22.41	0.00	17.23
	17:22:34	-0.05	0.00	-0.45	-3.72	0.00	11.29
	17:27:45	0.08	-0.01	0.56	12.06	0.00	23.86

Notes: first sample using new set up

Sample of a Low-Flow output report using the Export to Excel function and the In-Situ template InSituLowFlow.xlt. Normalized data = change in indicator parameters mapped from 0 to 1. A graph may be generated using Win-Situ 4 and inserted manually into the report, if desired.

21 CARE & MAINTENANCE

REPLACING BATTERIES

The MP TROLL 9500 uses—

- two standard 1.5V alkaline D cells, or
- two 3.6V lithium D cells—recommended for use with an RDO optical dissolved oxygen sensor, and with a turbidity wiper

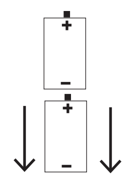
Use only Saft LSH-20 3.6V lithium D cells. Use of any other lithium battery will void the product warranty.

Battery voltage and approximate percentage remaining is displayed in the software interface when the instrument is connected to a PC. *Note:* Due to the voltage supplied by two lithium D cells, the software may report that the TROLL 9500 is operating on external power.

To replace batteries:

1. Unscrew and remove the white battery compartment cover. If the cable is attached, slide the battery compartment cover up onto the cable.
2. Press down slightly on the top battery to remove it, or knock it out gently into your hand.
3. Tip the unit to slide the bottom battery out.

4. Insert the new batteries according to the diagram on the inside of the battery compartment (positive up for both).



Insert batteries negative side first, positive side up

5. Slide the white cover back down over the battery compartment and hand-tighten to thread it to the instrument body.

Screw the cover down firmly to compress the o-rings and create a waterproof seal. When properly assembled, the o-rings will not be vsible.

6. At your next software connection in Win-Situ 4 or Pocket-Situ 4, edit the device to update the battery information. (See “Editing the Device Properties” in Section 4.)

O-RING SEALS

LUBRICATION

The Viton® o-rings used in the MP TROLL 9500 and other submersible In-Situ instruments are crucial to insure the integrity of the watertight seal. We recommend that you inspect them each time they are stressed (insertion/removal of sensors, attachment/removal of the restrictor, battery replacement, etc.) for any indication of dirt, cracks, tears, splitting, shredding, desiccation, and other damage. If the o-rings are in good condition, apply silicone lubricant before re-assembling the instrument. Remove excess lubricant with a lint-free tissue. If the o-rings are damaged, they should be replaced, as described below.

When lubricating the sensor o-rings, take special care to keep grease away from the area around the connector at the bottom of the sensors. Should lubricant get into this area, remove it with a clean cotton swab.

REPLACEMENT

If the o-rings become damaged to the extent that no longer provide an effective seal, they should be replaced. If there is any doubt whether the o-rings should be replaced, it is best to err on the side of safety and replace them.

Before replacing o-rings, clean all mating surfaces, including the o-ring grooves.

O-rings and lubricant are included in the MP TROLL 9000 Maintenance kit available from In-Situ Inc. or your distributor.

GENERAL CLEANING

Rinse the instrument body well, especially if it has been in contact with contaminated media. Air-dry or wipe with a lint-free tissue.

Ultrasonic cleaning is not recommended.

STORAGE

Store the TROLL 9500 clean and dry. Place the protective red dustcap on the cable end, or store with cable attached to protect the connector pins and o-ring.

Store the instrument where it will be safe from mechanical shocks that may occur, such as rolling off a bench onto a hard surface.

Protect the instrument from temperature extremes. Store within a temperature range of -40°C to +80°C (-40°F to +176°F).

If the sensors are removed for storage, place plugs in the dry sensor ports as protection from dust and dirt.

SENSOR STORAGE

For long-term storage, return the water-quality sensors to their original packaging. Protect the lubricated o-rings from dust and dirt.

For up to a week, the sensors may be left in the instrument, with a moist sponge in the bottom of the Cal Cup to provide a moist environment for those sensors that require it.

TWIST-LOCK CONNECTORS

Keep the pins on all connectors free of dirt and moisture by using the soft protective dustcap when cable is not attached.

22 TROUBLESHOOTING

TROUBLESHOOTING CONNECTIONS

Problem: Win-Situ or Pocket-Situ cannot "find" (connect to) the MP TROLL 9500. Error 6146 may be displayed.

Probable Cause: Wrong COM port selected, loose cable connections, device is taking a measurement as part of a test, batteries are low, elastomer is worn

Suggested Remedy: Check the following:

- all cable connections are tight
- the back end is securely attached to the instrument
- the correct COM port is selected
- the internal battery has voltage remaining; attach external power
- If a test is running, try connecting again—several times if necessary to "sneak" in between test data points.

Problem: Readings are in the wrong units

Probable Cause: Default units are being used

Suggested Remedy: Select the desired units on the Win-Situ Options menu, or select the Home site in Pocket-Situ and tap Setup in the command bar

Problem: Pocket-Situ hangs

Suggested Remedy: Reset the PDA; see your PDA documentation for details on hard and soft reset

Q: ***The MP TROLL 9500 rolled out of the back of my truck and hit the ground pretty hard. It still talks. Is it OK to use?***

A: *The instrument is pretty rugged, and can survive a few drops and rolls. We hope the restrictor was on to protect the sensors! First, check the joint between the body and the restrictor. It should appear smooth and tight to preserve the integrity of the water seal. Next, remove the restrictor and insure the pressure sensor is snug against the sensor block. Push it firmly into the sensor block if you see a gap. If the temperature sensor is bent, straighten it gently but firmly by hand (no tools, please).*

If the instrument is dropped repeatedly on the nose cone, check for damage to the batteries.

TROUBLESHOOTING DATA COLLECTION (TESTS)

Problem: Test ABENDed (came to an "ABnormal END")

Probable Cause: Device lost power or ran out of memory

Suggested Remedy: None; indication of ABEND in software cannot be reversed. but data collected up until the time the test ABENDed is likely to be fine

Check clock, check memory free, check device power

Problem: Scheduled test did not start

Probable Cause: Incorrect device clock, full memory, power removed at time of first scheduled data point

Suggested Remedy: Synchronize device clock and reschedule test; insure device has sufficient battery power and free memory; insure device is powered at time of first scheduled data point

TROUBLESHOOTING SENSORS

Problem: Sensor will not go into port

Probable Cause: (1) Insufficient lubrication on sensor o-rings. (2) Incorrect sensor alignment.

Suggested Remedy: (1) Generously lubricate sensor o-rings with a good silicone lubricant. Remove excess lubricant with a tissue, and take care to keep grease away from the area around the connector at the bottom of the sensor. (2) Align the mark on the side of the sensor (it looks like a small white "V") with the tic mark on the sensor port. If you have trouble locating these marks, visualize the sensor block as a clock face, with the pressure/turbidity sensor or plug at 12:00. The port alignment marks are at the 3:00 position for each port.

Problem: Sensor will not come out of port

Probable Cause: Inability to grasp sensor

Suggested Remedy: Try the sensor removal tool. Insert it between the widest part of the sensor and the instrument body and press down on the handle, prying the sensor up until it pops out.

Problem: Software does not recognize sensor in port

Probable Cause: (1) Sensor is not firmly seated in port. (2) Excess lubricant or dirt in port. (3) Sensor is in a wrong port for its type.

Suggested Remedy: (1) Re-insert the sensor: Align the mark on the side of the sensor (it looks like a small white "V") with the tic mark on the sensor port. Use sensor insertion tool to press sensor firmly into port until you feel it dock with the connector. When properly inserted a only a very small gap (0.060-0.075 inch, the width of the sensor removal tool) remains between the widest part of the sensor and the instrument body. (2) Remove excess lubricant and/or dirt from the connector on the sensor and from the connector in the port.
(3) Insure the sensor is in the correct port for its type. Some sensors will function properly in any port, others will work only in specific ports. Refer to diagrams in section 3 or specific sensor section of this manual. Remove sensor and re-install in correct port, if necessary, then refresh device information in the software.

TROUBLESHOOTING CALIBRATION

Problem: The Cal Cup leaks when rinsing sensors

Probable Cause: Cal Cup is not tightened to probe body sufficiently to seat against the o-ring

Suggested Remedy: Carefully align threads on Cal Cup with threads on instrument body. Thread the Cal Cup onto the body until it is seated against the o-ring, then back off slightly to avoid overtightening.

Problem: The DO readings stabilized during the Quick Cal but now the readings are off (too high or too low)

Probable Cause: (1) Too much solution in Cal Cup during the Quick Cal to expose the DO sensor to air. (2) Cal Cup is too tightly sealed during calibration.

Suggested Remedy: (1) The DO membrane must be exposed to air for a valid 100% DO calibration. If the membrane is submerged when you invert the Cal Cup during the Quick Cal, remove the end cap and pour out some of the calibration solution until the membrane is in air. (2) Loosen the end cap of the inverted Cal Cup during DO calibration to avoid pressurizing the chamber.

APPENDIX

ELECTRONIC DRIFT AND DEVICE RECALIBRATION

The electronics of the Multi-Parameter TROLL 9500 will experience accuracy drift over time. This drift applies to all channels and is additive to the initial calibration accuracy. Electronic drift does not apply to user-calibrated sensors because the drift is compensated for during calibration.

The system wide long-term drift is dominated by the stability of the voltage reference used in the device. Other components exhibit long-term drift of a much smaller magnitude.

The equation used to calculate drift over time is:

$$D = K * \sqrt{(t / 1000 \text{ hours})}$$

where:

D is the drift in ppm

K is the long term stability coefficient listed as ppm / 1000 hours but actual units are ppm

t is the time expressed in hours

Using this information, the maximum drift over time is shown in the table on this page.

Time Period		Drift	
Years	1K Hours	ppm	%
0.00	0.00	0	0.000
0.25	2.19	178	0.018
0.50	4.38	251	0.025
0.75	6.57	308	0.031
1.00	8.76	355	0.036
1.25	10.95	397	0.040
1.50	13.14	435	0.043
1.75	15.33	470	0.047
2.00	17.52	502	0.050
2.25	19.71	533	0.053
2.50	21.90	562	0.056
2.75	24.09	589	0.059
3.00	26.28	615	0.062
3.25	28.47	640	0.064
3.50	30.66	664	0.066
3.75	32.85	688	0.069
4.00	35.04	710	0.071
4.25	37.23	732	0.073
4.50	39.42	753	0.075
4.75	41.61	774	0.077
5.00	43.80	794	0.079

***TIP:** The recommended frequency of factory recalibration of the MP TROLL 9500 depends upon the amount of drift a user is willing to tolerate. For example, if a drift of 0.025% is acceptable, then the recalibration period is 6 months; if a drift of 0.05% is acceptable, then the recalibration period is 2 years.*

DETERMINING DENSITY

The density of water in a well can be determined using an accurate tape measure and a pressure transducer. A change in pressure is recorded between two points as the transducer is lowered into the water and the corresponding change in depth is recorded using the measuring tape. Density is then calculated using a simple formula. This method is valid if the pressure and depth measurements are accurate and the water within the well is homogeneous throughout the entire depth of the well.

Note: Density can also be measured using a hydrometer if it is possible to withdraw a water sample from the well. We recommend an accuracy of ±0.0005.

Procedure

There are two possible methods for measuring the change in water depth. Choose the method that is the most convenient and accurate.

- Attach the tape measure to the transducer cable using an adhesive (e.g., duct tape). The tape measure can be attached to the transducer itself or to a segment of the cable that will be adjacent to the top of the well casing. Read the cable positions directly from the measuring tape. The measuring device must have a resolution of at least 1 mm or 1/16 in.
- Alternatively, mark the positions of the cable with an indelible felt tip pen. The distance between marks is then determined with a tape measure after the corresponding cable segment is removed from the well.

1. Lower the transducer into the well until it is submerged under about one meter of water.
2. Secure the transducer at a fixed depth using the cable at the top of the well casing. Wait an hour or so for the system to equilibrate.
3. Take an electronic pressure reading, manually, from the transducer and record this measurement in PSI. This is measurement P_1.
4. Read the tape measure relative to some fixed reference point (e.g., top of well casing) or mark the position on the cable with an indelible pen. This is measurement L_1.
5. Lower the transducer at least three meters deeper into the water and repeat steps 3 and 4. These are measurements P_2 and L_2.
6. Density (ρ) in g/cm^3 is calculated using the following:

$$\rho = \frac{(P_2 - P_1) \times 6.894757}{g \times (L_2 - L_1)}$$

where g is the gravitational acceleration for the location of the well in m/s^2. P must be in PSI units and L must be in meters. If using a tape measure calibrated in feet, 1 ft = 0.3048 m (exactly).

An error of 0.001 m (1 mm) in the depth measurement translates into an error of 0.00085 g/cm^3 for density.

GLOSSARY

ABend: Indication in the software interface that a test has come to an "ABnormal END"—usually because the device memory is full, or power was lost.

ABS: Acrylonitrile Butadiene Styrene, a plastic material.

Absolute pressure sensor: Non-vented pressure sensor that measures all pressure forces detected by the strain gauge, including atmospheric pressure. Fluid levels measured with an absolute pressure sensor must be corrected through subtraction of the atmospheric pressure to obtain accurate fluid level measurements. *Compare* Gauged pressure sensor.

AC: Absolute or Actual Conductivity.

Accuracy: Closeness of agreement between the result of a measurement and the true value. Usually expressed as a deviation from 100% accuracy.

A/D (analog to digital) converter: Converts an electrical signal to a numeric value that can be interpreted by a computer.

Ambient pressure (temperature): The pressure (temperature) of the medium surrounding the sensor or instrument.

Ammonia (NH_3): A toxic, colorless gas with a pungent odor, highly water-soluble.

Ammonium (NH_4^+): Solvated ammonium cation produced when ammonia gas is dissolved in water.

Ammonium chloride (NH_4Cl): A salt used to make ammonium and chloride calibration standards.

Anion: Negatively charged ion (e.g., Cl^-, NO_3^-).

Atmospheric pressure: Pressure due to the atmosphere, altitude-dependent.

Barometric pressure, *see* Atmospheric pressure

Bithermal: At two temperatures, e.g., a three-point calibration of an ammonium, chloride, or nitrate sensor conducted at two different temperatures.

Basic sensor set: pH, pH/ORP, conductivity, and polarographic (Clark cell) dissolved oxygen; *compare* Extended sensor set.

Boxcar filtering: A smoothing scheme that looks at the 5 most recent data points.

Cable, *see* Comunication cable, Network cable, RuggedCable, TROLL Com, Vented cable

Calibration: The process of determining the response of a measurement system to a known amount of the measured component in order to permit the measurement of unknown samples.

Calibration, out-of-box: Use of new Basic sensors for the MP TROLL 9500 directly from the box, with factory-supplied calibration coefficients. Sensors should be calibrated after they are used and begin to drift.

Calibration, Quick Cal: A rapid calibration procedure available for the Basic sensors, using a single solution.

Calibration, traditional: Single- or multi-point methods for calibrating water-quality sensors individually to gain higher accuracy.

Calibration coefficients: Sensor slope and offset that convert analog measurements to user units; calculated during calibration.

Calibration cup: Clear PVC vessel that attaches to the front end of the MP TROLL 9500 in place of the restrictor and holds the recommended amount of calibration solution during calibration of the water-quality sensors.

Calibration kit: Boxed set of standards for calibrating a specific water-quality sensor for operation in a specific range.

Calibration solution, Calibration standard: A solution whose concentration is accurately known.

Cation: Positively charged ion (e.g., NH_4^+, Na^+).

Cell constant: A value that describes a conductivity cell which is determined by electrode area and electrode separation.

Chloride (Cl^-): Common anion in water that gives it a salty taste.

Chlorophyll: Green pigment in plants that transforms light energy into chemical energy during photosynthesis.

Clone: Copy all elements of a selected test definition to a new test.

Combination electrode: A combination of a sensing or measurement electrode and a reference electrode in one unit.

COM port: RS232 serial communication port on a PC.

Communication cable: see TROLL Com

Conductivity, electrical: A measure of the ability of an aqueous solution to carry an electric current. Increases with increasing temperature.

Connection node: Node in the Win-Situ or Pocket-Situ Navigation tree, representing the COM port on the host PC.

Data folder: Node in the Win-Situ or Pocket-Situ Navigation tree, providing a view of tests that have been extracted from the device memory to the host PC. The Data Folder can be expanded to show the device type, device serial number, and test name.

Data point: In logged data, one reading from every channel being sampled.

Density: Mass of a substance per unit volume (e.g., grams per liter, g/L; grams per cubic centimeter, g/cm^3). Water is most dense at 4° Celsius.

Depth: The distance between the water surface and the pressure sensor of the MP TROLL 9500. Converted from pressure units using values selected by the user during pressure parameter setup.

Derived measurement: Value calculated in software from the output of more than one sensor; e.g., salinity is derived from conductivity and temperature.

Device node: Node in the Win-Situ or Pocket-Situ Navigation tree, representing the connected MP TROLL 9500.

Digital DO: Proprietary method of powering the dissolved oxygen sensor; digital pulsing eliminates the need to stir the sample to avoid oxygen depletion.

Dissolved oxygen (DO): The amount of oxygen present in water and available for respiration.

DO: Dissolved Oxygen.

Downhole cable, *see* RuggedCable

Drift: Gradual change in sensor response with time.

DSP: Digital signal processor.

Electrode: An electric conductor through which an electric current enters or leaves a medium (such as an electrolyte).

Electrolyte: A chemical compound which when dissolved in water will conduct an electric current; sensor filling solution.

Event test, Event sampling: Test measurement schedule in which the selected parameters are measured at the same regular, unvarying linear interval, but the data are logged only if the measurements on the designated event channel exceed a user-specified value. Conserves storage memory while logging all meaningful data.

Extended sensor set: Ammonium, chloride, nitrate, turbidity, and optical dissolved oxygen sensors; *compare* Basic sensor set.

Extract: Copy test data from the MP TROLL 9500 memory to a host PC. Initiated by the ***Extract*** button when a test is selected in the Navigation tree.

Firmware: Software program that resides in the memory of the MP TROLL 9500; firmware can be field-upgraded.

Flow cell: Clear vessel with input and output ports for routing flow past the sensors of the MP TROLL 9500; alternative to in-situ installation of the instrument where in-place installation is not possible or practical.

Flow-Sense Wizard: Low-flow application in Win-Situ software for monitoring water-quality indicator parameters in a flow cell during low-flow pumping.

FNU: Formazin Turbidity Units; compare NTU

FS: Full scale.

Gauged pressure sensor: Pressure sensor that is vented to the atmosphere; measures only pressure exerted by the water column, excludes the atmospheric pressure component. *Compare* Absolute pressure sensor; *see also* Vented cable.

HDPE: High-density polyethylene.

HIF: U.S. Geological Survey's Hydrological Instrumentation Facility.

Home site: Default site node (top node) in the Win-Situ or Pocket-Situ Navigation tree, representing the host computer.

Host PC: Desktop computer running Win-Situ, or PDA running Pocket-Situ, connected to the MP TROLL 9500 via TROLL Com or other communication interface.

Interference: The presence of a species in a sample other than the species being measured that causes erroneous values.

Ionic strength: A measure of the total effect of all the ions, both positive and negative, present in a solution.

ISA (Ionic Strength Adjustor): Solution of high ionic strength which can be added to both sample and calibration solutions in equal proportions before measurement to minimize differences in ionic strength.

ISE (Ion-Selective Electrode): An electrode which responds selectively to the ions of a particular species in solution.

Isopotential point: The ion concentration at which changes in temperature do not cause a change in ISE sensor response (voltage).

Isothermal: At constant temperature.

Kcell, *see* Cell constant

KCl: Potassium chloride.

LED: Light-emitting diode, used in turbidity and Optical DO sensors.

Level reference: User-specified starting point for level readings; entered during pressure parameter setup.

Level—Surface: A mode for displaying logged pressure measurements; readings are positive up; useful for measuring surface water; permits use of zero or other user reference.

Level—Top of Casing: A mode for displaying logged pressure measurements; readings are positive down, as the water level draws down from the top of the well casing; permits entry of zero or other user reference.

Limnology: The science of the life and conditions for life in lakes, ponds, and streams.

Linear average: Test measurement schedule in which each measurement stored to the data file is the average of multiple closely-spaced measurements.

Linear test, Linear sampling: Test measurement schedule in which the selected parameters are measured at the same regular, unvarying sample interval and all measurements are logged.

Log test, Log sampling: Test measurement schedule in which measurements begin closely spaced and the interval between measurements continuously increases. Short for Logarithmic sampling.

LSZH: Low smoke zero halide

µM, µmol/L: micro Molar, unit of dissolved oxygen concentration; to convert to mg/L, divide by 31.25.

mg/L: Milligram per liter; equivalent to one part per million (ppm).

miniTROLL: In-Situ's 0.72" diameter downhole pressure/temperature smart probe.

Molarity (M): A unit of measure indicating concentration in moles of solute per liter of solution.

Multi-ISE: An ion-selective electrode that measures more than one parameter.

$NaNO_3$: Sodium nitrate.

Na_2SO_3: Sodium sulfite.

Navigation tree: Left side of the Win-Situ application interface, or top of the screen in Pocket-Situ, showing selectable nodes: Site, Data Folder, Connection, Device, Parameters, Tests.

Nernst equation: The fundamental equation that relates the electrode potential to the activity of measured ions in a solution.

NH_4Cl: Ammonium chloride.

N.I.S.T.: National Institute of Standards and Technology, a non-regulatory federal agency within the U.S. Department of Commerce. Formerly known as the National Bureau of Standards.

Nitrate (NO_3^-): Oxidized form of nitrogen that is highly soluble in water, present in soils, fertilizer, wastewater, etc.

Node: Element in the Navigation tree on the left side of the Win-Situ interface, or at the top of the screen in Pocket-Situ. When a node is selected, the remainder of the screen displays details about the node. Nodes include the Site, Data Folder, Connection, Device, Parameters (group node), single Parameter, Tests (group node), single Test.

Non-vented pressure sensor, *see* Absolute pressure sensor

Nose cone: Detachable threaded protective stainless steel piece at the front end of the MP TROLL 9500.

Nose cone stirrer, *see* Stirrer

NTU: Nephelometric turbidity unit, a measure of the intensity of light scattered by a water sample. From nephelometer, a type of turbidimeter. Comparable to previously reported Formazin Turbidity Unit (FTU), and Jackson Turbidity Unit (JTU).

Optode: optical electrode.

ORP, *see* Oxidation-reduction potential

Oxidation-reduction potential (ORP), also called “redox” potential (from “reducing” and “oxidizing”): Voltage difference at an inert electrode immersed in a reversible oxidation-reduction system; measurement of the state of oxidation of the system.

Parameter node: Node in the Win-Situ or Pocket-Situ Navigation tree, representing a single parameter (pressure, temperature, pH, conductivity, etc.).

Parameters node: Node in the Win-Situ or Pocket-Situ Navigation tree, providing a view of all parameters the device can measure.

Partial pressure: In a mixture of gases, the pressure a single gas would exerted if it occupied the entire volume.

Pascal: Unit of pressure equal to the pressure resulting from a force of 1 newton acting uniformly over an area of 1 square meter.

PC: Desktop or laptop computer.

PDA (Personal Data Assistant): Generic term for a hand-held personal computer.

pH: Term used to describe the hydrogen-ion activity of a system; the negative logarithm of the activity of the hydrogen ions (H^+) in the solution.

Pocket PC: A type of PDA with an ARM processor and Pocket PC (Windows Mobile) operating system.

Pocket-Situ: Win-Situ 4 software for supported PDAs.

PocketSync for Pocket-Situ: Synchronization utility that runs on a desktop/laptop PC; automatically installs or updates Pocket-Situ on a connected PDA; synchronizes data and other files between the PDA and the PC where Win-Situ is installed

Polarization: Application of a direct or alternating current to a sensor.

Potassium chloride (KCl): A salt used to make conductivity calibration standards.

ppm: Part-per-million; equivalent to a milligram per liter (mg/L).

Precision: The closeness of agreement between independent test results obtained under stipulated conditions. A measure of the reproducibility of a method.

Pressure: A type of stress which is exerted uniformly in all directions. Its measure is the force exerted per unit area; e.g., pounds per square inch (psi), newtons per square meter (pascals).

Pressure transducer: Instrument or component that detects a fluid pressure and produces an electrical signal related to the pressure.

Professional: MP TROLL 9500 model containing memory; able to log data; accommodates the Basic sensor set.

Professional XP: MP TROLL 9500 model with all features of the Professional model and in addition allows use of the Extended sensor set.

Profiler: MP TROLL 9500 model without memory; must be used with a PC or PDA; accommodates the Basic sensor set.

Profiler XP: MP TROLL 9500 model with features of the Profiler and in addition allows use of the Extended sensor set.

Profiling: Taking continuous real-time readings of all enabled parameters.

PRT: Platinum resistance thermometer, a type of resistance temperature detector (RTD).

psia: A pressure unit, pounds per square inch absolute, measured with respect to zero pressure. All forces detected by the strain gauge are measured, including atmospheric pressure.

psig: A pressure unit, pounds per square inch gauge, measured with respect to atmospheric pressure. Thus the atmospheric pressure component is excluded.

PSU: Practical Salinity Units, based on the Practical Salinity Scale.

Pulsing: Periodic low-frequency polarization of a dissolved oxygen sensor.

Pump test, Pumping test: Aquifer characterization test that involves pumping out a known volume of fluid from a well and measuring the time of recovery to stable conditions.

Quick Cal: Rapid calibration procedure available for the MP TROLL 9500 Basic sensors that uses a single solution.

Quick Cal solution: A calibration standard of an appropriate chemical composition to calibrate four parameters simultaneously (pH, ORP, Dissolved Oxygen, Conductivity).

Quinhydrone: Dark green water-soluble compound, a 1:1 complex of benzoquinone and hydroquinone used as an ORP calibration standard when dissolved in pH buffer solution.

Reading: Measurement from a single channel (parameter).

Redox potential, *see* Oxidation-reduction potential

Reference (water level measurements), *see* Level reference

Reference electrode: A standard electrode of known potential against which the measurement or sensing electrode is compared.

Repeatability: Closeness of the agreement between the results of successive measurements carried out under the same conditions.

Reproducibility: Closeness of the agreement between the results of measurements of the same measurand carried out under nearly identical conditions but after an intermediate change was made and removed.

Resistance thermometer: Temperature sensor that changes electrical resistance with temperature.

Resistivity: The reciprocal of conductivity; calculated from conductivity.

Resolution: The smallest unit that can be measured by a device over its full range.

Response time: Time required for the MP TROLL to power a sensor and the sensor to return an accurate reading.

Restrictor: Perforated stainless steel area of the MP TROLL 9500 between the nose cone and the body; protects the sensors and allows free circulation of environmental fluid.

RDO: Rugged optical dissolved oxygen sensor

RS-485: Communications protocol using Recommended Standard 485 of the Electronic Industries Association (EIA-485) for the orderly transfer of electrical data signals; a balanced (differential), multipoint Interface Standard that uses two lines to transmit/receive data and can operate at 100 Kbps with cable lengths up to 4000 feet.

RTD: Resistance temperature detector, a type of resistance thermometer that has nominally 100 Ω at 0°C.

RuggedCable™: Waterproof, submersible, TPU-jacketed vented or non-vented cable for a Multi-Parameter TROLL 9500; carries power and communication signals; provides strain relief and a means to anchor the instrument to a stationary object; Twist-Lock connectors on both ends, Rugged (titanium) or Standard (carbon-filled ABS plastic); halogen-free version available.

S, *see* Siemens

Salinity: A measure of the amount of salts dissovled in water, usually expressed in parts per thousand (ppt); calculated from conductivity and temperature.

Saturation: The point at which a substance contains a maximum amount of another substance at a given temperature and pressure.

SC: Specific Conductance, conductivity corrected to 25°C.

SDI-12: A serial-digital interface operating at 1200 baud.

Sensor kit: Package containing an In-Situ sensor, along with necessary installation items and instructions for installing in the Multi-Parameter TROLL 9500.

SI: International System of Units.

Siemens (S): SI unit for conductivity, reciprocal of the ohm; this unit was formerly known as the “mho” (ohm spelled backwards).

Site node: Topmost node in the Win-Situ or Pocket-Situ Navigation tree, representing the host computer.

Slope: Sensor response vs. concentration (quantity). Slope and offset are the coefficients calculated during calibration that convert analog measurements to user units.

Slug test: Aquifer characterization test that involves “slugging” a well with a known volume of fluid or solid and measuring the time of recovery to stable conditions.

Soak time: Length of time a sensor is immersed in a calibration solution or sample, ideally at the same temperature at which measurements will be taken.

Sodium nitrate ($NaNO_3$): A salt used to make nitrate calibration standards.

Specific conductance: Conductivity of a solution at 25°C.

Standard Methods: Approved methods of analyzing for water-quality parameters, as specified in the reference work *Standard Methods for the Examination of Water and Wastewater,* published jointly by the American Public Health Association, American Water Works Association, and Water Environment Federation.

Stirrer: Battery-powered motorized low-power stirring mechanism with magnetic stirring bar for use during calibration and/or in stagnant waters.

Submersible cable: Waterproof, quick-connect cable designed for submersion; Instrument backshell located at downhole end; surface connector at surface end.

Surface connector: Multi-function vented nylon connector at the surface end of the MP TROLL's submersible cable; accommodates a variety of top-of-well devices for communications, networking, and power supply.

TDS, *see* Total Dissolved Solids

Tefzel®: Dupont®'s modified ETFE fluoropolymer

Temperature, Solution temperature: Amount of heat present in the solution in which the instrument is submerged.

Test: Instructions to the MP TROLL's internal logger for collecting data; the logged data from one set of instructions.

Test node: Node in the Win-Situ or Pocket-Situ Navigation tree, representing a single test.

Tests node: Node in the Win-Situ or Pocket-Situ Navigation tree, providing a view of all tests currently stored in the device memory.

TOC (Top of Casing), *see* Level—Top of Casing

Torr: A unit of pressure, equal to 1/760 atmosphere.

Total Dissolved Solids (TDS): The amount of dissolved substances, such as salts or minerals, in water remaining after evaporating the water and weighing the residue. Calculated from conductivity.

TPU: Thermoplastic Polyurethane, a cable jacket option.

TROLL Com: Communication cable interface between MP TROLL 9500 and a desktop/laptop PC or RuggedReader handheld PDA.

Turbidity: A measure of the transparency of water.

Twist-Lock Hanger: Back end hanger without venting or communication capabilities; allows use of inexpensive hanging cable while taking absolute (non-vented) pressure data with a preprogrammed instrument.

Units: Measurement units; user-selectable in software interface.

Vented cable: RuggedCable with a vent tube that applies reference atmospheric pressure to the back of the pressure sensor diaphragm.

Vented pressure sensor, *see* Gauged pressure sensor

Vertical profile: Characterization of a water column from surface to bottom (or vice-versa) through multiple real-time readings of the water-quality parameters of interest taken at varying depths.

Win-Situ 4: Instrument control software for instrument setup, calibration, profiling, data logging, data retrieval and display.

ZoBell's: A redox standard solution with a known state of oxidation-reduction potential (measured in milliVolts) used to calibrate ORP.

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Environmental Monitoring Systems

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In-Situ Inc.

www.in-situ.com

Declaration of Conformity

Manufacturer: In-Situ, Inc.
221 East Lincoln Avenue
Ft. Collins, Co. 80524
USA

Declares that the following product:

Product name:	Multi-Parameter TROLL 9500
Model:	WQP-100
Product Description:	The Multi-Parameter Troll 9500 provides real-time readings for and logs up to 9 water-level and water-quality parameters 7 of which are multi-configurable in addition to the built-in temperature and barometric pressure parameters.

is in compliance with the following Directive

89/336/EEC for Electromagnetic Compatibility (EMC)

and meets or exceeds the following international requirements and compliance standards:

- **Immunity**
  EN 61326:1997, Electric Equipment for Measurement, Control and Laboratory Use

- **Emissions**
  Class A requirements of EN 61326:1997, Electric Equipment for Measurement, Control and Laboratory Use

Supplementary Information:
The device complies with the requirements of the EU Directive 89/336/EEC, and the CE mark is affixed accordingly.

Todd Campbell
New Product Development Program Manager
In-Situ, Inc.
October 28, 2005

In-Situ Inc.
221 East Lincoln Avenue • Fort Collins, CO 80524 USA
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WWW.IN-SITU.COM

Declaration of Conformity

Manufacturer: In-Situ, Inc.
221 East Lincoln Avenue
Fort Collins, CO 80524
USA

Declares that the following product:

Product name: TROLL Com
Model: USB TROLL Com
Product Description: RS485 to USB converter

is in compliance with the following Directive

89/336/EEC for Electromagnetic Compatibility (EMC) Directive
73/23/EEC for Safety Directive

and meets or exceeds the following international requirements and compliance standards:

- **Immunity**
  EN 61326, Electrical Equipment for Measurement, Control and Laboratory Use, Industrial Location

- **Emissions**
  Class A requirements of EN 61326, Electrical Equipment for Measurement, Control and Laboratory Use

Supplementary Information:
The device complies with the requirements of the EU Directives 89/336/EEC and 73/23/EEC, and the CE mark is affixed accordingly.

Todd Campbell

Todd Campbell
New Product Development Program Manager
In-Situ, Inc.
June 17, 2006

CE FC