



**Multi-Parameter TROLL 9000  
WQP-100  
Operator's Manual**



**September 2005**

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Revision history	initial release May 24, 2002
	rev. 001 October 3, 2002
	rev. 002 December 11, 2002
	rev. 003 April 2, 2003
	rev. 004 April 30, 2003
	rev. 005 September 11, 2003
	rev. 006 December 3, 2003
	rev. 007 May 24, 2004
	rev. 008 November 19, 2004
	rev. 009 April 2005
	rev. 010 September 2005

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# 1 INTRODUCTION

## GENERAL DESCRIPTION OF THE MP TROLL 9000

Your new Multi-Parameter TROLL 9000 water quality probe uses the latest sensor and electronics technology to provide a robust, durable, and user-friendly instrument.

Designed for both short- and long-term monitoring, the MP TROLL 9000 logs data from up to 7 optional pressure 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 9000 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 9000.

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 9000

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 and Pocket-Situ

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 9000: Sensor installation and calibration, software options, calibration reports

Section 11: pH

Section 12: Conductivity

Section 13: Dissolved Oxygen  
Polarographic  
RDO™ Optical Dissolved Oxygen

Section 14: Oxidation-Reduction Potential (ORP)

Section 15: Ammonium

Section 16: Chloride

Section 17: Nitrate

Section 18: Turbidity

Section 19: Setting up networks of MP TROLL 9000s

Section 20: SDI-12 Operations

Section 21: Field installation of the MP TROLL 9000—guidelines and precautions for long-term deployment

Section 22: Applications—and a place to store your In-Situ Application Notes and Tech Notes

Section 23: Care and Maintenance advice

Section 24: Troubleshooting: Look here first if you have problems making connections or calibrating . . .





**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 9000*



*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 9000 and simplify its setup and operation*

**UNPACKING AND INSPECTION**

Your MP TROLL 9000 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 9000. The shipping boxes have been performance-tested and provide protection for the instrument and its accessories.*

The instrument will arrive with batteries installed, basic sensors installed and kept moist in the Calibration Cup. Sensor port plugs are included for all sensor ports.

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 engraved on the body of the Multi-Parameter TROLL 9000. It is also programmed into the instrument and displayed when the instrument is connected to a PC running Win-Situ or Pocket-Situ. We recommend that owners keep a separate record of this number. Should your Multi-Parameter TROLL 9000 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  
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**WHAT WE PROVIDE****WARRANTY PROVISIONS**

In-Situ Inc. warrants all products sold, excluding batteries sold with such products, against defects in materials and workmanship under normal operating conditions. Consult the separate warranty for specific warranties that may apply.

**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](http://www.in-situ.com) to download the latest firmware and software.

**HOW TO CONTACT US**

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*Toll-free 24 hours a day in the U.S. and Canada*  
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 Ft. Collins, CO 80524  
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 Phone: 970 498 1500  
 Fax: 970 498 1598  
 Internet: [www.in-situ.com](http://www.in-situ.com)

**TO OBTAIN REPAIR SERVICE (U.S. AND CANADA)**

If you suspect that your Multi-Parameter TROLL 9000 is malfunctioning and repair is required, you can help assure efficient servicing by following these guidelines:

1. Call In-Situ Customer Service toll-free at 1-800-446-7488. Have the product model and serial number handy.
2. Be prepared to describe in detail the exact nature (symptoms) of the problem, including how the instrument was being used and the conditions noted at the time of the malfunction.
3. If service personnel determine that service is required, they will assign an RMA (return material authorization) number.

4. Write a description of the problem for service personnel, indicating whether the malfunction occurs intermittently or constantly. Save printouts or other materials that illustrate the problem.
5. Clean the Multi-Parameter TROLL 9000 and cable. Decontaminate thoroughly if it has been used in a toxic or hazardous environment. See the cleaning guidelines and form at the end of this section.
6. Pack your Multi-Parameter TROLL 9000 in its original shipping box, if possible. Include your write-up of the symptoms, a statement



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

certifying that the instrument and cable have been decontaminated, and any supporting information.

7. Send the package, shipping prepaid, to

In-Situ, Inc.  
 Customer Service  
 ATTN: RMA #      (assigned no. here)  
 221 E. Lincoln Ave.  
 Ft. Collins, CO 80524

The warranty does not cover damage during transit. In-Situ recommends the customer insure all shipments. Warranty repairs will be shipped back prepaid.

**Outside the U.S. and Canada**

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

**CERTIFICATION**

The MP TROLL 9000 complies with all applicable directives per the CE and FCC and was tested to the EN 55022 / ICES-003 / 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.

- A good cleaning solution, such as Alconox® (a glassware cleaning product available from laboratory supply houses) is recommended.
- Clean all cabling. (Don't forget connectors and protective caps.) Remove all foreign matter.
- 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.

**INSTRUMENT RETURN PROCEDURE**

1. Contact In-Situ Inc. Customer Service at 1-800-446-7488 and obtain an RMA (Return Materials Authorization) number from service personnel.

2. Complete and sign a Decontamination & Cleaning Statement (below) for each instrument.
3. Carefully pack the instrument in its original packaging, if possible. Include your write-up of symptoms displayed by the instrument, the Decontamination & Cleaning form, and any supporting information.
4. Send the package, shipping prepaid, to:

In-Situ, Inc.  
Customer Service  
ATTN: RMA#                      (assigned number here)  
221 E. Lincoln Ave.  
Ft. Collins, CO 80524

*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 9000 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, a suite of cables for single instrument operation, network boxes and cables for network operation, external power accessories, and consumable items.

### STANDARD FEATURES

- 4.5 cm (1.79 in) diameter
- 316L stainless steel and acetal body construction
- Viton® seals
- Fast data sampling
- Continuous real-time readings (profiling)
- User-replaceable off-the-shelf D-cell alkaline batteries
- Two A/D converters (24-bit and 10-bit)
- Triple protection against moisture
- 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
- Error-proof connector system
- Easy-to-use Win-Situ™ control software for setup, downloading, text and graphical data display
- Optically isolated communication signals
- Cable available in standard and custom lengths of vented polyurethane or FEP\*\*, or non-vented HDPE

- 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), ORP, pH, Conductivity, Combination pH/ORP
  - 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, log, event, and linear average measurement schedules
- SDI-12 or RS485 interface—or both
- FlowSense™ 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

\* within the ratings of the installed sensor options.

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

## POWER OPTIONS

The MP TROLL 9000 operates in 3 power modes:

- internal power
- external battery pack
- external AC line power

These may be used separately or together in any combination.



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

## INTERNAL POWER

MP TROLL 9000:

- 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 replacement lithium batteries supplied by In-Situ. Use of any other lithium battery will void the product warranty.

MP TROLL 9000E:

- 4 standard 1.5V alkaline D cells

External power is recommended for long-term monitoring and for networks.

## EXTERNAL POWER

A single stand-alone MP TROLL 9000 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 MP TROLL shuts down the battery regulator, thus preserving the internal or external batteries. Both the comm cable and the direct-read cable include external power jacks.

## NETWORK POWER SUPPLIES, 12 VDC

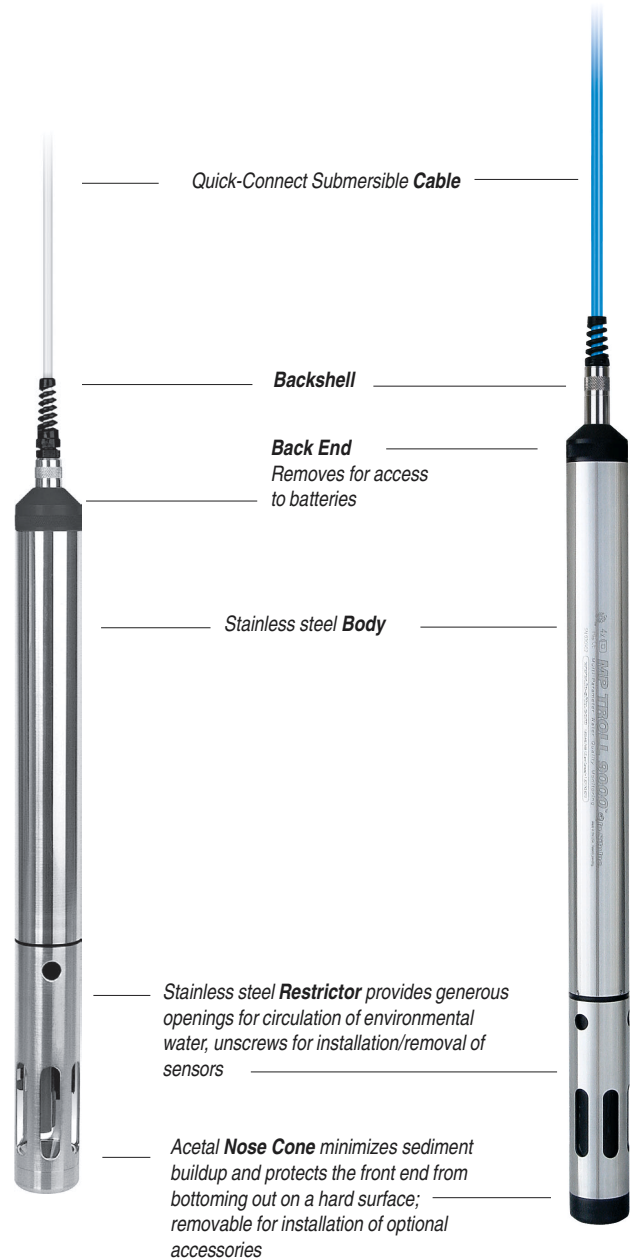
Three regulated DC network power supplies are available:

- North American (120 VAC, 0° to 50° C)
- Universal (95-250 VAC, 0° to 40° C)
- Universal Environmental (100-120, 200-240 VAC, -10° to 60° C)

Alternatively, a 12 VDC automotive or marine battery may be used.

## MP TROLL 9000

## MP TROLL 9000E



## CABLES

Several basic cable types are used in the MP TROLL 9000 system:

- Submersible cable:
  - Vented: yellow polyethylene or blue FEP\*
    - Non-vented: black high-density polyethylene (HDPE)
    - Stainless steel suspension cable: non-vented, no communication capabilities
  - Network cable: non-vented non-submersible gray PVC
  - Communication cables



*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.*

### QUICK-CONNECT SUBMERSIBLE CABLE

Vented submersible cable includes the instrument's backshell and provides conductors for power and communication signals, a vent tube, strain relief, and a service grip to anchor the instrument securely.

Vented cable is designed for use with gauged pressure/level sensors, atmospheric pressure reference for DO sensors, and to measure barometric pressure.

Non-vented submersible cable is designed for use with absolute pressure/level sensors.

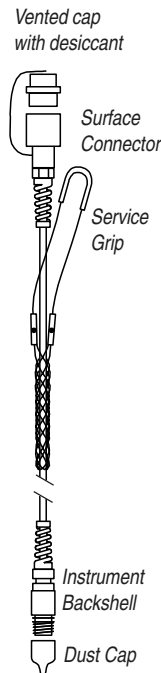
### Surface Connector

The Surface Connector remains above the water surface and mates with a variety of cables and accessories:

- Communication Interface
- Comm cable with AC line power input
- External battery packs
- Network boxes
- SDI-12 adapter
- High-volume desiccant pack

### Vented Cap

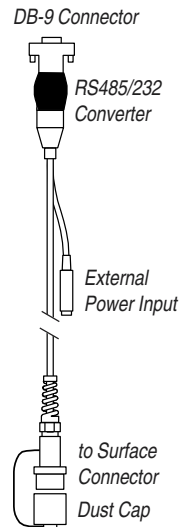
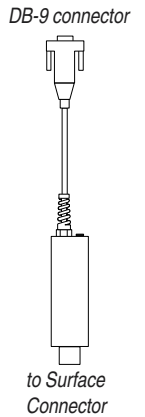
The surface connector cap is vented to allow the cable's vent tube to carry atmospheric pressure to the back of the pressure sensor diaphragm. A hydrophobic membrane (moisture barrier) of high-density polyethylene (HDPE) under the vent keeps water droplets out. A canister of indicating desiccant (replaceable) protects the cable and electronics from condensation of water vapor.



## COMMUNICATION CABLES

### ComIT2™ Communication Interface

A “null modem” cable that connects the MP TROLL's quick-connect submersible cable to a desktop or laptop PC or to a handheld PDA. Includes a port-powered RS485 to RS232 converter. Weatherproof, withstands temporary immersion. Cable vents into ComIT body, protected by a hydrophobic membrane.



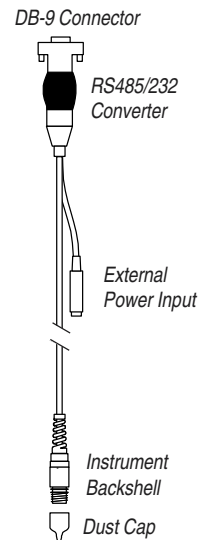
### Computer Connection Cable ("Comm Cable")

Vented polyurethane cable (1.8 m, 6 ft), connects the MP TROLL's submersible cable to a PC or PDA. Converts the instrument's RS485 signal to RS232. Includes a 2.5 mm external power jack to connect the instrument to 9-12 VDC external power.

Recommended for applications where a permanent desktop PC connection is required.

### Direct-Read Cable

Combines the functions of the quick-connect submersible cable and comm cable; connects the MP TROLL 9000 directly to a PC or PDA; includes RS485/RS232 converter and external power jack.



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

### Versions and Feature Sets

Feature \ Version	MP TROLL 9000					MP TROLL 9000E		
	Profiler	Profiler XP	Professional	Professional XP	LTS	Professional	Professional XP	LTS
Available WQ sensor ports	4	4	4	4	1	4	4	1
Sensors								
Dissolved Oxygen, (mg/L, %)	•	•	•	•	•	•	•	•
Conductivity (SC, TDS, Resistivity, Salinity)	•	•	•	•	•	•	•	•
Temperature	•	•	•	•	•	•	•	•
pH	•	•	•	•	•	•	•	•
ORP	•	•	•	•	•	•	•	•
pH/ORP Combination	•	•	•	•		•	•	
Level, Depth, Pressure	•	•	•	•	•	•	•	•
Barometric Pressure	•	•	•	•	•	•	•	•
Nitrate		•		•			•	
Chloride		•		•			•	
Ammonium		•		•			•	
Turbidity		•		•			•	
Replaceable Sensors	•	•	•	•	•	•	•	•
Data Logging			•	•	•	•	•	•
Memory, 4MB			•	•	•	•	•	•
Quick-Connect Cable	•	•	•	•	•	•	•	•
SDI-12 communications		•						
Upgradeable	•	•	•		•	•	•	•
Calibration								
Quick (single-point)	•	•	•	•	•	•	•	•
Traditional (multi-point)	•	•	•	•	•	•	•	•

### VERSIONS AND FEATURE SETS

The features available in different versions of the Multi-Parameter TROLL 9000 are shown in the table above.

### CONTROL SOFTWARE

Win-Situ enables communication between the MP TROLL 9000 and a desktop or laptop PC. Pocket-Situ is Win-Situ for PDA.

Both versions of the software provide instrument control for calibration, profiling, long-term data logging, direct readings, 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.

### WAKEUP

The MP TROLL uses a technique we call “sleeping” to minimize power consumption and extend battery life. When the instrument is asleep—whenever there is no immediate task to perform—only its internal clock remains active. The MP TROLL will “wake” when its clock indicates it is time to take a data point, or when you are directly communicating with it via Win-Situ or Pocket-Situ.

## SMART SENSORS

The MP TROLL's smart sensors retain manufacturing and calibration information for plug-and-play ease and flexibility in the front end option ports. Sensor insertion and removal tools simplify insertion and removal.

## SYSTEM CONNECTORS

The lightweight, weather-resistant nylon connectors used throughout the Multi-Parameter TROLL 9000 system are designed for straightforward connection. Connector keying prevents misconnections. For example, submersible cable cannot mate with network cable.

Each connector is protected by a dust cap. Replacements for worn or damaged dust caps are available from In-Situ Inc. or your local distributor.

## TRIPLE MOISTURE PROTECTION

A vented connector cap at the top of the Multi-Parameter TROLL 9000's submersible cable is fitted with a hydrophobic membrane that will not allow water droplets to pass into the cable. This replaceable cap contains indicating desiccant to protect the cable and electronics from condensation of water vapor. Additional desiccant in the Multi-Parameter TROLL 9000 body provides further protection against moisture damage, but is not user-replaceable.

## COMPONENTS & ACCESSORIES LIST

### Cables:

- Quick-Connect Submersible Cable with instrument backshell & surface connector
- ComIT Communication Interface with RS485/232 converter
- Communication Cable with RS485/232 converter & external power input
- Direct Read Cable with instrument backshell, RS485/232 converter & external power input
- Stainless steel suspension cable: non-vented, no communication

### Power Accessories:

- External battery packs
- External power supply
- Alkaline batteries
- Lithium batteries

### Water Quality Accessories:

#### Basic Sensors

- Polarographic Dissolved Oxygen
- ORP
- pH
- Conductivity (Low Range or High Range)
- Combination pH/ORP

#### Extended Sensor Set

- RDO Optical Dissolved Oxygen
- Ammonia
- Chloride
- Nitrate
- Turbidity

**Calibration Cup:** clear PVC vessel that attaches to the front end of the MP TROLL 9000 in place of the restrictor and holds the recommended amount of calibration fluid.

**Nose Cone Stirrer:** battery-powered magnetic stirrer for sample agitation during calibration and/or deployment of the MP TROLL 9000 for best performance in stagnant water.

#### Calibration Kits

- Quick Cal (for Basic Sensors)
  - pH
  - ORP
  - Dissolved Oxygen
  - Conductivity (Normal range, Low range, High range)
  - Nitrate (Normal range, Low range, High range)
  - Ammonium (Normal range, Low range, High range)
  - Chloride (Normal range, Low range, High range)

### Network Accessories:

- T-Box, Quad Box, Mid-Line Tap Box
- 12 VDC Network Power Supplies
- Cables:
  - Network Comm Cable (2 varieties)
  - Network Interconnect Cable
  - Network Extension Cable

### Installation Accessories:

- Non-Vented Backshell:** stainless steel combination backshell cap and hanger to suspend the MP TROLL 9000 while taking data. No venting, no communication capabilities.
- Well Dock:** top-of-well support for 2" or 4" well
- Flow Cells** for low-flow sampling



**PRODUCT SPECIFICATIONS**

Wetted Materials	316L stainless steel, acetal, Viton®, nylon, PVC, FEP or poly cable
Operating Temperature	-5°C to 50°C (23°F to 122°F)
Storage Temperature	
Base unit*	-40°C to 80°C (-40°F to 176°F)
Basic W.Q. sensors	-5°C to 50°C (23°F to 122°F)
Pressure rating (Base unit)	350 psi (246 m, 807 ft)
Dimensions	
MP TROLL 9000	45 mm (1.79 in) diameter, 47.3 cm (18.6 in) long
with RDO sensor	88.4 mm (3.48 in) diameter, 48.3 cm (19 in) long
MP TROLL 9000E	45 mm (1.79 in) diameter, 59.5 cm (23.45 in) long
with RDO sensor	88.4 mm (3.48 in) diameter, 61 cm (24 in) long
Weight (without cable)	
MP TROLL 9000	1.9 Kg (4.2 lbs)
MP TROLL 9000E	2.7 Kg (5.8 lbs)
<b>Power</b>	
Battery type	
TROLL 9000	2 standard alkaline D-cells (1.5 V), or 2 lithium D cells (approx. 3.6 V)
TROLL 9000E	4 standard alkaline D-cells (1.5 V)
External power input	9-12 VDC (optional)
Battery life estimates	see table below
<b>Data Sampling</b>	
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	Runs on desktop/laptop PC with Microsoft® Windows® 95 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, Pocket PC 2002, or Pocket PC 2003, also known as Windows Mobile 2003

**Internal 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 (0-211 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
Pressure Rating	150 psi (105 m, 346 ft)
Accuracy	± 5% or 2 NTU (whichever is greater)
Resolution	0.1 NTU

\* Base unit = pressure, temperature, barometric pressure

Instrument	Estimated Battery Life		
	At 60 min. sample intervals	At 15 min. sample intervals	At continuous sample intervals
MP TROLL 9000 with Turbidity & Wiper	63 Days	52 Days	10 Days
MP TROLL 9000 no Wiper	75 Days	70 Days	11 Days
MP TROLL 9000 no Turbidity	76 Days	73 Days	
MP TROLL 9000E with Turbidity & Wiper	137 Days	117 Days	24 Days
MP TROLL 9000E no Wiper	204 Days	193 Days	35 Days
MP TROLL 9000E no Turbidity	206 Days	198 Days	

**Basic Sensors****Conductivity**

Type	4-cell conductivity, AC drive
Operating Range	
Low Range sensor	3 $\mu\text{S}/\text{cm}$ to 50,000 $\mu\text{S}/\text{cm}$
High Range sensor	70 $\mu\text{S}/\text{cm}$ to 200,000 $\mu\text{S}/\text{cm}$
Accuracy	
Low Range sensor	$\pm 0.5\%$ or 2 $\mu\text{S}/\text{cm}$ (whichever is greater) between 5 and 20,000 $\mu\text{S}/\text{cm}$ when calibrated in region of interest
High Range sensor	$\pm 0.8\% + 2 \mu\text{S}/\text{cm}$ between 150 and 112,000 $\mu\text{S}/\text{cm}$ when calibrated in region of interest
Resolution	Range-dependent
Pressure Rating	350 psi (246 m, 807 ft)

**pH**

Type	Glass sensing bulb with Ag/AgCl reference half-cell, double junction, reference electrolyte gel
Range	0 to 12 pH units
Pressure Rating	350 psi (246 m, 807 ft)
Accuracy	$\pm 0.09$ pH units
Resolution	0.01 pH unit

**ORP**

Type	Platinum wire with Ag/AgCl reference half-cell, double junction, reference electrolyte gel
Range	$\pm 1400$ mV
Pressure Rating	350 psi (246 m, 807 ft)
Accuracy	$\pm 4.0$ mV
Resolution	1 mV

**Dissolved Oxygen (polarographic)**

Type	Clark polarographic
Range	0 to 20 mg/L, 0 to 200% saturation
Pressure Rating	350 psi (246 m, 807 ft); deployment & retrieval at up to 4 ft per second
Accuracy	$\pm 0.2$ mg/L
Resolution	0.01 mg/L

**Extended Sensors****Ammonium ( $\text{NH}_4^+$ )**

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 $\text{NH}_4^+$ )
Pressure Rating	20 psi (14 m, 46 ft)
Accuracy	$\pm 10\%$
Resolution	0.01 ppm

**Chloride ( $\text{Cl}^-$ )**

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 $\text{Cl}^-$ )
Pressure Rating	100 psi (70 m, 231 ft)
Accuracy	$\pm 15\%$
Resolution	0.01 ppm

**Nitrate ( $\text{NO}_3^-$ )**

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 $\text{NO}_3^-$ )
Pressure Rating	20 psi (14 m, 46 ft)
Accuracy	$\pm 10\%$
Resolution	0.01 ppm

**Dissolved Oxygen (RDO)**

Type	Optical, fluorescence quenching
Range	0 to 20 mg/L, 0 to 200% saturation
Pressure Rating	exceeds that of MP TROLL 9000
Accuracy	$\pm 0.1$ mg/L @ 0-10 mg/L $\pm 0.2$ mg/L @ 10-20 mg/L
Resolution	0.01 mg/L



## 3 GETTING STARTED

This section provides a quick overview of the initial steps necessary to get the Multi-Parameter TROLL 9000 ready to take measurements.

You will need—

- Power
- Sensors
- Cable
- Software (Win-Situ or Pocket-Situ) and a desktop or laptop PC, or a supported PDA
- Calibration Kit—one for each sensor to be calibrated, or the QuickCal Kit for the Basic Sensor set (pH, ORP, polarographic D.O., Conductivity)

### POWER

The Multi-Parameter TROLL 9000 and TROLL 9000E ship with internal alkaline batteries—standard off-the-shelf 1.5V alkaline D-cells. For use with an RDO optical dissolved oxygen sensor, and with a turbidity wiper, the alkaline batteries in the TROLL 9000 (*but not the TROLL 9000E*) may be replaced with In-Situ-supplied 3.6V lithium D cells (shipped separately, customer installation required).

### SENSORS

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

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

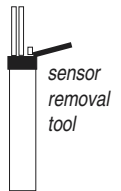
1. Remove the restrictor from the front end of the MP TROLL 9000.



**TIP:** When unscrewing the restrictor, it is best to grasp the body (not the back end) with one hand and the smooth area of the restrictor with the other.

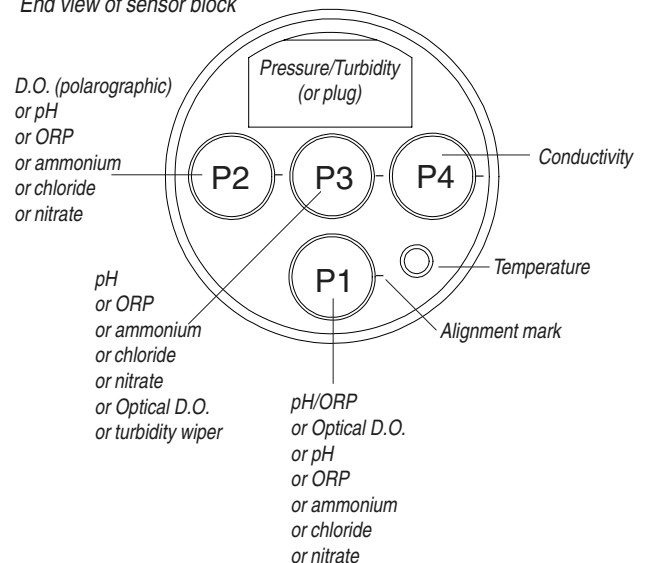
This allows access to the sensor block depicted in the drawing below. There are four sensor ports, P1 through P4, plus a permanently installed pressure and/or turbidity sensor or plug.

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. Use the sensor removal tool to remove the plug from the port where you will install the sensor. Retain the plug for use when deploying the instrument with fewer than 4 removable sensors installed.
4. 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.*

End view of sensor block

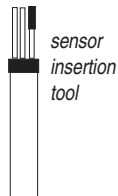


5. Align the mark on the side of the sensor with the mark on the port.



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 6.

6. Press the sensor firmly 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 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.

## CABLE

The cable port at the back end of the MP TROLL 9000 accommodates different quick-connect cables, depending on the application.

- Quick-Connect Submersible Cable—designed to be capped off and left in the field during deployment. To connect to a PC, simply add a communication interface or comm cable.
- Quick-Connect Direct-Read Cable—connects directly to a PC for calibrating, profiling, programming, and downloading.

## QUICK-CONNECT CABLE

1. Remove the soft dust cap from the instrument backshell at the end of the quick-connect cable.



**TIP:** Retain the dust cap to protect the backshell's contact board from damage when not attached to the instrument.

2. Remove the protective plug from the cable port at the back end of the MP TROLL 9000 body.
3. Attach the backshell end of the quick-connect cable to the cable port. The threads will screw smoothly together. Hand-tighten.



**Why do I need to connect the MP TROLL 9000 to a PC?**

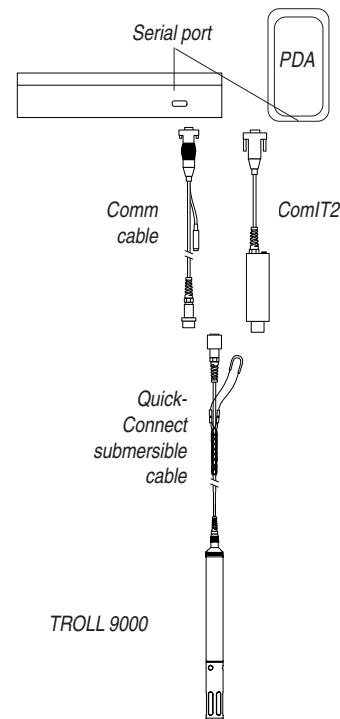


A PC running Win-Situ or Pocket-Situ control software is an easy-to-use interface that enables you to—

- calibrate the water-quality sensors
- use the MP TROLL 9000 for profiling
- program the instrument for data collection
- set up a pressure channel to display as desired
- monitor battery and memory usage
- download and view the collected data

## PC CONNECTION

1. Attach a ComIT2 Communication Interface or comm cable to the surface connector of the MP TROLL 9000's quick-connect submersible cable.
2. Attach the DB9 connector on the ComIT or comm cable to a PC's standard RS232 serial port (a serial cable or card may be needed with some PDAs).



**TIP:** External power is optional but useful for conserving the internal batteries during setup and downloading. To use external power, connect a 9-12 VDC power supply to the comm cable's external power jack and plug the AC line cord into a 90-264 VAC line source.


## SOFTWARE SETUP

### INSTALL THE SOFTWARE

For communication using a desktop or laptop PC, install Win-Situ from the CD. Details are in Section 4.

To install Pocket-Situ on a handheld PDA for field use, install PocketSync from the CD, then establish a connection in ActiveSync and Pocket-Situ will be installed on the PDA. Details are in Section 4.

### ESTABLISH COMMUNICATION WITH THE MP TROLL 9000

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

Or tap the Pocket-Situ 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 9000 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 (RS232 serial port) to which the device is attached. 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.



**What do I do if the MP TROLL 9000 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 9000 has sufficient battery power, or that external power is being supplied.
- Check that the elastomer in the back end is shiny and not compressed (more on the elastomer in Section 23).

- 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.

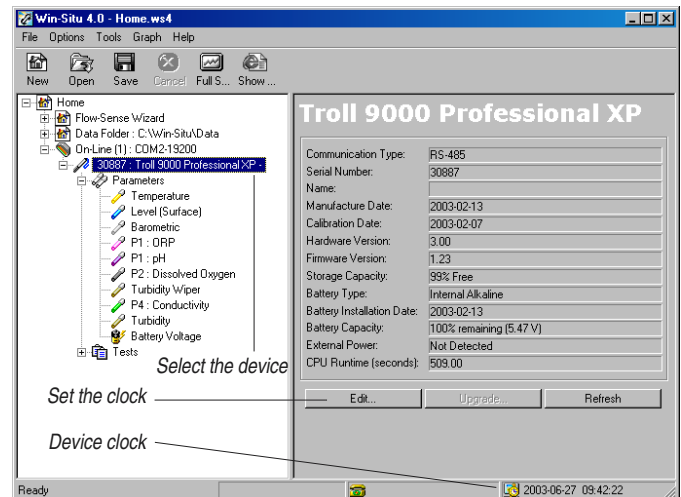


**TIP:** For an introduction to the appearance and controls of the user interface, turn to Section 4, Control Software.

### 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 9000'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.



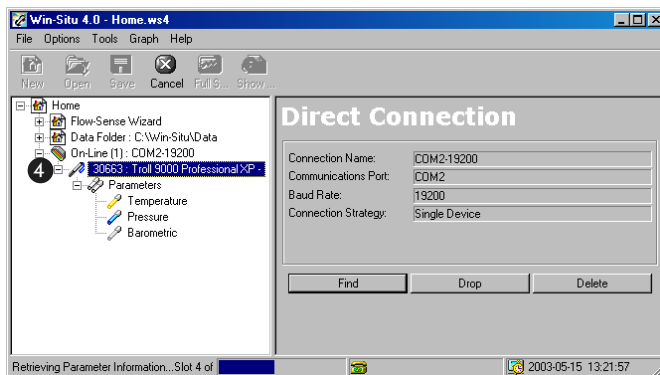
**TIP:** Due to the size of the PDA screen, the device clock is not displayed in the Pocket-Situ interface. We recommend you edit the device as above to synchronize the device clock to the PDA clock.

## QUICK-CAL THE BASIC WATER-QUALITY SENSORS

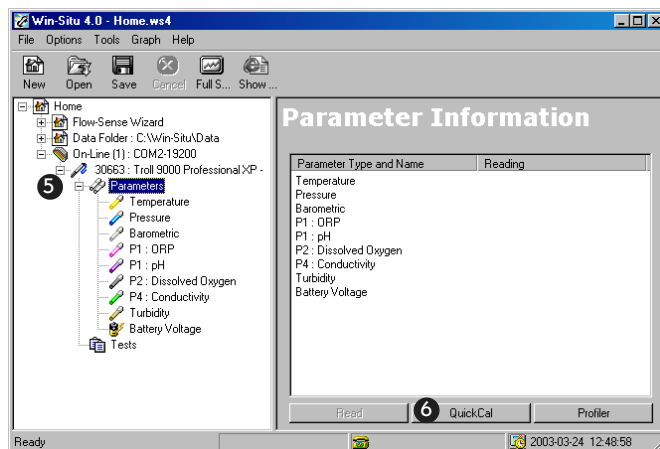
You will need:

- MP TROLL 9000 with Basic sensors installed (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 9000 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 9000 to a PC and establish a connection in Win-Situ or Pocket-Situ.
4. Select the MP TROLL 9000 in the Navigation tree. The software will automatically detect and display the installed sensors.



5. In the Navigation tree, click on Parameters.

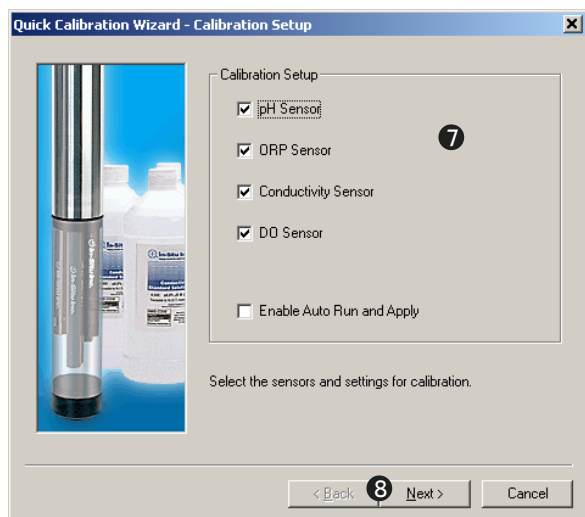


6. In the Information pane, select **QuickCal**.

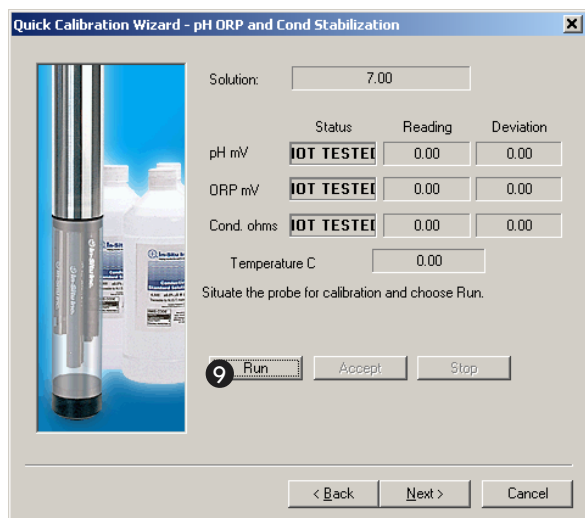
## Quick-Cal Tips

- 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.
- Use the following guidelines when 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 membrane at the tip of the D.O. sensor 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.
- 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 9000 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 bewide 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 polarographic 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



#### What is the difference between NOMINAL and STABLE?



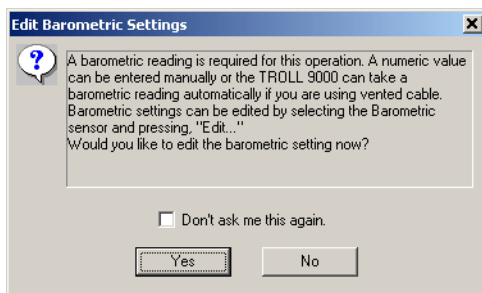
To meet the criteria for a valid calibration point, the change (deviation) in sensor response is monitored over time. The software is looking for a specific trend in the signal deviation over a specific time period. The criteria for STABLE are designed to meet the published specifications. The NOMINAL criteria are designed to shorten the calibration time. When 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 D.O. measurement. If this TROLL 9000 will be deployed on vented cable, an accurate barometric pressure value can be read automatically from the onboard barometric pressure sensor. If the TROLL will be deployed on non-vented cable, then a barometric pressure value should be entered manually.

Do one of the following in this screen:

- If the TROLL 9000 is on vented cable now and will be deployed on 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 be deployed on non-vented cable, click Yes. In the Edit Barometric Channel screen, check the box indicating non-vented cable for deployment but vented cable for calibration/programming. For help, see Section 9, Monitoring Barometric Pressure.
- If the device is on non-vented cable now and will be deployed on non-vented cable, click Yes. In the Edit Barometric Channel screen, check the box indicating non-vented cable for deployment 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.

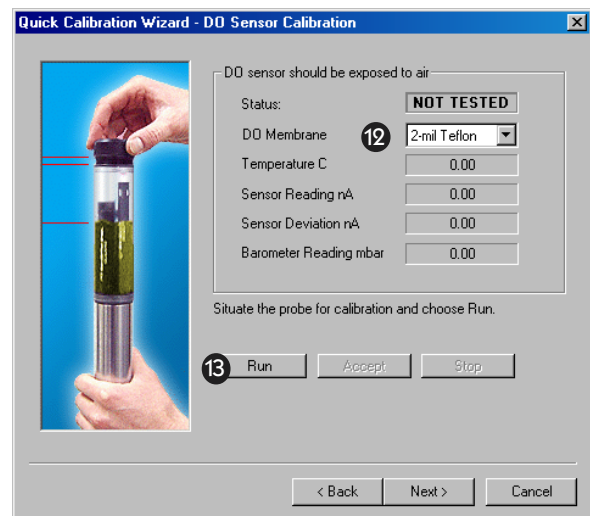


While you have the cap off, remove any droplets on the membrane by blotting gently with a clean swab or the corner of a tissue. Re-attach the end cap **loosely** to insure the volume is not pressurized.



**TIP:** Win-Situ on a desktop PC and Pocket-Situ on a handheld PDA do not interface with each other. Except through PocketSync for Pocket-Situ, new in Win-Situ 4.51. PocketSync can install Win

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



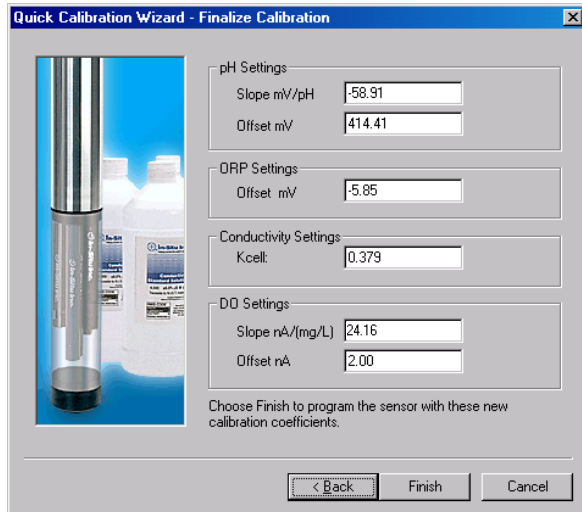
13. Click **Run** to begin the stabilization.

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 will be displayed 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 should calibrate just before deployment of the MP TROLL 9000. However, if the the instrument will not be deployed immediately, store it as follows:

- Leave the sensors installed. Remove the Cal Cup and rinse it and the sensors. Moisten a small 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.

### CALIBRATE THE EXTENDED SENSORS

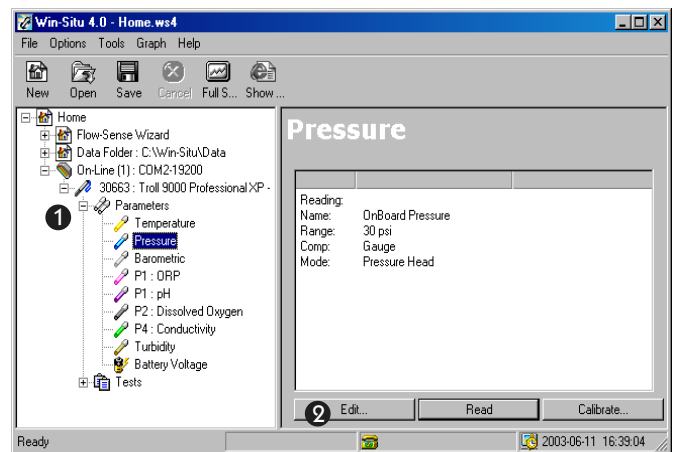
For some sensors, the Quick-Cal procedure is not available. A traditional calibration is recommended. To calibrate, select the sensor in the Parameters list and click or tap **Calibrate** to launch a Calibration Wizard. Complete calibration information is in the following sections of this manual:

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 9000 connected to a host PC, select the pressure parameter in the Navigation tree.
2. Click or tap **Edit...**



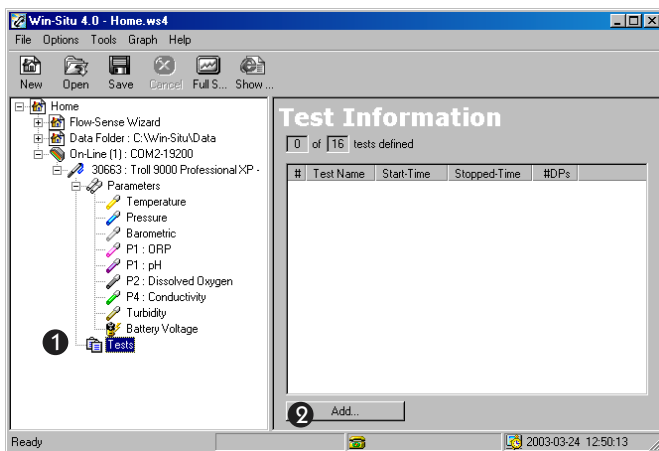
The Parameter Wizard will help you enter the required information. The choices are explained in greater detail in Section 7 below.

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.

## 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 9000 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 a “scheduled” test (indicated by  in the Navigation tree), it will start at its programmed time.

If you set up a test for 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.

## COMPLETE THE SETUP

When Setup is complete, exit Win-Situ or Pocket-Situ, remove the comm cable and cap the Surface Connector. The instrument is now ready for transport to the site where it will be deployed.

## DEPLOYMENT—PROFILING

### CHECKLIST

- ✓ Restrictor: Attach the restrictor to the front end of the MP TROLL 9000, if necessary. Thread the restrictor onto the instrument body; hand-tighten. *Do not overtighten.*
- ✓ Stirrer: When measuring dissolved oxygen in still water with a polarographic D.O. sensor, attach the stirrer to the MP TROLL 9000 in place of the restrictor.
- ✓ Quick-Connect Submersible Cable: Ensure the cable is firmly attached to the MP TROLL 9000 back end.
- ✓ Communications connection: Attach ComIT or comm cable to the Surface Connector and to a PC or PDA.
- ✓ Power: The internal batteries can power hours of direct reads. If it is desired to supplement internal battery power, attach a 6-12 VDC external power supply to the external power input on the comm cable, and plug the AC line cord into a 90-264 VAC line source.
- ✓ Control Software: Power on the PDA and launch Pocket-Situ. Establish communication with the MP TROLL 9000 by double-tapping the COM port. Select the MP TROLL 9000 in the Navigation tree, then tap Parameters. Tap Profiler to start the Profiler. For more information on the Profiler, refer to Section 5 of this manual.

## DEPLOYMENT—LONG-TERM MONITORING

### CHECKLIST

- ✓ Restrictor: Attach the restrictor to the front end of the MP TROLL 9000, if necessary. Thread the restrictor onto the instrument body; hand-tighten. *Do not overtighten.*
- ✓ Quick-Connect Submersible Cable: Ensure the cable is firmly attached to the MP TROLL 9000 back end.
- ✓ Installation: Lower the MP TROLL 9000 to the desired depth in a well or surface water body. Secure to a stationary object using the service grip on the cable.
- ✓ Control Software: To communicate with the instrument—E.g., to start a manual-start test, or take a manual depth reading, or to check the progress of a running test—attach a ComIT or comm cable to the Surface Connector and to a PC or PDA.
- ✓ Before leaving the site: It is prudent to check to insure your test is running before leaving the instrument in the field for a long-term deployment.
- ✓ Disconnect the comm cable and cap the Surface Connector.



## 4 CONTROL SOFTWARE

The interface from a desktop or laptop computer (PC) to the Multi-Parameter TROLL 9000 is provided by instrument control software called Win-Situ. 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 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 9000 to the host computer
- to view logged data in text or graph format
- to delete data from the Multi-Parameter TROLL 9000 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)

### SYSTEM REQUIREMENTS

#### WIN-SITU

Win-Situ requires a desktop or laptop computer running Microsoft® Windows® 95 or later with a serial communications port and a CD-ROM drive.

#### POCKET-SITU

Pocket-Situ runs on supported PDAs with

- Operating System: Microsoft Pocket PC, Pocket PC 2002, or Pocket PC 2003, also known as Windows Mobile 2003
- A serial communications port for connection to the TROLL 9000,
- 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,
- PocketSync utility

#### INSTALLATION

##### WIN-SITU (DESKTOP OR LAPTOP PC)

The Win-Situ CD-ROM contains an automatic setup program to install Win-Situ to your local hard drive.

1. Insert the Win-Situ CD in your computer's CD-ROM drive.
  - If the CD-ROM drive is set to Auto-Play, the installation program will start automatically.
  - If necessary, choose Run from the Windows Start Menu and type D:\Setup, where *D* is your CD-ROM drive letter.
2. Follow the on-screen instructions to install the program to your local hard drive. A shortcut will be created on the desktop: 

##### POCKET-SITU (PDA)

1. Install ActiveSync (if not already installed), connect the computers, and establish a "partnership." For more information on this, see your ActiveSync documentation.



**TIP:** Be sure Microsoft ActiveSync is installed on your desktop or laptop PC before connecting the computers for the first time.

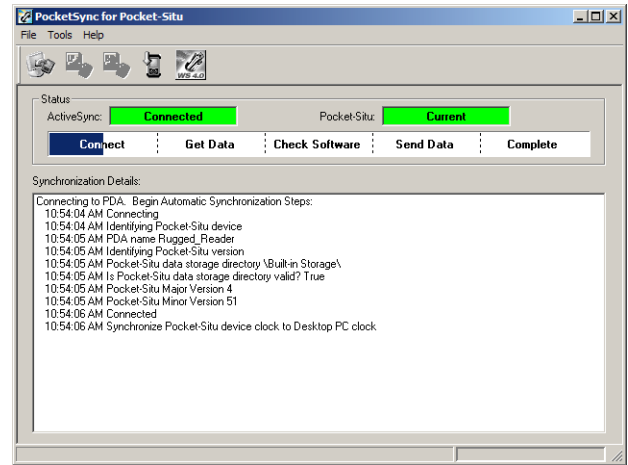
2. Install Win-Situ on the desktop PC as described above.
3. Install Pocket-Situ on the desktop PC from the CD. *Note: The CD menu option is "Install Pocket-Situ," but you are actually installing the PocketSync utility to your desktop computer. PocketSync will install Pocket-Situ on a connected PDA.*
4. When the connection is established, the desktop utility PocketSync launches and begins its automatic synchronization (Fig. 2). To install Pocket-Situ on the PDA, do one of the following:
  - If Pocket-Situ is not installed on the PDA (sidebar), or needs an update you will be asked if you want to install it. Click **Yes**.
  - Or, after synchronization is complete, click the Tools menu and select Un-Install Pocket-Situ to remove an earlier version, then choose Repair/Re-Install Pocket-Situ to install the newest version.

#### ABOUT POCKETSYNC

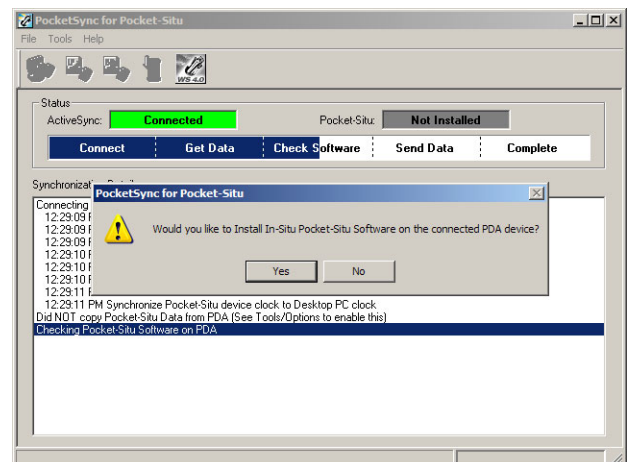
On startup PocketSync—

- Scans the contents of the connected PDA,
- Synchronizes the computer clocks
- Copies existing test data files from the PDA to the Win-Situ\ Data folder on the desktop PC (unless they already exist in that folder)
- Checks to see if Pocket-Situ on the PDA is current and if not asks if you want to install it. If you answer yes, PocketSync—
  - Uninstalls an old version of Pocket-Situ (if present),
  - Installs the latest version of Pocket-Situ to the PDA's Program Files folder,
  - Creates a Pocket-Situ \ Data folder in the device's non-volatile memory,
  - Creates a shortcut on the Start Menu,
  - Places a file called REINSTALL in non-volatile memory for re-installation in the field (if needed),
  - If the connected PDA is a RuggedReader, executes the backup utility,
  - If this PDA has been used to create low flow files or calibrate a TROLL 9000, PocketSync copies the low flow data and calibration reports to the proper locations in the Win-Situ Data folder on your desktop PC.

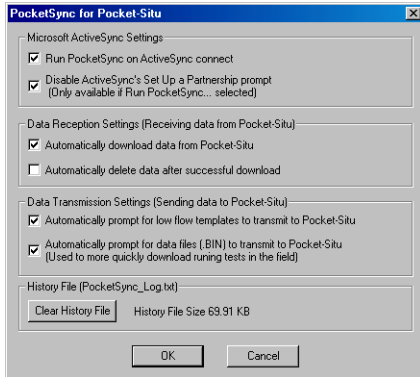
For more detail on PocketSync operations, click Help while running PocketSync.



*PocketSync for Pocket-Situ starts automatically when it detects the ActiveSync connection*



*Pocket-Situ is not installed on the connected PDA. Select Yes to install*



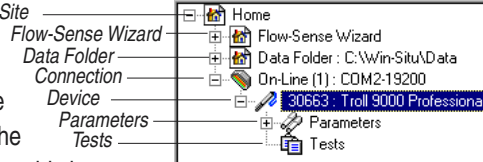
**SETTING POCKETSYNC OPTIONS**

Click Options on the Tools Menu while running PocketSync to check or change the automatic synchronization settings. The screen above shows the startup defaults. For more information, see PocketSync’s online help.

**THE USER INTERFACE**

Win-Situ and Pocket-Situ 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.

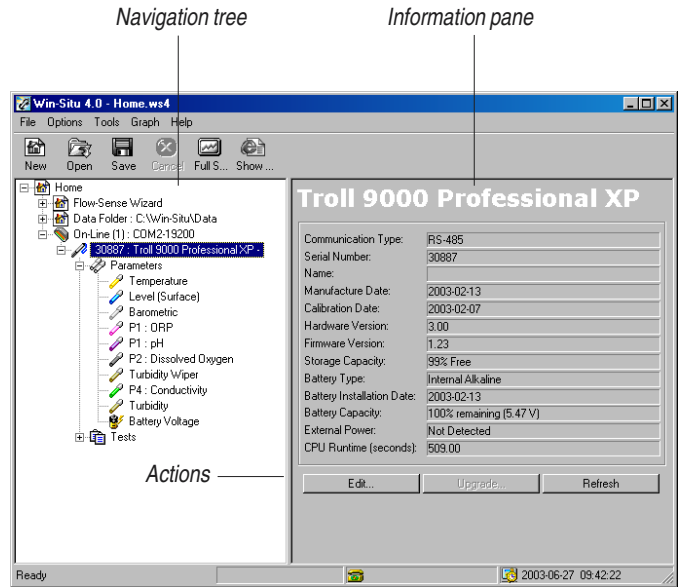
**THE NAVIGATION TREE**



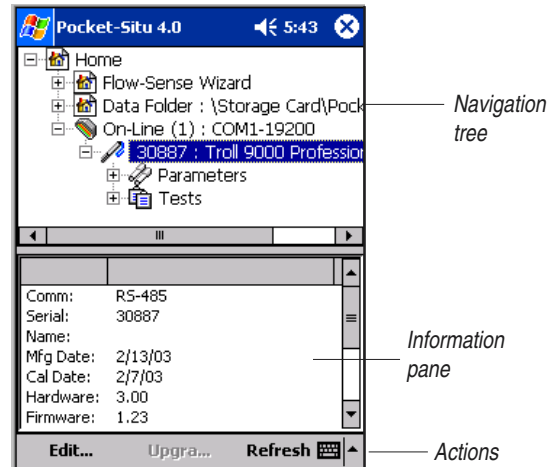
At the top of the tree is the “Home” site (the host computer). Below this is the Flow-Sense Wizard (see Section 22), then the Data Folder containing tests that have been extracted from the device to the host computer. This is followed by one or more connections (COM ports), and then one or more devices (Multi-Parameter TROLL 9000s 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 Application Window (desktop or laptop PC)**



**The Pocket-Situ Application Window (PDA)**



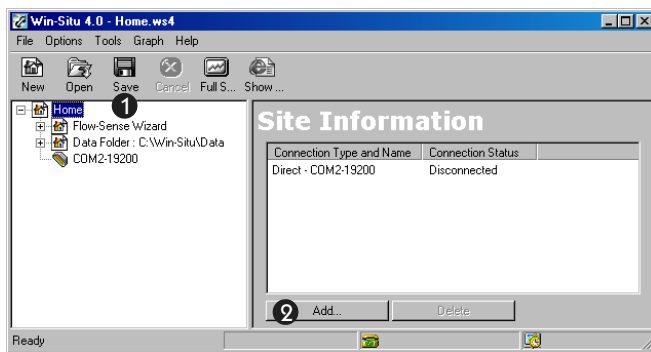
## SOFTWARE FUNCTIONS

### 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.

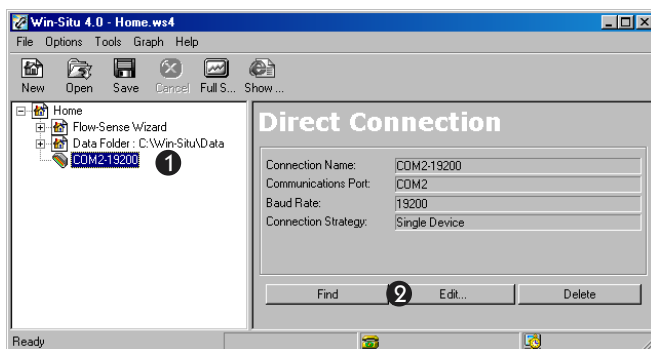
To add a new connection to the site—or if the Connection Wizard does not start automatically for some reason—proceed as follows:

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 9000

#### New Connection

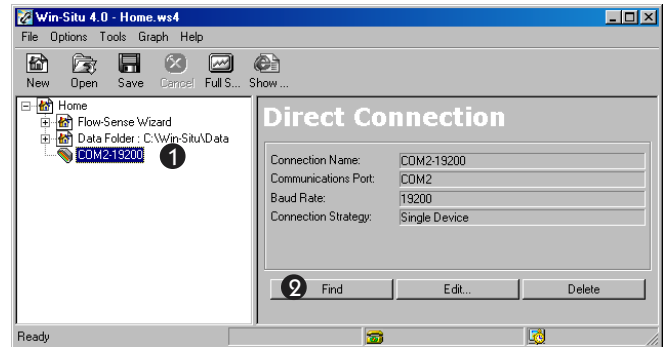
The last option in the Connection Wizard is to **Connect and find devices on "Finish."** If you select this option, the software will automatically establish communication with the MP TROLL 9000.

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

#### 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 device baud rate, locate the device, and display it in the Navigation tree.

3. Click to select the MP TROLL 9000 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 9000 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 below (you may need to scroll to view all the information in Pocket-Situ).

 **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.


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


## UPGRADING FIRMWARE AND FEATURES

### Firmware Upgrade

New software releases may include a new version of firmware for the MP TROLL 9000. 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 9000. 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.

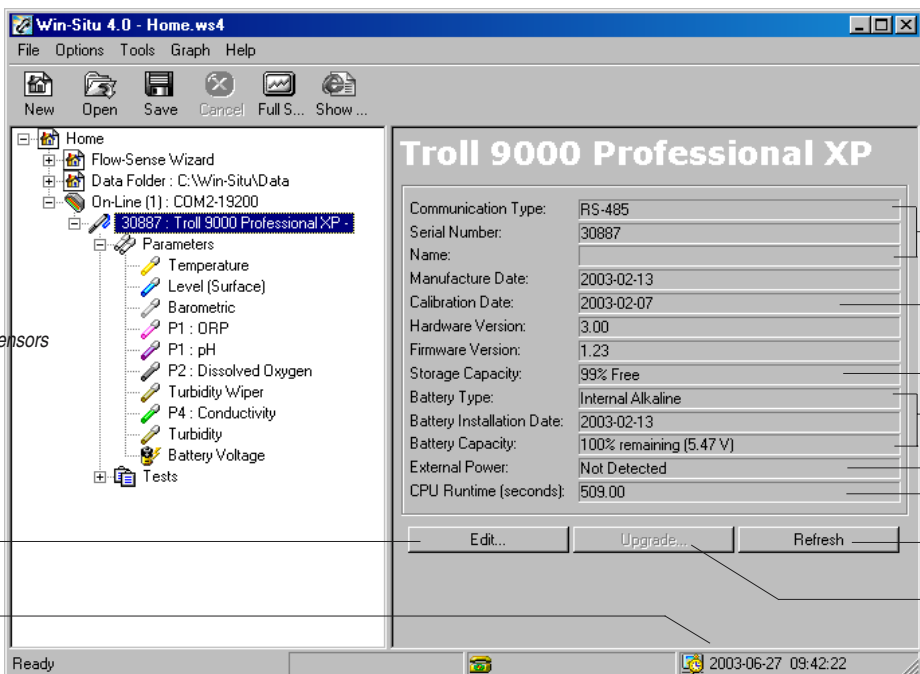
Firmware is automatically copied to these locations when new software is installed.

### Features Upgrade

The MP TROLL 9000 is available in several versions or 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 action will be available in the Information pane when the MP TROLL 9000 is selected in the Navigation tree. If you have purchased a features

## Device View of an MP TROLL 9000



**Win-Situ 4.0 - Home.ws4**

File Options Tools Graph Help

New Open Save Cancel Full S... Show...

Home

- Flow-Sense Wizard
- Data Folder : C:\Win-Situ\Data
- On-Line (1) : COM2-19200
  - 30887 : TROLL 9000 Professional XP
    - Parameters
      - Temperature
      - Level (Surface)
      - Barometric
      - P1 : ORP
      - P2 : Dissolved Oxygen
      - Turbidity Wiper
      - P4 : Conductivity
      - Turbidity
      - Battery Voltage
    - Tests

Installed sensors

Click “Edit” to set the clock, change the name, or update battery data

Device clock

### Troll 9000 Professional XP

Communication Type:	RS-485
Serial Number:	30887
Name:	
Manufacture Date:	2003-02-13
Calibration Date:	2003-02-07
Hardware Version:	3.00
Firmware Version:	1.23
Storage Capacity:	99% Free
Battery Type:	Internal Alkaline
Battery Installation Date:	2003-02-13
Battery Capacity:	100% remaining (5.47 V)
External Power:	Not Detected
CPU Runtime (seconds):	509.00

Device identification

Date of factory calibration

Available memory

Battery information

External power indicator (see tip)

Time the unit has been “awake” since last battery replacement

“Refresh” requires the device

If the software detects later firmware on the PC, “Upgrade” is available

Edit... Upgrade... Refresh

Ready 2003-06-27 09:42:22

upgrade for your MP TROLL 9000, press **Upgrade** and key in the upgrade code issued by In-Situ Inc. Follow the instructions in the Upgrade Wizard.

## EDITING THE DEVICE PROPERTIES

### 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 9000 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 9000'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 a Device Name

The software recognizes each device on the network by its type and its serial number. In addition, you can assign a meaningful description—such as 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 9000 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 Battery Information

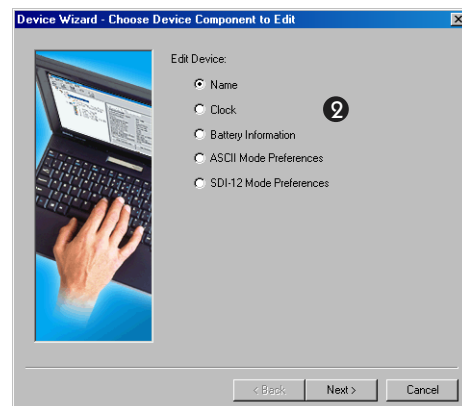
When the MP TROLL 9000's batteries are replaced, the device battery information should be updated as follows:

1. With the MP TROLL 9000 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.

## 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:

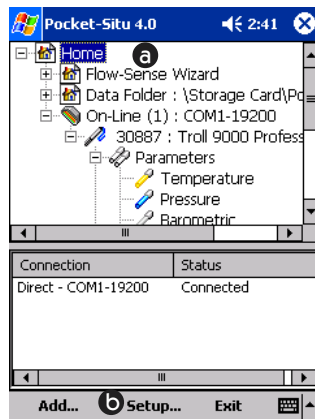
- Parameter measurement units & elapsed time units
- Data file view—report or graph
- Calendar date & time of day format
- Metric or English units for the Flow-Sense Wizard

The following Settings Options are also available:

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

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

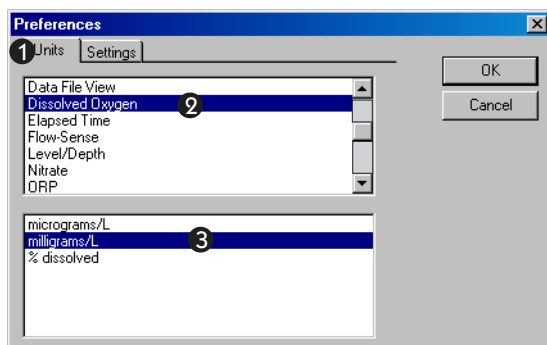
- In Win-Situ, select Preferences from the Options menu.
- In Pocket-Situ:
  - a. Tap the Home site in the Navigation tree...
  - b. then tap **Setup...** in the command bar.



## 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.

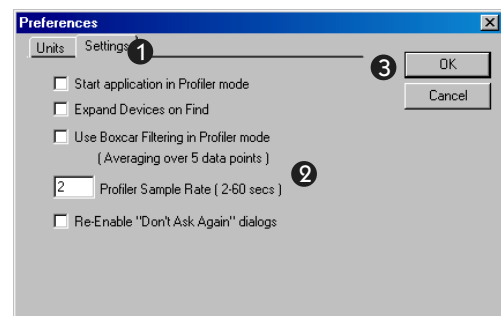


2. In the top of the Units window, select a parameter whose unit you wish to change.
3. In the bottom of the window, select the unit you want for the highlighted measurement. Repeat for as many units as you like.
4. Do one of the following:
  - Click **OK** to apply the new units and close the window.
  - 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:
  - a Start application in Profiler mode. This will take effect at your next session.
  - b 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.
  - c Use boxcar filtering for Profiling (see the Appendix for a description of boxcar filtering).
  - d Set desired Profiling rate—the Profiler default rate is 2 seconds, but you may select any rate from 2 to 60 seconds.
  - e Re-display the “Don’t Ask Again” dialogs. This appears if you have selected “Don’t ask me this again” in any of the following:
    - Profiler Log Naming
    - View Calibration Report
    - Verify Units in LowFlow
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. If you change these settings, the software will inform you, on exiting, that the site has been modified. Be sure to save the modifications or the changes will be lost.

## CHOOSING PRESSURE DISPLAY & CONVERSION OPTIONS

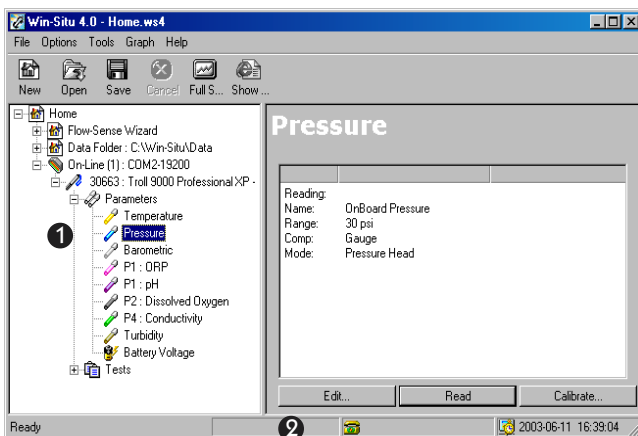
Measurements from the optional pressure sensor may be displayed as raw pressure head above the sensor, as depth, or as water level with a reference. When measuring depth or level, you have a choice of methods for conversion from pressure measurements. The specified settings are easily changed from one 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 9000 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 deployment, 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 11-19) 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.

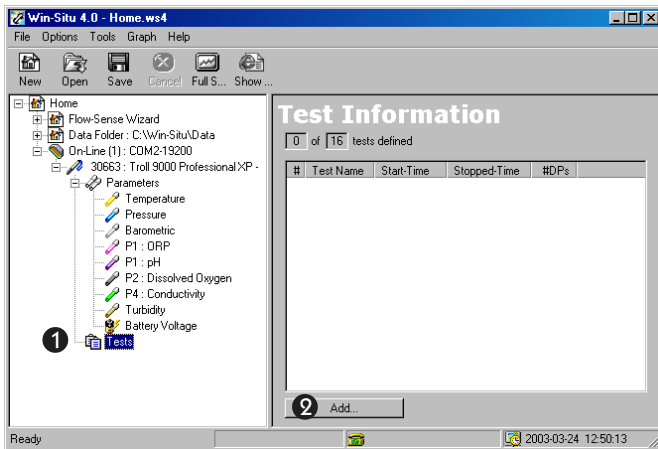
## LOGGING DATA (ADDING A TEST)

Logging data with the MP TROLL 9000 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 9000 connected to a host PC and selected in the Navigation tree, click or tap Tests.
2. Click or tap **Add...**



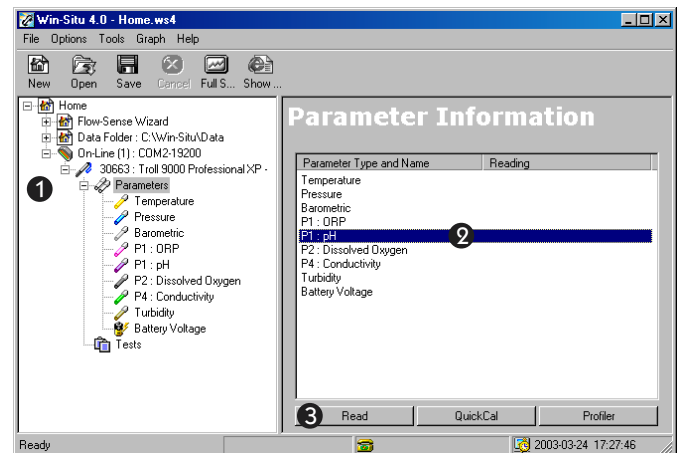
The Test Wizard starts. See Section 6 for a description of the elements that constitute a complete test definition.

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

## TAKING "MANUAL" READINGS

The MP TROLL 9000 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 9000 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 9000 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



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

computer, it can be viewed. A test can be extracted and viewed at any time, even while it or another test is running.

To extract a test:

1. With the MP TROLL 9000 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 9000. Test data files remain in the Multi-Parameter TROLL 9000’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 9000 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.

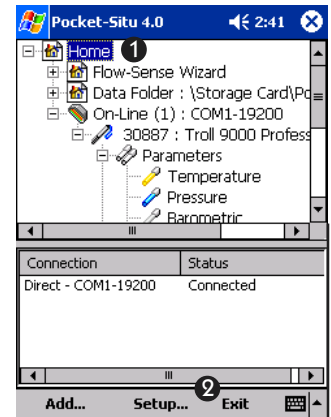
## EXITING THE SOFTWARE

### WIN-SITU

Select **Exit** from the File menu.

### POCKET-SITU

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



If changes have been made to the site, Win-Situ or Pocket-Situ will ask if you want to save the modifications. Such modifications may include adding or deleting a connection as well as measurement units and other preferences, which are saved with the site.

- Select **Yes** to save the current settings.
- Select **No** to abandon the changes.



**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 9000, or to a desktop PC using ActiveSync.



## 5 PROFILING

All models of the Multi-Parameter TROLL 9000 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 9000 with water quality sensors installed and calibrated
- Quick-Connect Submersible cable
- ComIT or comm cable
- PDA running Pocket-Situ

### 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 9000 to a host PC and establish communication in Win-Situ or Pocket-Situ.



**Q:** Can I do profiling if the MP TROLL 9000 is running a test?



**A:** 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 9000 in the Navigation tree.

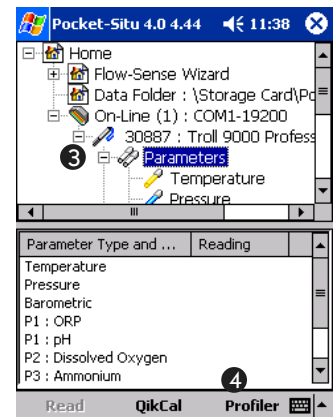
The software will automatically detect the installed sensors and display them in the Information pane.



*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.*

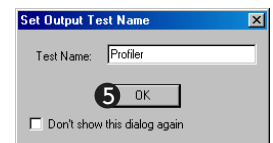
3. Click or tap Parameters in the Navigation tree.

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)

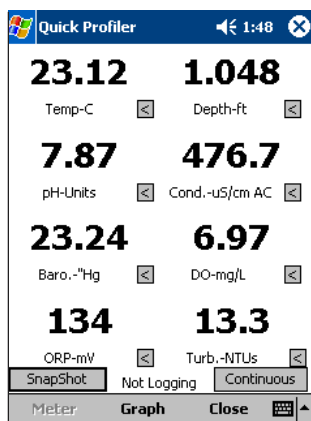
- To use the default name click **OK**.
- To specify another name, key it in and click **OK**.
- To avoid this question each time you start the Profiler, check the option box and click **OK**.



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 on [page 33](#) 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.



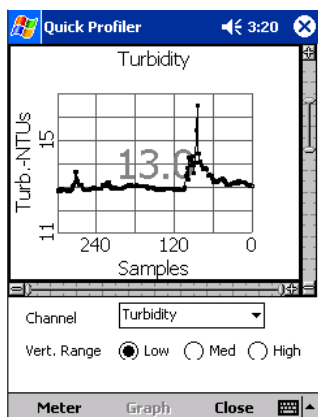
**TIP:** If a channel you wish to see is not displayed, click the symbol below a reading you can do without and select the channel you want to add from the list of available channels. This is particularly useful for RDO readings.

## 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 response time ranges from about 6 seconds (T63, when the oxygen level is increasing) to 57 seconds (T95, when the oxygen level is decreasing)

## 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 long-term 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 9000, 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 on [page 33](#) for details.

Section 18 below has additional information on the turbidity wiper.

The screenshot shows the 'Quick Profiler' window with the following data and controls:

- Temp-C: 23.12
- Depth-ft: 1.048
- pH-Units: 7.87
- Cond.-uS/cm AC: 476.7
- Baro.-"Hg: 23.24
- DO-mg/L: 6.97
- ORP-mV: 134
- Turb.-NTUs: 13.3
- Buttons: Snapshot, Not Logging, Continuous
- Bottom Bar: Meter, Graph, Close

Annotations and their descriptions:

- Select a different channel for display in this position**: Points to the channel selection arrows next to the top two readings.
- Click any reading to display a graph of the channel**: Points to the large numerical values.
- Log next set of readings to the Data Folder on the PC**: Points to the Snapshot button.
- Log continuously updated readings to the Data Folder on the PC. Changes to "Stop Log" during continuous logging.**: Points to the Continuous button.
- Close the Profiler and return to the Parameter display**: Points to the Close button.
- Profiler logging status**: Points to the Not Logging button.
- Display a graph of the data, starting with the first channel**: Points to the Graph button.

The screenshot shows the 'Quick Profiler' window in graph mode for Turbidity. The graph displays a line plot of Turbidity (NTUs) over time (Samples). The Y-axis ranges from 11 to 15, and the X-axis ranges from 240 to 0. A current reading of 13.0 is shown on the graph.

Annotations and their descriptions:

- Up to 300 readings (including the current reading) can be graphed**: Points to the X-axis range slider.
- X axis range slider**: Points to the X-axis range slider.
- Auto-scales the Y axis for the selected range (available for some channels)**: Points to the Y-axis range slider.
- Y axis range slider. Double-click to zoom fully out; double-click again to restore.**: Points to the Y-axis range slider.
- Select the channel to graph**: Points to the Channel dropdown menu.
- Return to the Profiler's channel display**: Points to the Meter button.
- Close the Profiler and return to the Parameter view**: Points to the Close button.

## 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.

### 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**.

### TO STOP LOGGING

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



**Q:** Can I log Profiler readings if the MP TROLL 9000 is running a test?



**A:** Yes, again with the restriction that the Profiler will defer to the test measurement schedule.

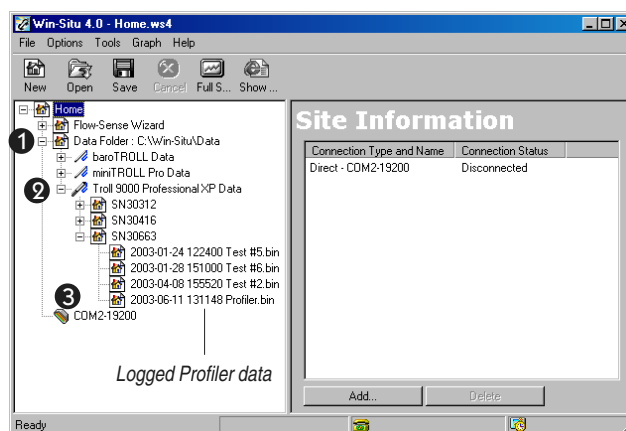
In Continuous mode, click **Stop Log**. Note that this does not stop Profiling; readings will continue to be updated on the screen.

## 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 9000 are ideal for long-term monitoring of water quality. The ability to schedule tests in advance, the large data storage memory, and long-life battery power mean the instrument can collect data unattended at remote sites over the long term.

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:

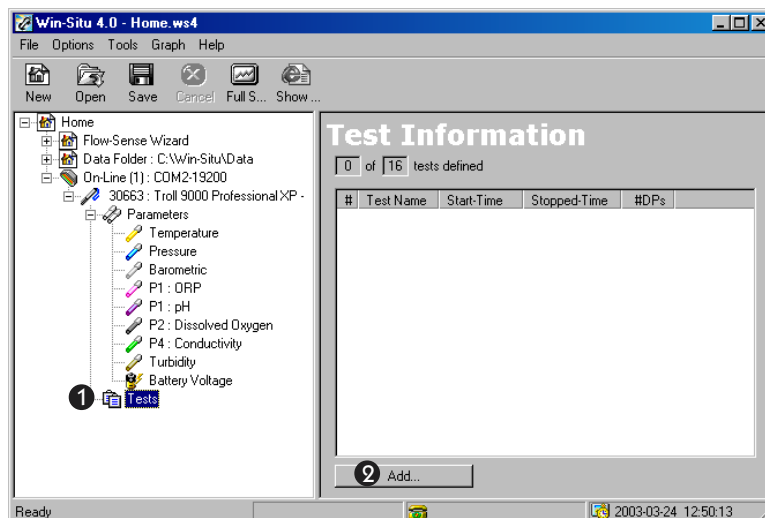
- which parameters to measure
- how often to measure
- when to start taking and logging measurements

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.

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



These actions are initiated by actions 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 37.

### 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.

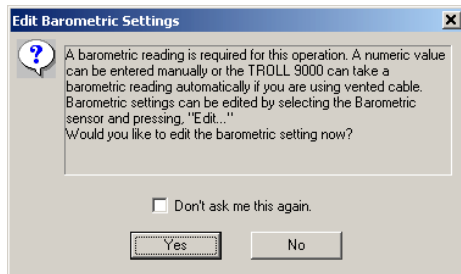
1. With the MP TROLL 9000 connected to a host PC and selected in the Navigation tree, click or tap Tests.
2. Click or tap **Add**. The Test Wizard starts. The choices are discussed below.
3. When you finish the Wizard, the information is written to the device and the display is updated.



**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.

Before the Test Wizard starts, you will be asked how you want to handle barometric pressure. Cable venting is essential to obtain accurate measurement, and the software cannot tell if this cable is vented, so please take a moment to supply this information. Do one of the following:

- If the TROLL 9000 is on vented cable now and will be deployed on 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 be deployed on non-vented cable, click Yes. In the Edit Barometric Channel 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 Edit Barometric Channel screen, check the box indicating non-vented cable for deployment and enter a barometric pressure value. For help in supplying information if the cable is not vented, see [Section 9, Monitoring Barometric Pressure](#).



## 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.
- **Log.** *Not available for the MP TROLL 9000.*
- **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 9000 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.

**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.

**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)



**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.

**Event Test Setup**
**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.

**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.

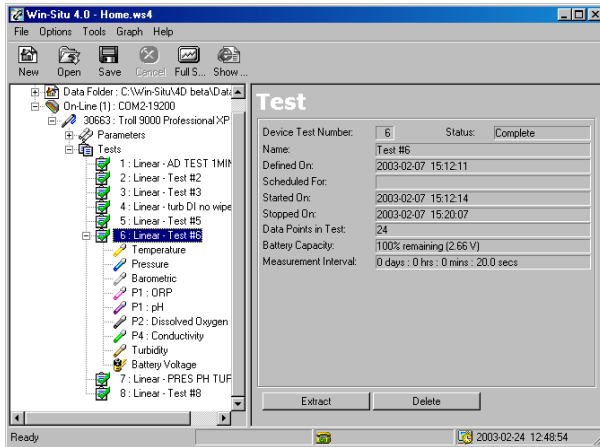


**TIP:** Units for the Event channel should be set to the "basic" parameter unit (e.g., psi); derived (software-calculated) units are not available.

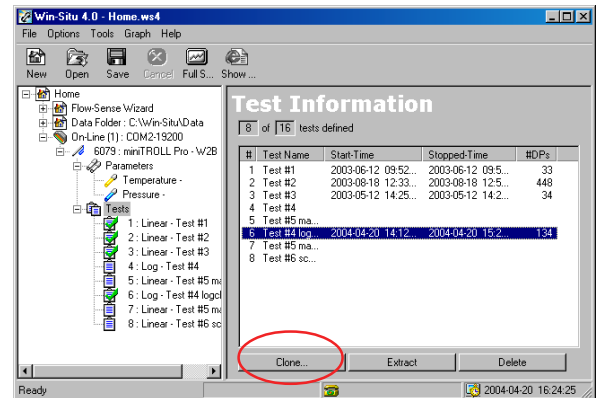
**Default Storage**

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 scenario of a long-term test containing 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 here—then data will be logged every hour regardless of the Delta comparisons.

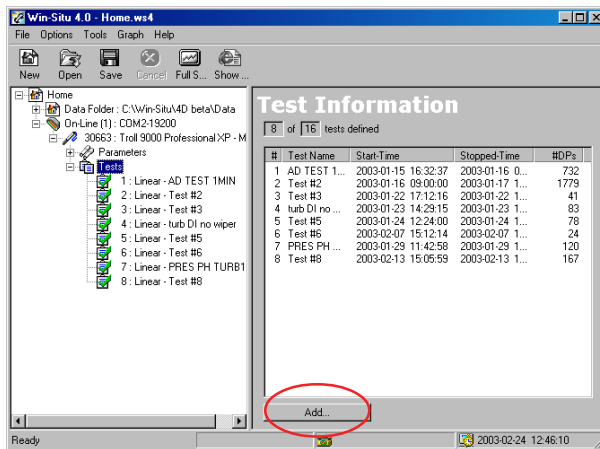
## Single test view vs. Multiple test view



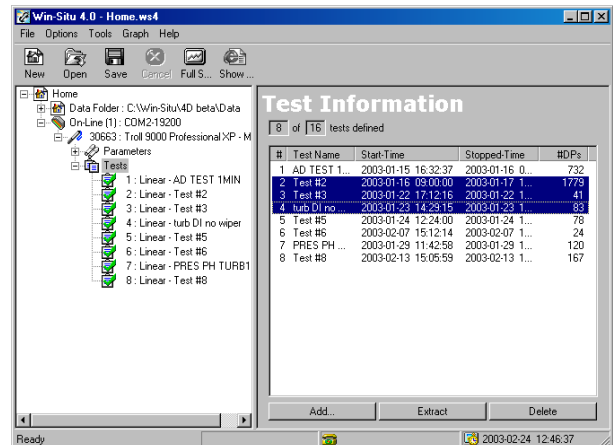
When a single test is selected in the Navigation tree, the Information pane shows details about the selected test.



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.

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  $\times$  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).

### Linear Average Test Setup

Test Wizard - Choose Measurement Interval

Take and store an averaged measurement every:

	Day	Hour	Minute	Second
(A)	0	1	0	0

(B) Seconds between averaging samples (1 - 255):

(C) Number of samples for averaging (2 - 99):

$A \geq 2(B \times C)$

Note: The interval between stored measurements (A) must be at least twice the time needed to take the measurements that will be averaged (B, C).  
For MPT-9000's Intervals A and B must be multiples of 5 seconds.

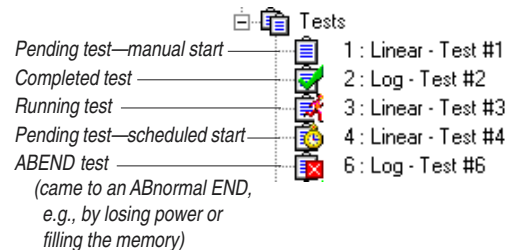
< Back    Next >    Cancel

## 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 9000 connected to a host PC, select a pending manual test  in the Navigation tree.

2. Click or tap **Start**.

3. You will be asked to confirm your selection.



**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.

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 9000 connected to a 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 9000 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 9000 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:** 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.



**TIP:** The “Extract” operation puts a copy 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.



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



Win-Situ extracts tests to a folder named “Data” in the folder where Win-Situ 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 9000 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.

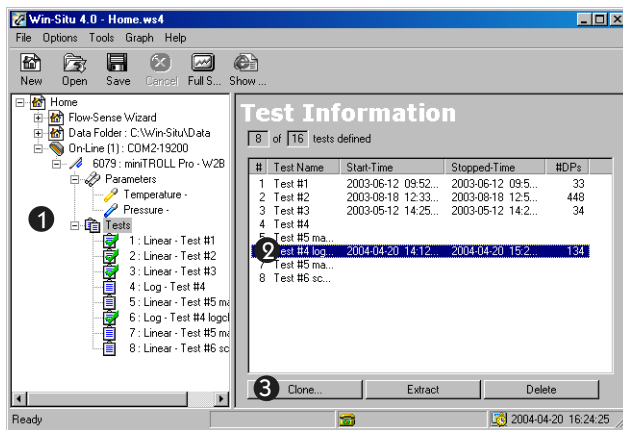


**TIP:** The Delete procedure can be used to cancel a pending scheduled test .

## 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 9000 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).



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

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.

## TRANSFERRING FILES FROM A PDA TO A DESKTOP PC

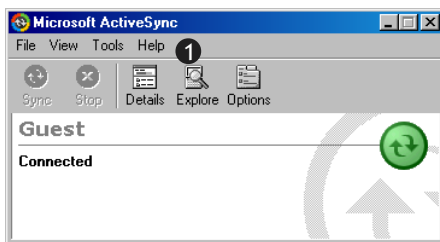
If PocketSync utility is installed in the Win-Situ folder on your desktop PC, file transfer is done automatically each time the computers are connected using ActiveSync. See Section 4, Software, for more information on setting PocketSync synchronization options.

If you wish to transfer files “manually” proceed as follows. **NOTE THAT MICROSOFT ACTIVESYNC IS NEEDED TO CONNECT THE COMPUTERS whether you use PocketSync or not.**

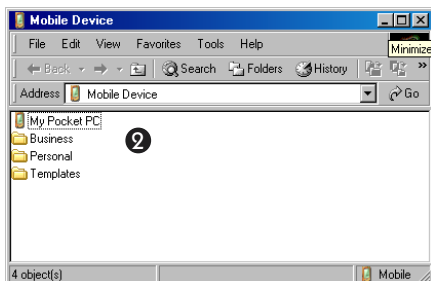


**TIP:** Install Microsoft ActiveSync on the desktop PC **before** the first connection to the PDA. Be sure to exit your last Pocket-Situ session. The following procedure is performed from the desktop PC side.

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

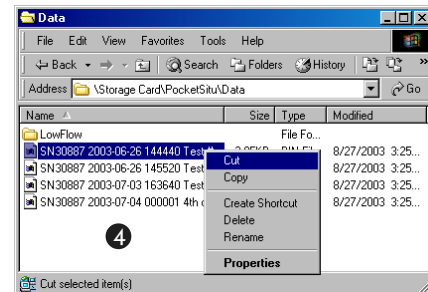


2. Double-click on “My Pocket PC.”



3. Browse to the folder where Pocket-Situ Data is stored. On many PDAs this will be in a folder called “Storage Card” or “SD Card.” On the Rugged Reader, 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 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. PocketSync, if used, will put the files in the proper locations automatically.

Test data files	Data folder in the folder where Win-Situ 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 is installed. These will be accessible from Win-Situ’s Tools menu.



## VIEWING LOGGED DATA

Logged data sets from the Multi-Parameter TROLL 9000 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:

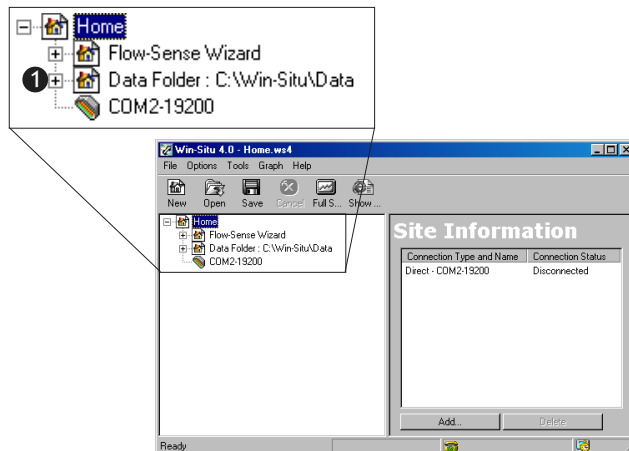
- If the test is in the instrument’s memory, extract it and select the **View** option at the end of the download. This launches the data viewer.
- If the test has been extracted to the host computer, it will appear in the Data Folder node in the Navigation tree. A connection to the instrument is not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

### SELECTING DATA IN THE DATA FOLDER

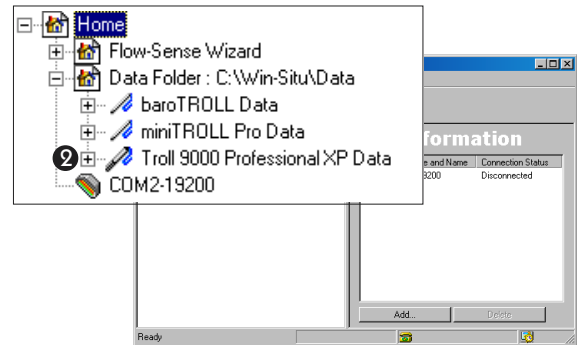
The Data Folder appears below the Home site in the Navigation tree. After data files have been extracted from the MP TROLL 9000 to the Data Folder, the node can be expanded to show device type, serial number, and extracted data files.

To view extracted test data:

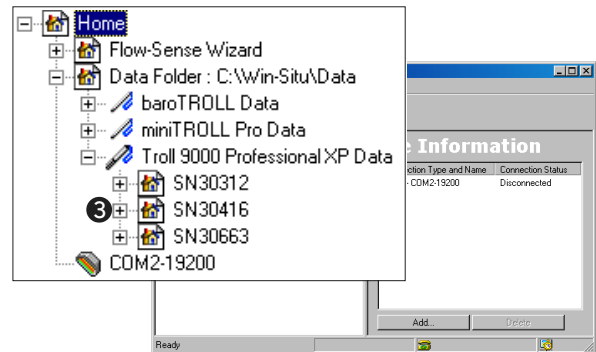
1. Click the + sign beside the Data Folder to expand the listings.



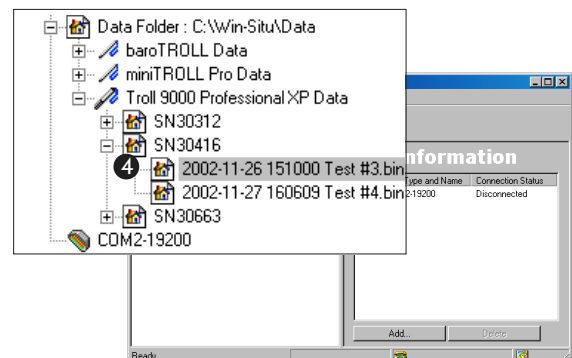
2. The Data Folder has a node for data from each device type—for example, miniTROLL Pro Data, TROLL 9000 Professional XP Data. If tests from more than one type of device have been extracted, click the + to expand the TROLL 9000 listing.



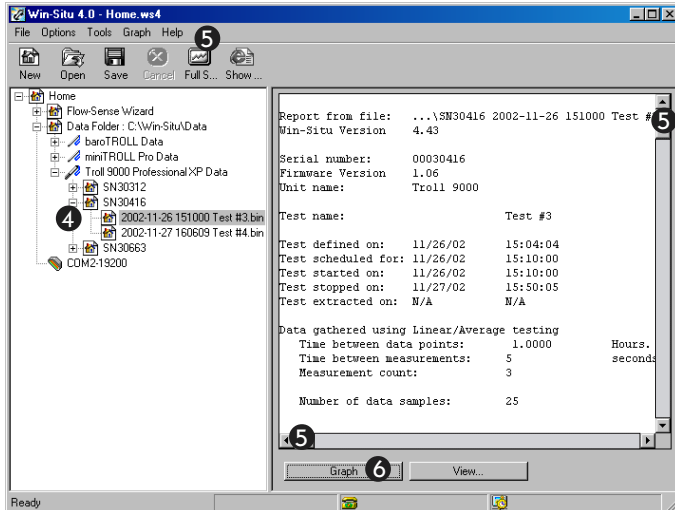
3. Device nodes are further subdivided by serial number. If tests from multiple TROLL 9000s have been extracted, the serial number of each will be displayed. Click the + beside the the serial number of the unit whose data you want to view.



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.



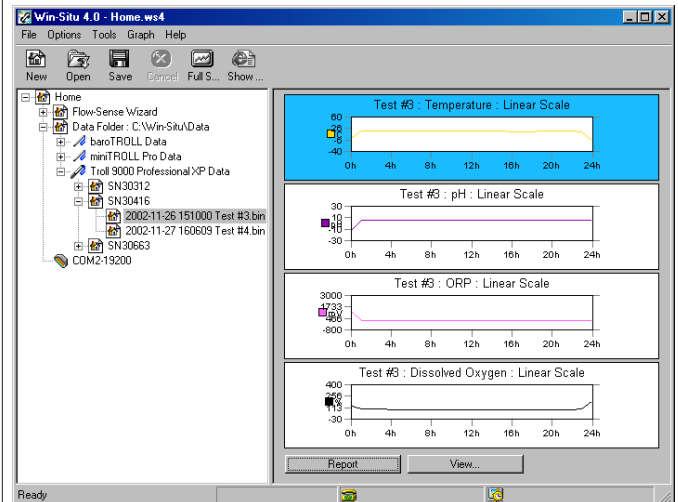
**TIP:** You can easily switch from Graph view to Report view and back using the **Graph** and **Report** buttons in the Information pane. However, the view chosen in this way is not “persistent” into your next session. To change the view so it always comes up as Graph or Report, specify the desired 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

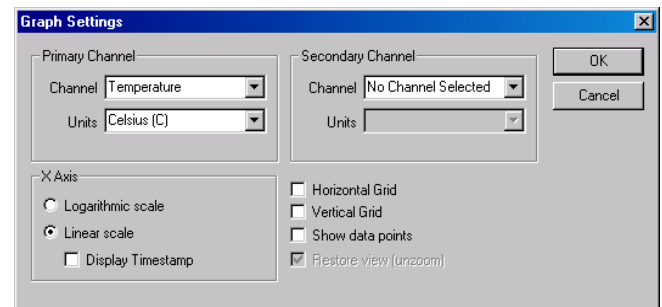
The Graph button displays data from the first four test channels in graph format. Time is shown on the X axis in the currently selected unit. The axes are auto-ranged. Click any graph to select it for formatting.



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.

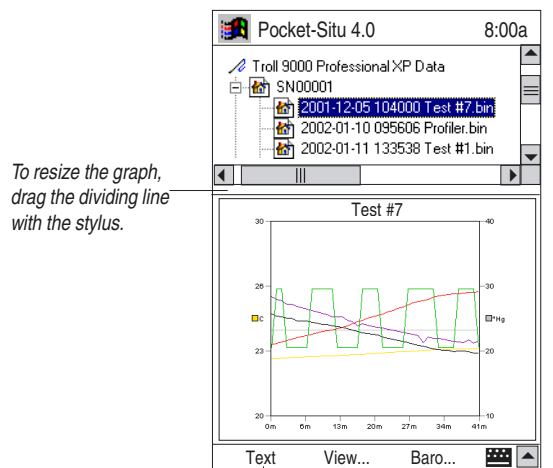
Tap **Graph** or **Text** in the command bar to change the view.

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.



To resize the graph, drag the dividing line with the stylus.

Switch to text view

Select channels, change units and other preferences

## 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

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

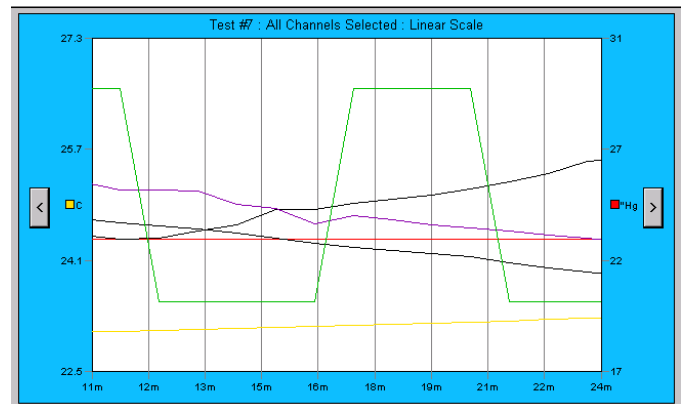
To print the graph or report as currently displayed:

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

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. Long-term 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 9000, if included, is permanently-installed and factory-calibrated. If your MP TROLL 9000 was ordered without a pressure 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:

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

If your MP TROLL 9000 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 9000’s onboard barometric pressure sensor, as long as the instrument is deployed on 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.

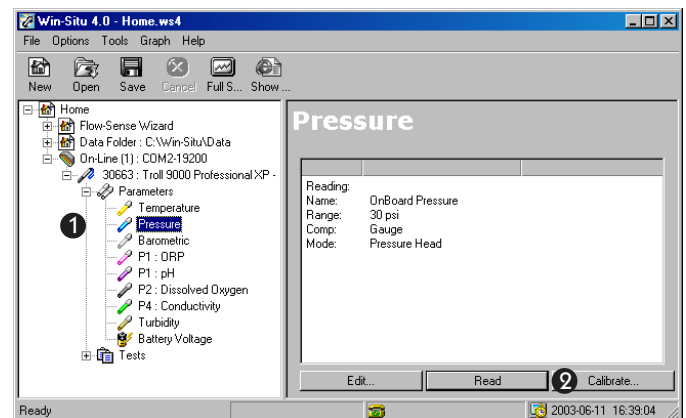
## ZEROING A GAUGED PRESSURE SENSOR

The following procedure may be used, **with caution**, to “zero” the offset of a gauged 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 Pressure in the Parameters list. If the pressure channel is set up to display in Depth or Level mode, use the Edit function to set it to Pressure Head mode.
2. Click or tap **Calibrate**. You will be prompted to ensure the device is in air.



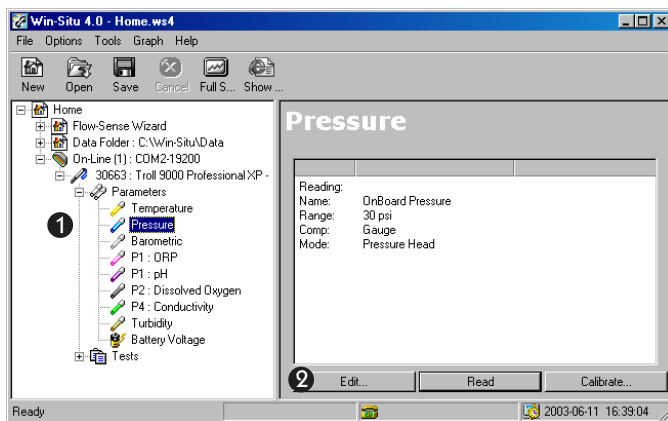
3. When the device is in air, click Yes.

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.



**What do I get with out-of-the-box pressure measurements (no setup)?**



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.

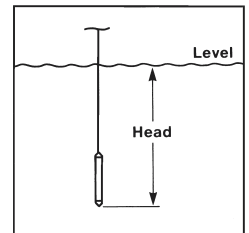
### 1. NAME (OPTIONAL)

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).

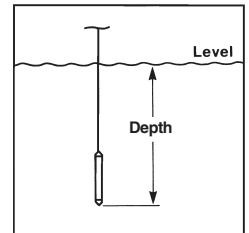
### 2. DISPLAY MODE

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

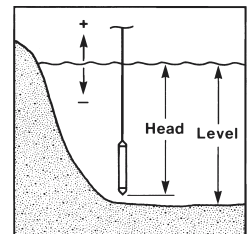
- **Pressure Head** displays the raw pressure exerted by the column of water above the pressure sensor, in kiloPascals or pounds per square inch (psi). If you choose this mode, click Finish to end the Wizard. Then select units on Win-Situ's Options menu.



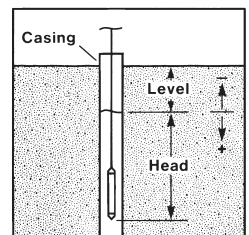
- **Depth** converts the pressure of the water column to a depth reading, in meters, centimeters, feet, or inches. If you choose this mode, you will be asked to choose a method for converting pressure to depth. Then select units on Win-Situ's Options menu.



- **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 ground-water 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<sup>3</sup>. 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.

#### LIQUID DENSITY

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

Use the values in the table below 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 to this manual.



**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.*

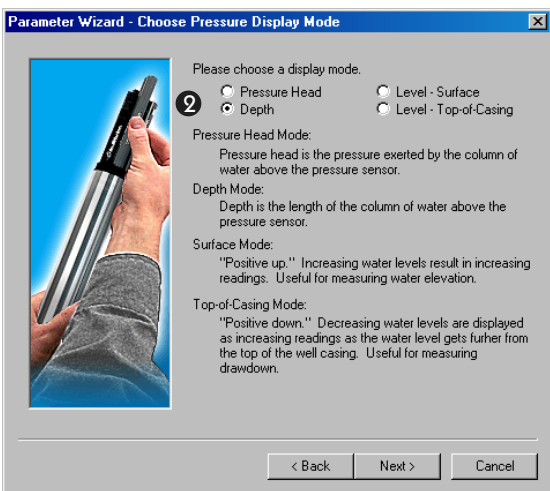
Fluid density by temperature

Temp. (°C)	Density (g/cm <sup>3</sup> )	Temp. (°C)	Density (g/cm <sup>3</sup> )	Temp. (°C)	Density (g/cm <sup>3</sup> )
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

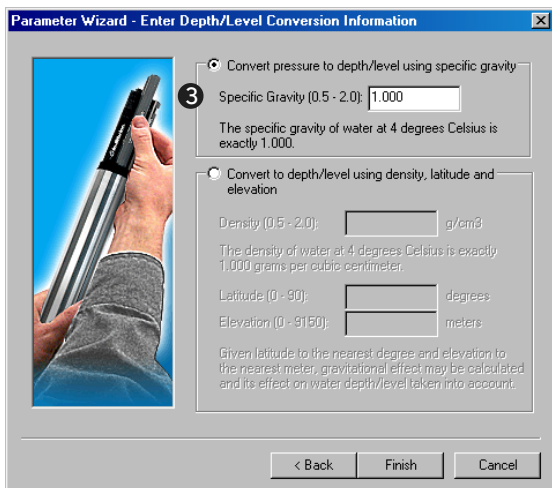
## QUICK SUMMARY OF PRESSURE SETUP

For **DEPTH**:

- 1 Select Pressure in Parameters list, select Edit
- 2 **Display Mode**: Select Depth, click Next.

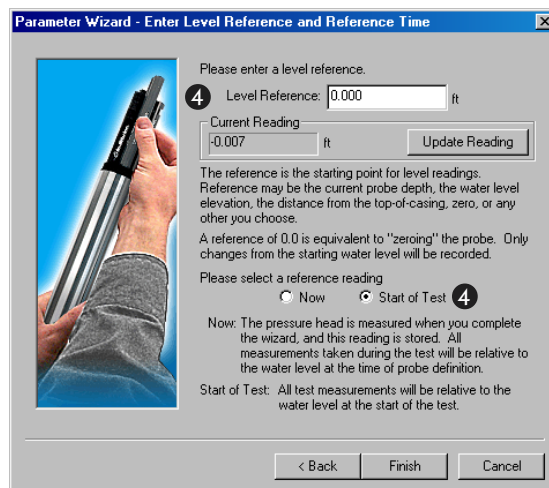


- 3 Select Depth/Level Conversion: Specific Gravity 1.0. Click Finish.



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 **LONG-TERM 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



## **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 9000 includes an onboard barometric pressure sensor, and the instrument is deployed on vented cable, the barometric pressure sensor output can be used to correct measurements from a submerged 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. 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).

## **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 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 PSIA instrument). Add a test. Ideally, this test should start before the test in the Absolute MP TROLL 9000 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 9000. 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 instrument with a PSIA 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 or Pocket-Situ. 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 9000 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:

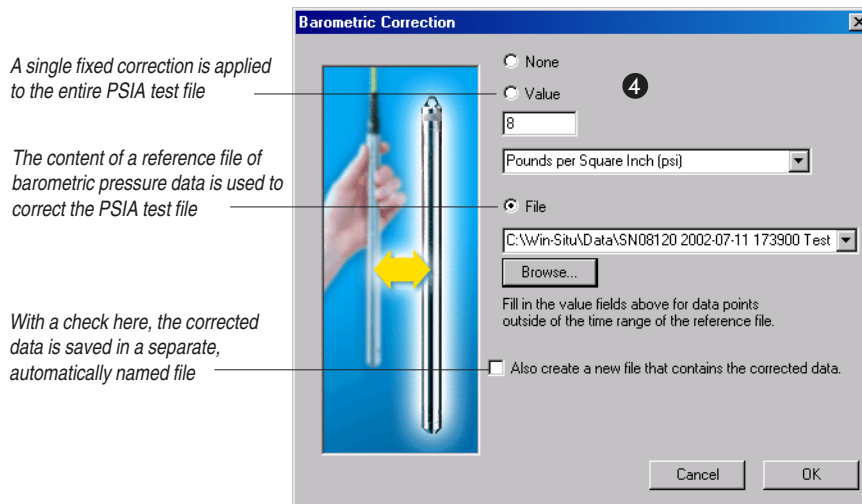
- None
- Value: Enter a barometric pressure value to be subtracted from all data points in the test file. Units are selectable, and your entry is checked for validity. For example, in inches of mercury the valid range is 14.3 to 33.5 (covering altitudes from the Alps to the Dead Sea). You may not leave 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. Calculations of the accuracy drift of the MP TROLL 9000 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

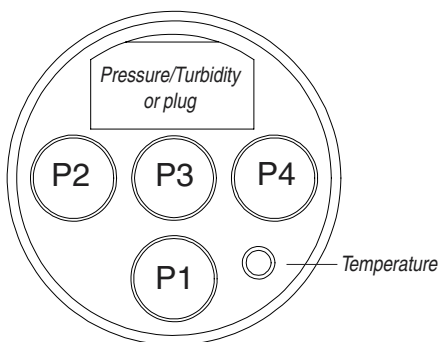
### WHY MONITOR TEMPERATURE?

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 9000 include a permanently installed, factory-calibrated sensor for measuring solution temperature.



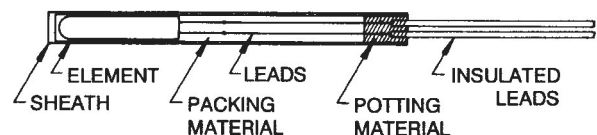
*Do not try to remove the permanently installed temperature sensor.*

The MP TROLL 9000 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 during field deployment of the instrument.

### 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, and A.E. Greenberg, eds., *Standard Methods for the Examination of Water and Wastewater*, 19th edition, Washington, D.C.: American Public Health Association, American Water Works Association, and Water Environment Federation, 1995. 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](http://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 9000 is deployed 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 9000 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)



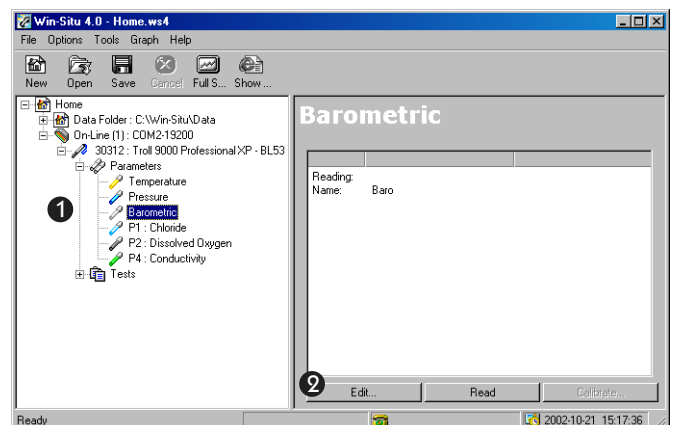
**TIP:** To change unit preferences: In Win-Situ, select Preferences on the Options menu. In Pocket-Situ, select the Home site, then tap Setup in the command bar.

### COLLECTING ACCURATE MEASUREMENTS WITHOUT VENTED CABLE

Win-Situ and Pocket-Situ cannot determine whether the MP TROLL 9000 is deployed 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:

3. Do one of the following:
  - If this MP TROLL 9000 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 be deployed on **non-vented** cable, select “Use non-vented cable or backshell.” Continue to step 4.
  - If the TROLL is on **vented** cable now but will be deployed 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<sup>3</sup> = 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



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



## 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 long-term 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 long-term trends and demonstrate compliance.

### THE SENSORS

The Multi-Parameter TROLL 9000 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 9000 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 9000 and moved to another port that accepts the sensor type, or used in another MP TROLL 9000, without recalibration. The most accurate results will be obtained when a sensor is calibrated and operated in the same MP TROLL 9000.

The water quality sensors available for the Multi-Parameter TROLL 9000 may be classed in two general types:

#### BASIC SENSOR SET

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

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

The Basic sensors can be factory-calibrated and pre-installed in the MP TROLL 9000. 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)
- 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 9000. There are four sensor ports, P1 through P4, 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.



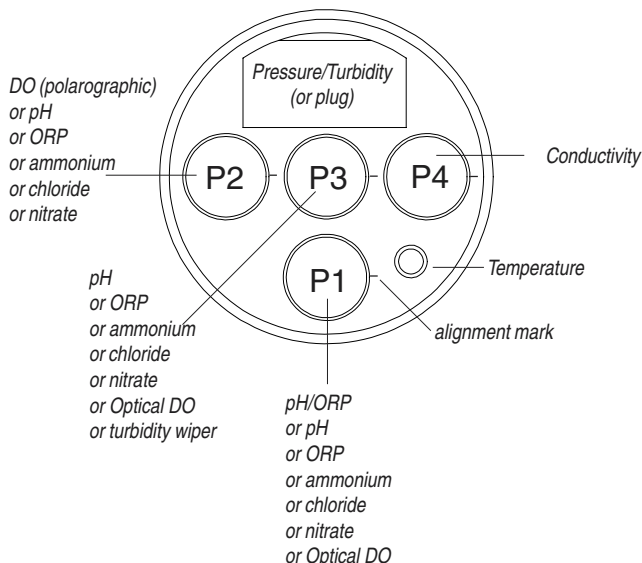
Do not try to remove the pressure or turbidity sensor or permanently installed plug.

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 from the front end of the MP TROLL 9000. This allows access to the sensor block depicted in the drawing.

End view of sensor block



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



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.

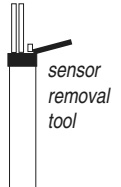
In this case, remove the offending sensor and install it in the correct port. Then “refresh” the device view in the software to update the display.

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 when deploying the instrument with fewer than 4 removable sensors installed.



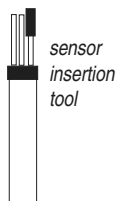
**TIP:** If you are installing a sensor in port P3 (the central port), install it first. This will make it easier to install sensors in other ports.

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).
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.

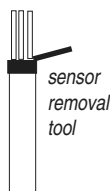




## REMOVING SENSORS

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 9000—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 9000 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 deployment, 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
- \* Custom Sensor Preparation

## 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 during deployment, 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 9000, 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.



### What is the difference between NOMINAL and STABLE?



To meet the criteria for a valid calibration point, the change (deviation) in sensor response is monitored over time. The software is looking for a specific trend in the signal deviation 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 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 (including the combination pH/ORP sensor), polarographic Dissolved Oxygen, and Conductivity.
- Requirements: MP TROLL 9000, 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 deployed right out of the box using factory-supplied default calibration coefficients.

- Available for: pH, ORP (including the combination pH/ORP sensor), and Conductivity.
- Requirements: MP TROLL 9000, 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.

**CUSTOM SENSOR PREPARATION**

Custom in-factory calibration may be performed to meet specific requests for range and accuracy requirements. Contact our Technical Support group for additional information about the availability of this option.



**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.

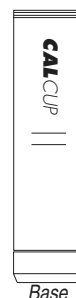
**THE CALIBRATION CUP**

The clear acrylic Cal Cup shipped with your MP TROLL 9000 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 9000 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 9000, 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 temperature that the sensor will be deployed in.

## RINSING

As a general guideline, we recommend you rinse the Cal Cup, the front end of the MP TROLL 9000, 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 deployment—for example, if the instrument will be installed 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).

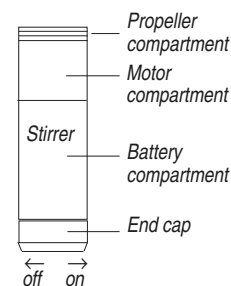
ISE sensors in close proximity to each other can sometimes create interferences. Constant stirring can enhance the performance of the ISE sensors.

## 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.

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



**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.

## Attaching the Stirrer for Calibration

To use the battery-powered stirrer for calibration, attach it to the MP TROLL 9000 and Cal Cup as follows. See illustration C on the following page.

1. Remove the restrictor (nose cone attached) from the MP TROLL 9000 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 9000.

To stabilize the instrument, you may wish to use a calibration stand or other support.

## 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

**MP TROLL 9000**

- 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

**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.

**SENSOR STORAGE**

It is best to calibrate as close to the time the sensors will be deployed as possible. However, should you need to store calibrated sensors until deployment, there are a couple of options:

- If the instrument will be deployed 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.

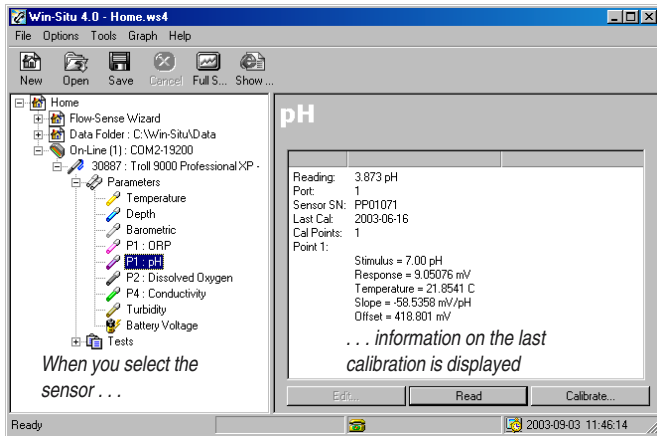


To seal the Cal Cup against leakage, seat it lightly against the o-ring on the instrument body. It is best not to overtighten.

- For longer storage, remove the sensors from the MP TROLL 9000. Store the conductivity sensor dry. Store the DO, pH, and ORP sensors in their storage bottles (located in the sensor kits): DO in deionized water, pH and ORP in the solution they were shipped in, or with a moist sponge in the sensor storage bottle to avoid depleting the reference solution.

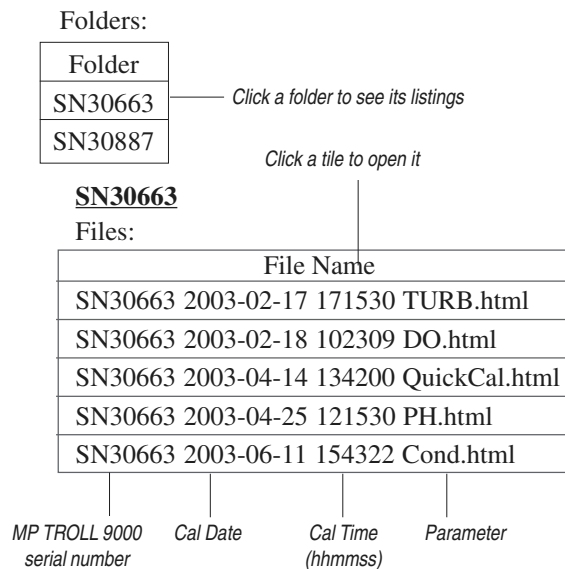
**CALIBRATION HISTORY**


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 screen below illustrates recent pH calibration information for a combination pH/ORP sensor in port P1.



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 or Pocket-Situ 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.

### Example of a calibration report index



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 is installed

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

### 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 the MP TROLL 9000 is deployed 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. When deployed 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

Also refer to the tech note on “Instrument Calibration.”

**HOW TO CHECK IF 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 THE 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 may be found in the individual parameter sections below.

**REFERENCES**

Eaton, A.D., L.S. Clesceri, and A.E. Greenberg, eds., *Standard Methods for the Examination of Water and Wastewater*, 19th edition, Washington, D.C.: American Public Health Association, American Water Works Association, and Water Environment Federation, 1995.

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](http://aquanic.org).

Rundle, Chris C., A Beginners Guide to Ion-Selective Electrode Measurements. Nico2000 Ltd., London, UK. On the web at [www.nico2000.net](http://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](http://wow.nrri.umn.edu)



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



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)



# 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):

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

Water (H<sub>2</sub>O) dissociates into hydrogen ions (H<sup>+</sup>) and hydroxide ions (OH<sup>-</sup>) in aqueous solution. At 25°C there are 1.0 x 10<sup>-7</sup> moles/L of hydrogen ions and 1.0 x 10<sup>-7</sup> 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 chemi-

cal reactions that sustain life. The solubility of many chemicals is pH dependent. Thus, pH determines their availability to living organisms.

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<sub>3</sub><sup>2-</sup>) and bicarbonates (HCO<sub>3</sub><sup>-</sup>). Extremely fresh water can even be slightly acidic (~ pH 6), depending on the concentration of dissolved carbon dioxide (CO<sub>2</sub>). The carbon dioxide combines with water to form a small amount of carbonic acid (H<sub>2</sub>CO<sub>3</sub>) and this process lowers the pH. Nitrogen oxides (NO<sub>x</sub>) and sulfur dioxides (SO<sub>2</sub>) from automobile exhaust and the burning of coal combine with water in the atmosphere to form nitric (HNO<sub>3</sub>) and sulfuric acid (H<sub>2</sub>SO<sub>4</sub>). 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<sub>3</sub>/NH<sub>4</sub><sup>+</sup>) 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:

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

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

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 9000 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 9000 may be shipped with a pH or combination pH/ORP sensor installed. If installation is necessary, unpack, pre-soak, and install the sensor in the MP TROLL 9000 as follows.



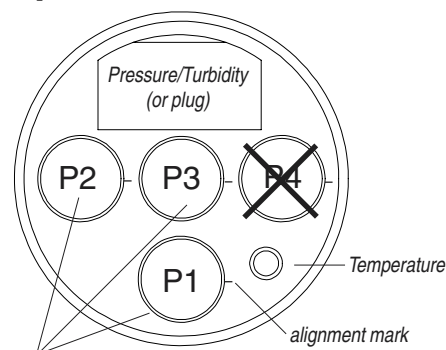
The combination pH/ORP sensor will work properly only in port P1. The pH sensor may be installed in port P1, P2, or P3.



**TIP:** Remember that a polarographic D.O. sensor (if present) will operate properly only in P2, and a turbidity wiper accessory only in P3.

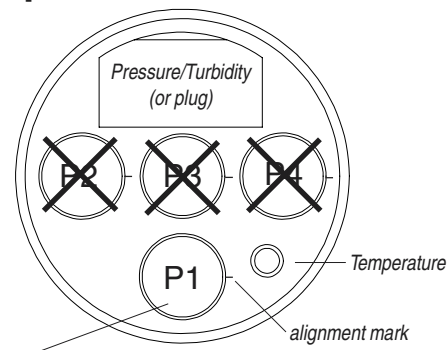
1. Remove the restrictor from the front end of the MP TROLL 9000. This allows access to the sensor block shown below.
2. Remove the sensor's protective cap or storage bottle and set aside for future storage of the sensor. If the connector end is covered with a cap, remove it also.

### pH Sensor Positions



pH sensor may be installed in port P1, P2, or P3

### pH/ORP Sensor Position

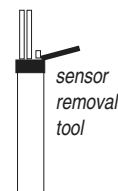


Install a pH/ORP sensor in port P1



**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 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. 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 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 *or* pH 7-10). Choose solutions that bracket the expected pH range:
  - 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.
- **Default Coefficients:** Resets the sensor's factory defaults. No solutions are required. 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 sensors are relatively new.

#### 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 4.01, pH 7.00, pH 10.01 buffer, and deionized water.



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

#### Calibrating with Other Solutions

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 degree of accuracy required. In clean water samples the pH sensor should retain its accuracy specification for at least one month before requiring recalibration.

Your own experience is the best guide to how often the pH 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.”

#### pH QUICK CAL

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

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



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

#### TRADITIONAL pH CALIBRATION PROCEDURE

1. With a pH or combination pH/ORP sensor installed and plugs or sensors in the other ports, rinse the front end of the MP TROLL 9000 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.
3. Insert the front end of the MP TROLL 9000 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.

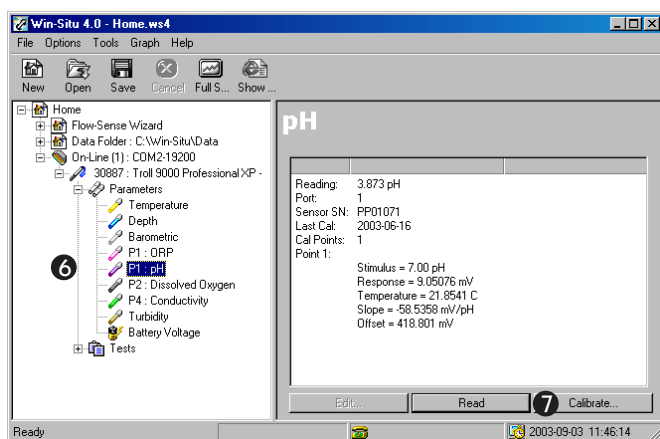
4. Connect the MP TROLL 9000 to a PC and establish a connection in Win-Situ or Pocket-Situ. Win-Situ screens are illustrated here. The Pocket-Situ interface is similar, with the Navigation tree at the top of the screen and the Information pane below it.
5. Select the MP TROLL 9000 in the Navigation tree.

The software will automatically detect and display the installed sensors. If one or more sensors is installed in the wrong port, an



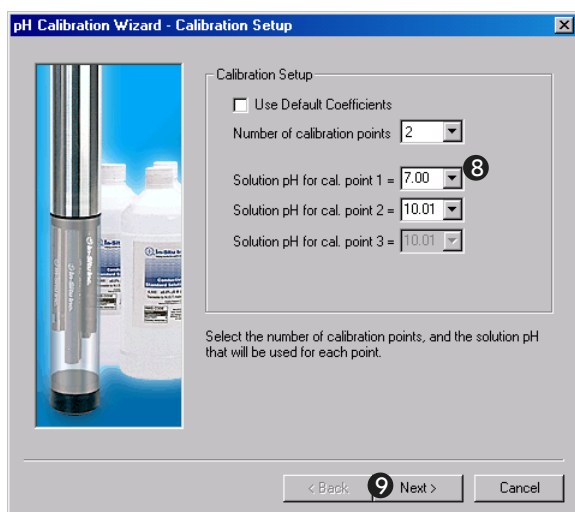
error message will be displayed. Simply remove the sensor and install it in the correct position, then “refresh” the device before continuing.

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



- Select **Calibrate**.

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

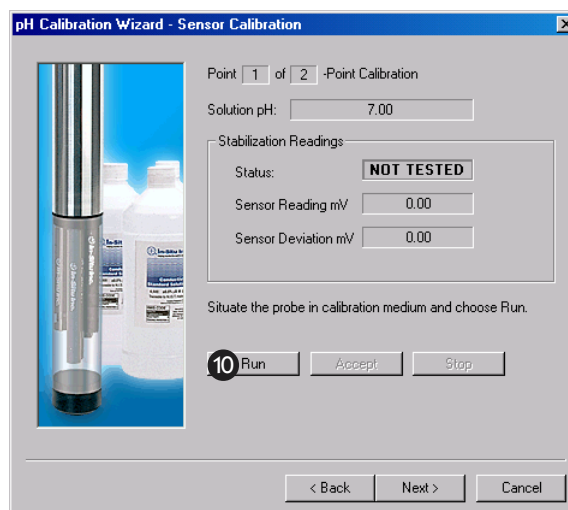


- Select the number of calibration points for this calibration, and the pH value of the calibration solution for each point.

Cal point 1 is the solution the sensor is soaking in now.

- Select **Next** to continue.

- 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.
- 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.



**TIP:** Most sensors stabilize within 1-3 minutes if the sensor is properly hydrated before calibration. To minimize stabilization times, do not handle the instrument during the time the sensor is taking readings in the calibration solution.

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

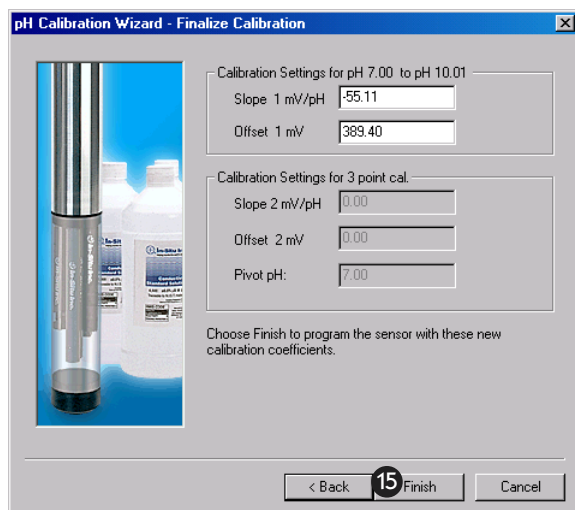
For a multi-point calibration, the Wizard returns to the screen shown at step 10 and waits for you to situate the probe in the next calibration solution and click Run.

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).
14. The final screen shows the sensor slope and offset calculated during the calibration process. For a 3-point calibration, 2 sets of calculated 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.

The pH sensor is now calibrated and ready to use.

#### Options for storing the sensor until deployment:

- If the instrument will be deployed 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 of the Cal Cup, or add a little water (deionized, distilled, or tap)—just enough to create a moist environment. Return the probe to the Cal Cup for transport to the field site.
- For longer storage, remove the sensor from the instrument and place in the electrode storage bottle (located in the sensor kit) in the conditioning solution in which it was shipped, or with a sponge moistened with pH4 buffer to avoid depleting the reference solution. For longer-term storage, see the section on Sensor Care and Handling at the end of this chapter.

#### RESETTING DEFAULT COEFFICIENTS

The sensor’s calibration may be reset back to factory defaults at any time. This option is most effective when the sensor is new.

1. With a pH or combination pH/ORP sensor installed, establish a connection to the instrument in Win-Situ or Pocket-Situ.
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. Offset calculated by the software in pH 7 will typically be between 390-450 mV. If the offset falls much outside these limits, it may be time to replace the sensor.

The calculated slope will typically be between -54 mV/pH and -62 mV/pH. A calculated slope greater than -50 mV/pH or less than -66 mV/pH may indicate the sensor is due to be replaced.

#### UNITS AND CALCULATED MEASUREMENTS

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

#### DEPLOYMENT RECOMMENDATIONS AND CAUTIONS

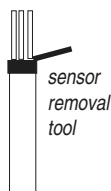
- Temperature compensation is provided in the software to account for measurements taken at temperatures different from the calibration temperature. For most accurate results, try to calibrate at the same temperature as the expected sample temperature.

- Calibration frequency will depend on the nature of the sample and degree of accuracy required. In clean water samples the pH sensor should retain its 0.09 pH accuracy specification for at least one month before requiring re-calibration.
- 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 if your sample fits this description.
- pH readings in pure water samples (<100uS/cm conductivity) 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 before deployment.
- The pH sensor is designed for optimal operation at an angle of 10° or more from horizontal. It may be deployed horizontally if you first shake the sensor smartly—as you might with an old-style mercury thermometer—to insure that the fill solution is fully residing at the bulb end of the sensor.
- The pH/ORP sensor is designed for optimal operation at an angle of 30° or more from horizontal.

## 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

If a film develops on the glass electrode, the sensor response will tend to be sluggish. A deposit on the junction will result in an erratic response. In these cases, rinse the sensor in a detergent solution, followed by a rinse in deionized water, then soak it in pH 4 buffer. This should restore the response. If not, sensor response may be restored by soaking in 0.1 M HCl solution, followed by a thorough rinsing. Soak the sensor in 2M KCl (the solution in the storage bottle) for at least an hour before calibrating.

If the sensing glass should become dehydrated, performance can often be restored by soaking the sensor for at least an hour in pH 4 buffer or 2M KCl. Check the reading after an hour or so of soak time. If the response has not improved, try soaking the sensor overnight, and test again. If the response has still not improved, the sensor should probably be replaced.

## STORAGE

### Short-Term Storage (up to a week)

Immerse the sensor tip in pH 4 buffer using the electrode storage bottle (located in the sensor kit). Tighten the cap to prevent drying. Alternatively, pH 7 buffer can be used for up to a few days.

### Long-Term Storage (up to several weeks)

The electrode storage bottle should be moist with pH 4 buffer but not filled. Prior to use the sensor must be conditioned by rinsing with deionized water and subsequently soaked in pH 4 buffer for 1-2 hours.



**TIP:** If the MP TROLL 9000 was shipped with the sensor installed, you will find the electrode storage bottle in the sensor kit.

After long-term storage, be sure to recondition the sensor by rinsing in deionized water then soaking in pH 4 buffer for an hour or two.

## REFERENCES

Eaton, A.D., L.S. Clesceri, and A.E. Greenberg, eds., *Standard Methods for the Examination of Water and Wastewater*, 19th edition, Washington, D.C.: American Public Health Association, American Water Works Association, and Water Environment Federation, 1995. Section 4500 H<sup>+</sup>, 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

Typical Conductivity values

Ultra-pure distilled water	0.05 $\mu\text{S}/\text{cm}$
Distilled water	1.0 $\mu\text{S}/\text{cm}$
Drinking water	50 to 300 $\mu\text{S}/\text{cm}$
Surface water	100 to 10,000 $\mu\text{S}/\text{cm}$
Sea water	40,000 to 55,000 $\mu\text{S}/\text{cm}$
Great Salt Lake	158,000 $\mu\text{S}/\text{cm}$

(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.

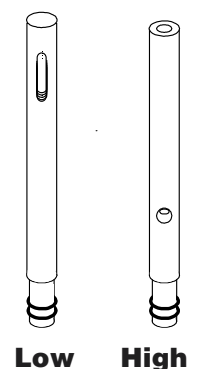
Early conductivity measurements were performed using cells with two electrodes. This method required using three conductivity cells with different cell constants in order to span the range of 1 to 100,000 microSiemens per centimeter ( $\mu\text{S}/\text{cm}$ ). Another inconvenience occurred when deposits 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 $\mu\text{S}/\text{cm}$	0.33 – 0.39 $\text{cm}^{-1}$
High	70 to 200,000 $\mu\text{S}/\text{cm}$	4.4 – 5.8 $\text{cm}^{-1}$

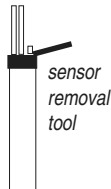
## SENSOR INSTALLATION

The MP TROLL 9000 may be shipped with a conductivity sensor already installed in port P4, as shown on the drawing below. If installation is necessary, unpack and install the conductivity sensor in port P4 as follows.



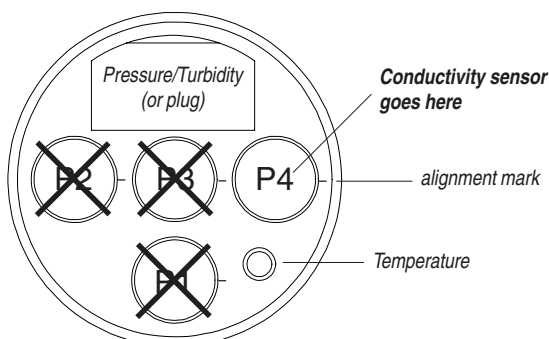
*The conductivity sensor will function properly only when installed in **port P4**.*

1. Remove the restrictor from the front end of the MP TROLL 9000. 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 P4, 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 deployment.

### 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 $\mu\text{S}/\text{cm}$ solution
Fresh to brackish water	1,412 $\mu\text{S}/\text{cm}$ solution
Brackish water	12,890 $\mu\text{S}/\text{cm}$ solution
Sea water	58,670 $\mu\text{S}/\text{cm}$ solution

The standard conductivity calibration kit includes a quart each of 147  $\mu\text{S}/\text{cm}$ , 1,412  $\mu\text{S}/\text{cm}$ , 12,890  $\mu\text{S}/\text{cm}$  and deionized water.

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  $\mu\text{S}/\text{cm}$  solution should be refrigerated.*

### Calibrating with Other Solutions

A custom solution may be used if its specific conductance value (in  $\mu\text{S}/\text{cm}$ ) 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  $\mu\text{S}/\text{cm}$ ), 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 9000.

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 9000 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.



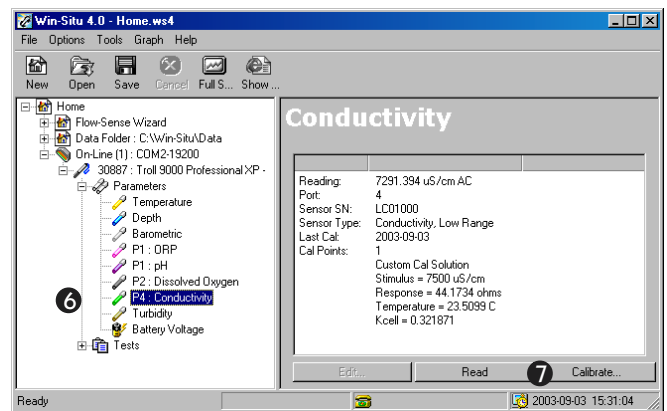
4. Connect the MP TROLL 9000 to a PC and establish a connection in Win-Situ or Pocket-Situ. Win-Situ screens are illustrated here.

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 9000 in the Navigation tree.

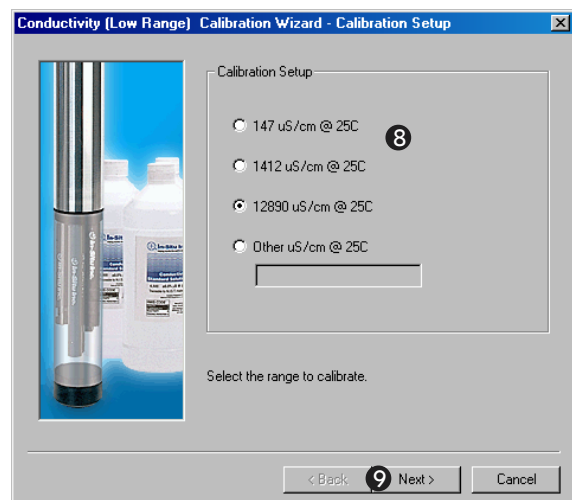
The software will detect and display the installed sensors. If any sensor is installed in the wrong port, an error message will be displayed. Simply remove the sensor and install it in the correct position, then “refresh” the device before continuing.

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)

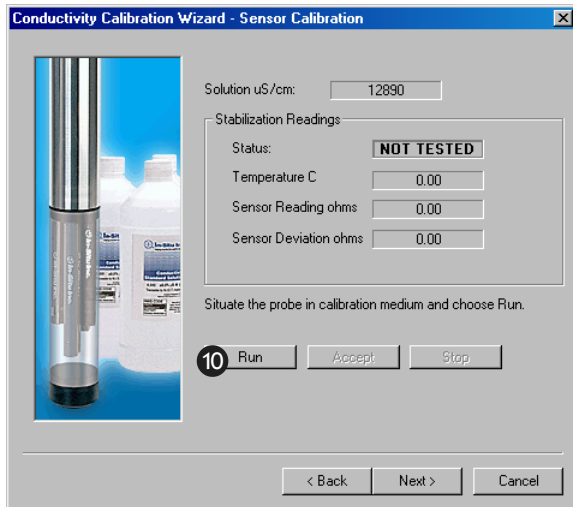


8. Select the calibration solution the sensor is soaking in.

For a custom solution, select **Other** and enter the Specific Conductance of the solution (conductivity corrected to 25°C) in  $\mu\text{S}/\text{cm}$ .

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.

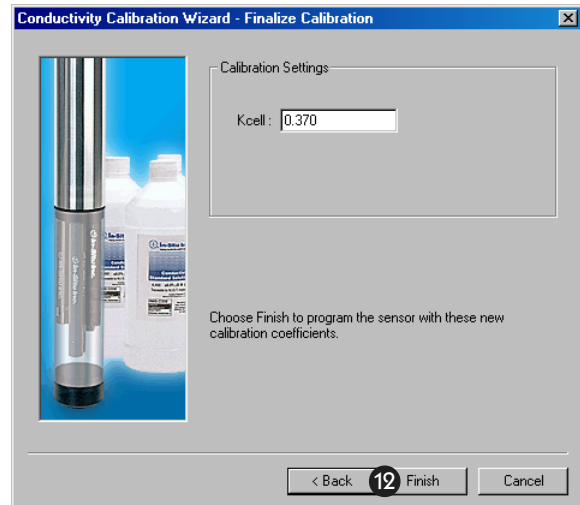
**NOMINAL** indicates the sensor deviation meets early stabilization criteria.

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	0.33 – 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 until deployment:

- If the instrument will be deployed in a day or so, leave all the sensors installed in the MP TROLL 9000. 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 9000, 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 or Pocket-Situ.
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 ( $\mu\text{S}/\text{cm}$  AC)  
milliSiemens per centimeter ( $\text{mS}/\text{cm}$  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  $\mu\text{S}/\text{cm}$

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 <sub>2</sub> SO <sub>4</sub>	0.96
10% HCl	1.32
5% NaOH	1.7
Dilute NH <sub>3</sub>	1.88
KCl salt (default)	1.91
NaCl salt	2.12
98% H <sub>2</sub> SO <sub>4</sub>	2.84
Ultrapure water	4.55
Sugar solution	5.64

Units: microSiemens per centimeter ( $\mu\text{S}/\text{cm}$  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.

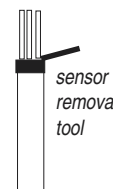
**DEPLOYMENT RECOMMENDATIONS AND CAUTIONS****CONDUCTIVITY AND TEMPERATURE**

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**

Clesceri, L.S., A.E. Greenberg, and A.D. Eaton, eds., *Standard Methods for the Examination of Water and Wastewater*, 20th edition, Washington, D.C.: American Public Health Association, American Water Works Association, and Water Environment Federation, 1998. 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

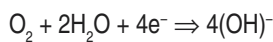
\* representative of solute concentration

## POLAROGRAPHIC MEASUREMENT OF DISSOLVED OXYGEN

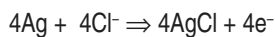
### THE POLAROGRAPHIC DISSOLVED OXYGEN SENSOR

#### 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:



while silver is oxidized at the anode:



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 P2, 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 9000 may be shipped with a polarographic D.O. sensor installed in port P2. 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

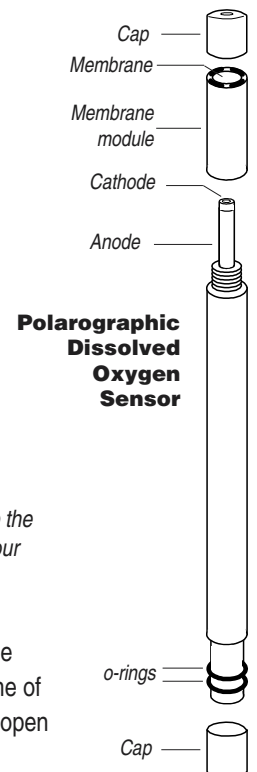
New sensors are shipped with a dry membrane module loosely attached.

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.

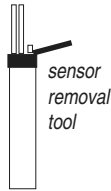
### INSTALL THE SENSOR IN THE MP TROLL 9000



*The polarographic D.O. sensor will function properly only when installed in **port P2**.*

1. Remove the restrictor or Cal Cup from the front end of the MP TROLL 9000. This allows access to the sensor block shown in the drawing below.

2. Remove any moisture or dirt from the area around port P2, then use the sensor removal tool to remove the plug or sensor from port P2. 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.



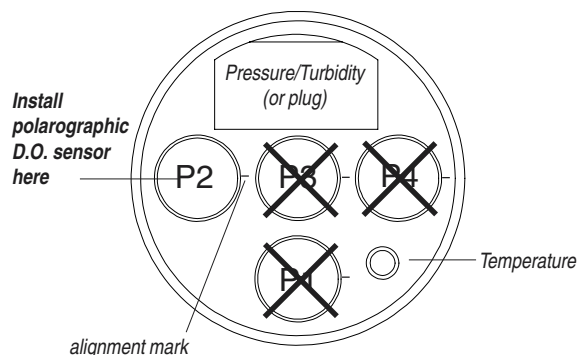
*TIP: The sensor o-rings require generous lubrication before installation. New sensors will be lubricated at the factory. If the o-rings appear dry, apply a silicone lubricant before installation.*

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.

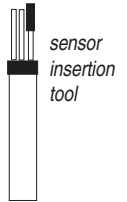


*Avoid touching the membrane at the tip of the sensor. Contaminants on the membrane can change its properties and affect measurements.*

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 9000 to a PC and establish a connection in Win-Situ or Pocket-Situ.
3. Select the MP TROLL 9000 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,



#### **I did a Quick Cal. Why should I recalibrate D.O.?**



*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.*

- when deploying the sensor at an elevation different from that at which it was last calibrated.

#### 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 9000 for water or air calibration as described 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 9000 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 9000.



**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 9000 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 9000 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 9000 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 9000. 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 9000 in this inverted position.

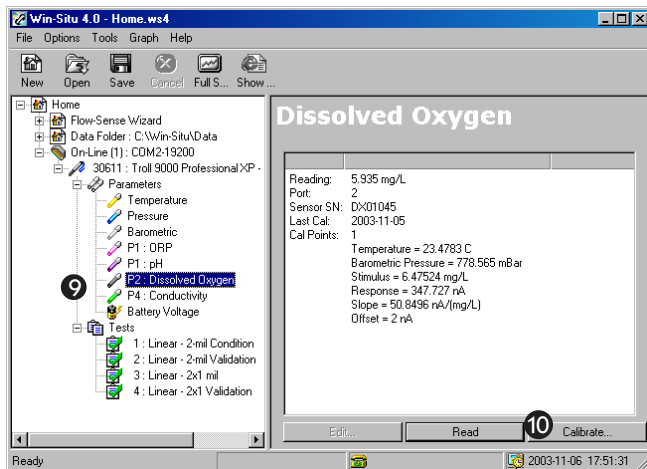


Allow a few minutes for the temperature to stabilize, especially if you plan to enter a temperature dependent value from a look-up table.

7. If not already connected, connect the MP TROLL 9000 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 9000 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.

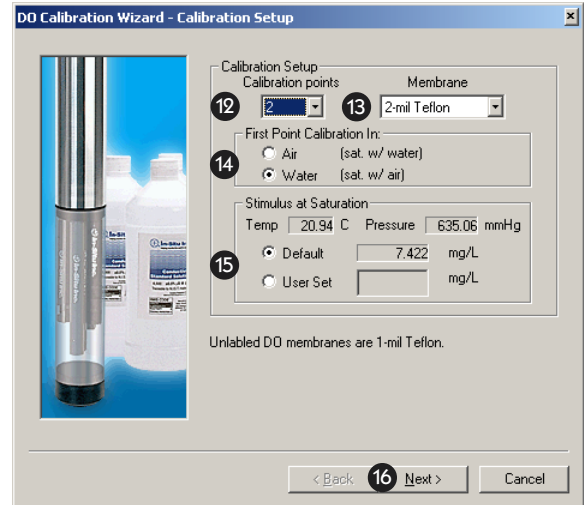


10. Select **Calibrate**.

11. Before the DO Calibration Wizard starts, you will be asked how you want to handle barometric pressure. Cable venting is essential to obtain accurate measurement, and the software cannot tell if this cable is vented, so please take a moment to supply this information. Do one of the following:

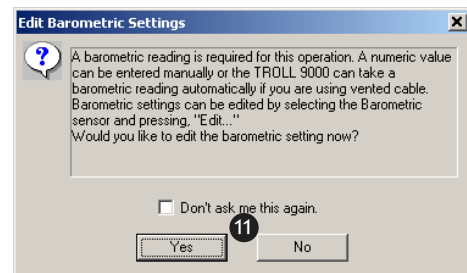
- If the TROLL 9000 is on vented cable now and will be deployed on vented cable, click No — and you may want to check the “Don’t ask me this again” box.
- If the device is on vented cable now but will be deployed on non-vented cable, click Yes. In the Edit Barometric Channel screen, check the box indicating non-vented cable for deployment but vented cable for calibration/programming.

After dealing with barometric pressure the D.O. Calibration Wizard displays a screen like the one below:



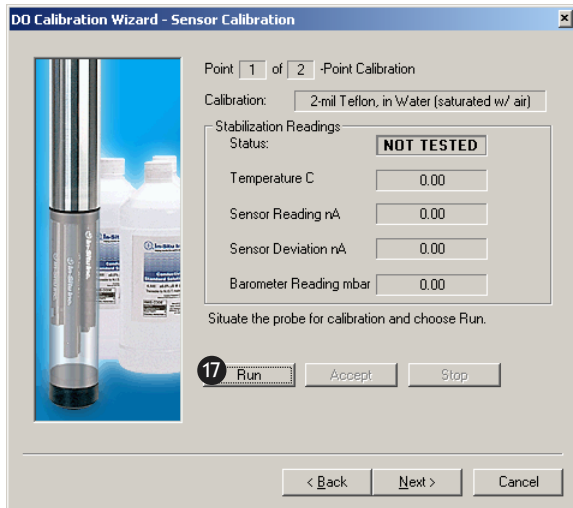
12. Select the number of calibration points.
  - 1 point—100% D.O.
  - 2 points—100% and 0% D.O.
13. Select the membrane type (stamped on membrane module, if not, it’s 1-mil Teflon). If calibrating in water, the membrane thickness is not crucial. When calibrating in air, be sure the correct membrane 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.

- If the device is on non-vented cable now and will be deployed on non-vented cable, click Yes. In the Edit Barometric Channel screen, check the box indicating non-vented cable for deployment 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.

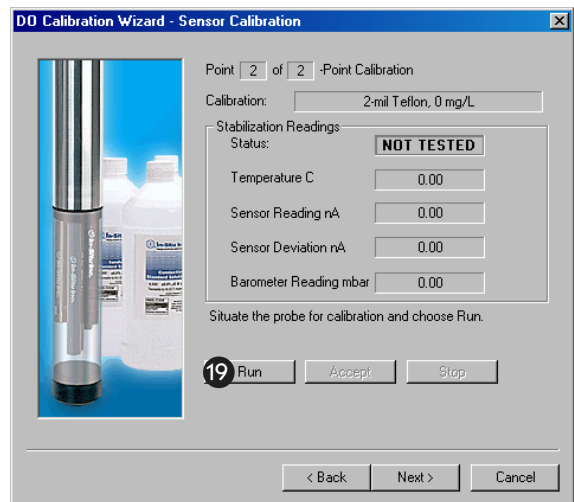


**TIP:** If the calibration stimulus was entered from a look-up table at step 15 and the temperature is not as expected, you may select Stop, then Back to retrieve the Setup page and re-enter the User Set stimulus.

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.



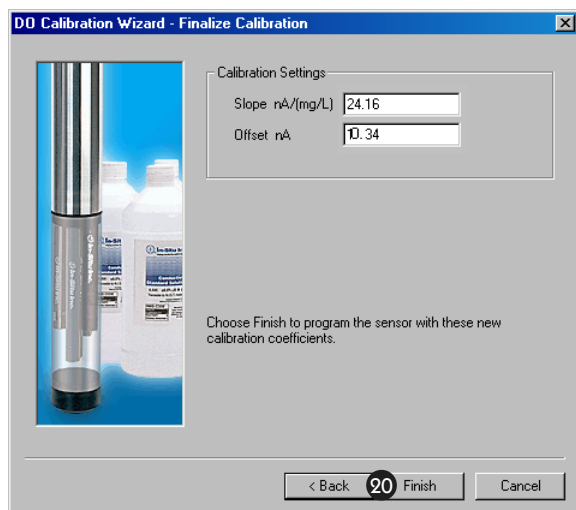
Allow about 15 minutes for the sensor to stabilize in the medium.

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 to use.



**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 until deployment:

We recommend you leave the D.O. sensor installed in the instrument until deployment; 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 ( $\mu\text{g/L}$ ).
- Oxygen concentration in microMolar ( $\mu\text{mol/L}$ ), =  $\text{mg/L} \times 31.25$
- 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 9000’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.

## DEPLOYMENT 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 9000 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 deploy the instrument in the mountains, you should perform a recalibration at the new altitude.

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 until deployment. This takes full advantage of the conditioning and polarization that was accomplished during calibration. After replacing the TROLL 9000 batteries, be sure to power the sensor for an hour or two before use, especially if the batteries were out for a while.

During long-term monitoring, some drift is to be expected during the first day after initial deployment. 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 deployed from 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.



**When do I need to stir and when can I skip it?**



Use a stirrer for best results

- when measuring D.O. in long-term tests,
- when measuring D.O. in 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 before deployment as follows:

1. Remove the nose cone from the MP TROLL 9000 and set it aside.
2. Screw the top of the stirrer (propeller end) to the stainless steel restrictor in place of the nose cone.

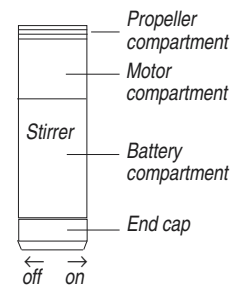


### Starting the Stirrer

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.

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



**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.

## SENSOR CARE AND HANDLING

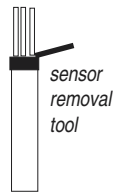
The D.O. sensor kit includes the following items for routine maintenance of the D.O. sensor:

- 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.

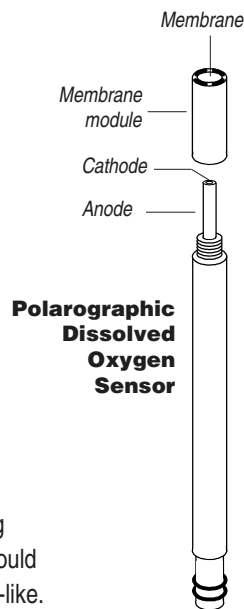
- Check for discoloration of the electrodes due to silver chloride (AgCl) deposition.
- Inspect the membrane for integrity of the surface, for the presence of algal growth or other contaminants, for crystallization that may indicate a leak in the membrane, and to ensure no air bubbles are trapped under 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.



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, and also after a long-term deployment.

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 P2 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 "Filling the Membrane Module" earlier in this section.
4. Install and condition the sensor. Refer to "Conditioning a Newly Installed Sensor" earlier in this section.



*Remember to condition the sensor for at least 2 hours, preferably 10 hours, before re-calibrating 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, when the slope and offset calculated during calibration change dramatically, and after a long-term deployment.

## 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, and A.E. Greenberg, eds., *Standard Methods for the Examination of Water and Wastewater*, 19th edition, Washington, D.C.: American Public Health Association, American Water Works Association, and Water Environment Federation, 1995. 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 OPTICAL DISSOLVED OXYGEN SENSOR

#### THEORY OF OPERATION

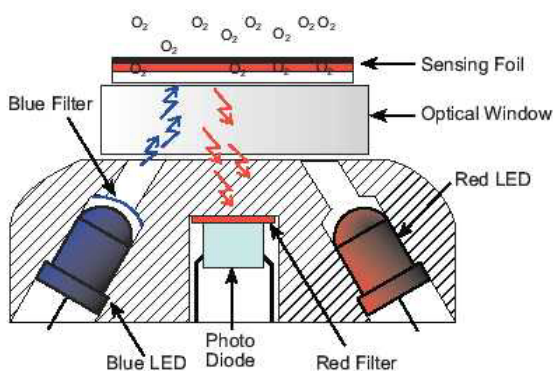
The RDO Optical Dissolved Oxygen sensor measures dissolved oxygen using the principle of “dynamic luminescence quenching.”

Certain molecules, called “luminophores,” fluoresce when excited by light of a specific wavelength. Oxygen molecules act as dynamic fluorescence quenchers.

The luminophores in the sensor are embedded in a gas-permeable sensing foil, which is protected by a gas-permeable black optical isolation coating.

In addition to the foil, the sensor contains a blue LED, a photodetector, and a DSP (Digital Signal Processor) chip. 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 photo diode. The LED is pulsed (on-time is approximately 200 msec) and the phase difference between the blue excitation light and the returned red light is measured by the DSP. The result is used to compute dissolved oxygen.

The amount of red light could be measured, but its intensity is affected by photo bleaching of the foil and other factors. A more reliable method is to measure the “phase” (or delay) of the returned signal. This measurement method is thus based on the “lifetime” rather than the “intensity” of the fluorescence.




#### COMPARISON TO POLAROGRAPHIC D.O. SENSOR

The RDO Optical Dissolved Oxygen sensor has 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 D.O. It does not require conditioning before use or hydration when not in 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 single replaceable item (sensing foil) could last up to five years if not damaged.

#### SENSOR INSTALLATION

You will need—

- Multi-Parameter TROLL 9000 instrument. Options:
  - 2-battery body (47.3 cm, 18.6 in long), hardware version 3.0 or greater, with lithium D batteries (packaged separately)
- 

*Use only the lithium batteries sold by In-Situ. Use of any other lithium battery will void the warranty of the RDO sensor and the TROLL 9000.*
- 4-battery body (59.5 cm, 23.45 in long), hardware version 3.0 or greater, with 4 fresh alkaline batteries or external power
- Latest version of MP TROLL 9000 firmware—this comes loaded in a new instrument, or is available with download of new software on the In-Situ website at [www.In-Situ.com](http://www.In-Situ.com)
- RDO sensor package, with
  - flow restrictor
  - nose cone
  - installation adapter plate
  - rigid sensor cable harness with adapter board firmware
- Latest version of Win-Situ / Pocket-Situ software—this is shipped on a CD with a new MP TROLL 9000, or is available from the In-Situ website at [www.In-Situ.com](http://www.In-Situ.com)
- Communication cable
- Desktop/laptop PC or PDA
- A reliable power supply, dependent on model of MP TROLL 9000 (see options listed above)

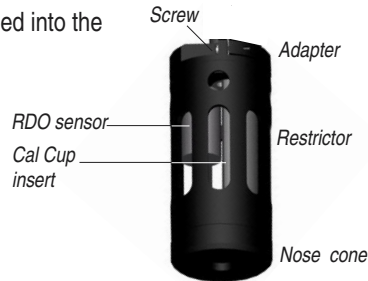
**UNPACK THE RDO SENSOR**

The sensor is shipped in a 3-part Adapter/Restrictor/Nose cone assembly.

1. Remove the nose cone, pull out the packaging and the soft Cal Cup insert, unscrew the restrictor from the adapter. The RDO sensor is installed in the adapter with its cable coiled into the restrictor.

The soft Cal Cup insert enables calibration of the Basic sensors when the RDO sensor is installed in the unit (the standard Cal Cup will not fit). 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

**PREPARE THE MP TROLL 9000**

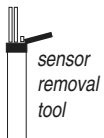
2. If using lithium batteries, install them in the MP TROLL 9000 following the instructions shipped with the batteries.



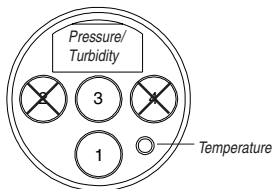
*Please exercise great care in handling, installing, deploying, and shipping lithium batteries. Refer to the instructions, cautions and MSDS packed with the batteries.*

3. Remove the stainless steel restrictor or standard Cal Cup from the MP TROLL 9000 (if attached). This allows access to the sensor block with its four sensor ports.

4. Use the sensor removal tool to remove the plug or sensor from port 1 or 3 for installation of the RDO sensor. 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).



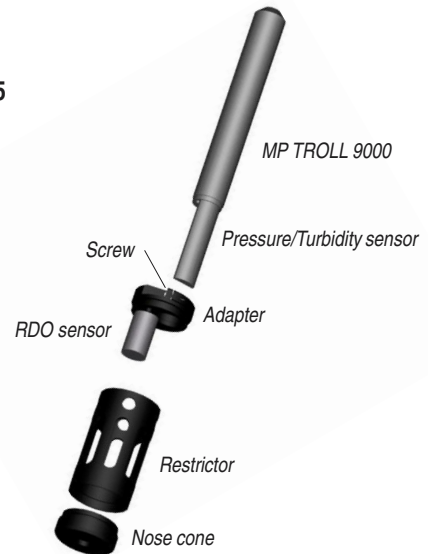
End view of sensor block

**Step 3**

Remove standard Cal Cup or restrictor

**ATTACH THE RDO SENSOR TO THE TROLL 9000**

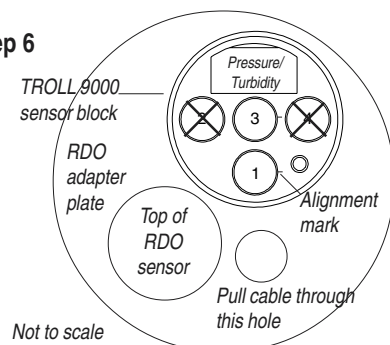
5. Insert the front end of the MP TROLL 9000 through the large hole in the adapter, alongside the RDO sensor.

**Step 5**

6. 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.

7. Tighten the adapter screw with a Phillips head screwdriver, not overly tight.
8. Feed the short black cable up through the open hole, so it is on the same side of the adapter plate as the TROLL 9000 sensor block (refer to the drawing below).

9. 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.

**Step 6**

Not to scale

10. 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.
11. Rotate the RDO sensor slightly as needed so that the optical window area is facing outward (away from the other sensors).



**TIP:** When a turbidity wiper is installed, be sure to pull the slack in the RDO adapter cable back against the TROLL 9000 body so it will not interfere with the wiper's rotation.

The RDO sensor is now installed and ready to calibrate.



**TIP:** New RDO sensors have been factory-calibrated at 0% and 100% dissolved oxygen. A field calibration at oxygen saturation (100%) should be done on a new sensor. For best results, a 0% calibration is also recommended.

For field deployment, attach the black flow restrictor to the adapter plate. The small holes in the restrictor face toward the MP TROLL 9000 body. The optional nose cone is recommended for sensor protection and when measuring turbidity.

When properly assembled to the TROLL 9000, the RDO sensor looks like this:



## CALIBRATION

### OVERVIEW

Calibration of the RDO Optical Dissolved Oxygen sensor has two parts:

- **Foil Coefficients:** Twenty constants (“coefficients”) unique to each batch of sensing foil describe the sensor’s behavior with respect to oxygen concentration and temperature. These coefficients are pre-loaded in a new sensor and *need to be changed only when the foil is changed*. Since changing the foil is not expected to be a frequent occurrence, this aspect of the calibration is deferred to the end of this chapter; see the section “[Sensor Care & Handling](#).”
- **Calibration Constants:** The sensor in combination with the sensing foil has four calibration constants (called “phase coefficients”) that are automatically calculated when a two-point calibration is performed using two controlled oxygen concentrations. These phase coefficients are stored in the sensor. After changing or moving the foil a new calibration must be performed to obtain the best accuracy.

### 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. For more on calibration reports, see Section 10 of this manual.

### CALIBRATION SOLUTIONS

**100% D.O.** calibration is performed in water saturated with air. We recommend a container of clean water aerated with In-Situ’s bubbler accessory or an aquarium pump.

**0% D.O.** calibration is performed in an oxygen-depleted solution. Sodium sulfite ( $\text{Na}_2\text{SO}_3$ ) 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 D.O. sensors, since the sensor does not drift appreciably and is not affected by fouling (except biofouling from organisms that generate or consume oxygen). If the foil is not mechanically damaged or moved, calibration can last a year or more.



**TIP:** For best results, recalibrate the RDO Optical DO sensor once a year.



**Why is there no Quick Cal option for the RDO Optical D.O. sensor ?**



*Quick Cal 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 presents the operator with a simple and potentially less accurate means to calibrate the sensor but in so doing 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.*

*Because the RDO Optical D.O. sensor does not appreciably drift during long-term applications in media void of bio-fouling, there is nothing to be gained from a Quick Cal. A traditional two-point laboratory calibration once a year will result in long-term accurate measurements. If biofouling is detected, thorough cleaning and subsequent calibration may need to be done more frequently.*



## TRADITIONAL TWO-POINT CALIBRATION

The optical D.O. sensor should be calibrated under stable and controlled conditions, such as are found in a laboratory setting.

One or both calibration points can be taken, in any order. If only one point is taken, the software retains 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 D.O. values (< 5 mg/L),
- when required by Standard Operating Procedures,
- after replacing the sensing foil,
- once a year if the sensing foil has not been replaced.

## OXYGEN SATURATION POINT

1. Submerge the RDO sensor in a container of clean water aerated with an aquarium pump or In-Situ's bubbler accessory. Insure the sensor is completely submerged.



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 MP TROLL 9000 to a PC and establish a connection in Win-Situ or Pocket-Situ. Win-Situ screens are illustrated here.



**TIP:** To see all of the information pane, you can click the "Full Screen" button on the Win-Situ toolbar.

Full Screen button

Information on the sensing foil

Device clock

Rugged Dissolved Oxygen	
Reading:	1
Port:	0D00387
Sensor SN:	3830
Sensor Model #:	2.71
Sensor Firmware Ver #:	1.05
Adapter Firmware Ver #:	2004-04-06
Last Cal:	2004-04-06
Saturation Point:	Optical Phase = 29.41 degrees Temperature = 21.12 C Barometric Pressure = 777.79 mBar Optical Phase = 62.13 degrees Temperature = 23.79 C
Zero Point:	
Calibrated Phase Coefficients:	{ 1.61084e+000, 9.58769e-001, 0.00000e+000, 0.00000e+000 }
Temperature Coefficients:	{ 1.95846e+001, -3.02596e-002, 2.89032e-006, -4.16826e-009 }
Foil Batch #:	3603
Foil Change Date:	2004-04-12
Foil Coefficients:	{ 3.89181e+003, -1.06834e+002, 1.12691e+000, 6.65855e-004 }
Coeff0	{ -2.38473e+002, 4.89671e+000, -2.58107e-003, -9.13882e-004 }
Coeff1	{ 6.01084e+000, -8.04611e-002, -1.50365e-003, 4.34436e-005 }
Coeff2	{ -7.15784e-002, 5.00751e-004, 3.40246e-005, -7.24466e-007 }
Coeff3	{ 3.28363e-004, -3.36700e-007, -2.21716e-007, 4.16159e-009 }
Coeff4	

The Pocket-Situ interface is similar, with the Navigation tree at the top and the Information pane below it.

3. Select the MP TROLL 9000 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**.

A screen like this will be shown for the Oxygen Saturation point.



6. When the sensor is situated in the calibration medium for Oxygen Saturation, click or tap **Run**.

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 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 in degrees C, and RDO sensor response in degrees of phase angle. 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 millibars.
7. 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 8 on this page.
- Select **Next**, then **Next** again to finalize the calibration if you are performing a one-point calibration. Go to step 11.
- Select **Run** to run the oxygen saturation point again if the temperature did not appear stable, or you believe the sensor values did not “bottom out.” Go back to step 6.

### ZERO OXYGEN POINT

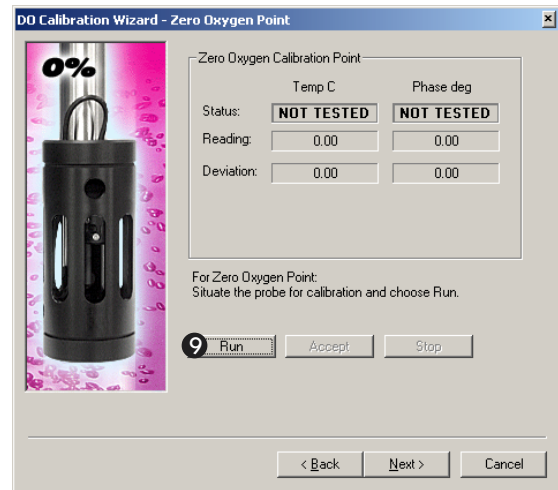
8. Immerse the RDO sensor in an oxygen-depleted medium:

- Sodium sulfite ( $\text{Na}_2\text{SO}_3$ ) 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. A titanium sensor will reach equilibration before an acetal sensor.

9. 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 Oxygen Saturation calibration point (step 6).

10. When readings have stabilized, the screen will appear similar to the one shown in step 7, and you have several choices:

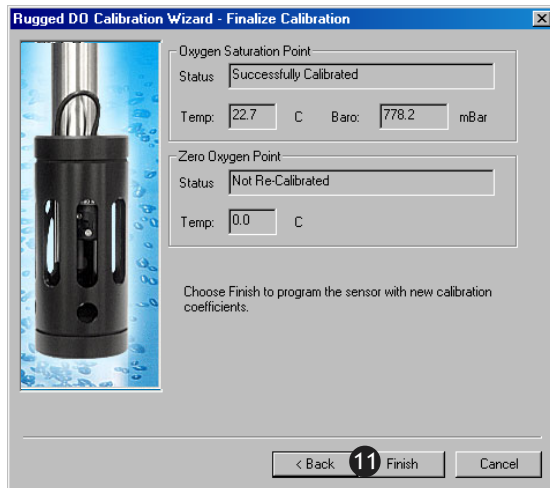
- Select **Next** to finalize the calibration. Continue with step 11.
- Select **Back** to calibrate the Oxygen Saturation point. Return to step 6.



**TIP:** Sodium sulfite consumes oxygen aggressively. If performing the oxygen saturation point next, be sure to rinse the TROLL 9000 and RDO sensor **thoroughly** to avoid cross-contamination.

- Select **Run** to run the zero oxygen point again if the temperature did not appear stable, or you believe the sensor values did not “bottom out.” Go back to step 9.

11. The final calibration screen is shown below. In this case, a one-point calibration at saturation was performed. To finalize the calibration click **Finish**.



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.



**TIP:** Rinse the sensor and front end of the instrument **very** thoroughly after calibrating in sodium sulfite solution to avoid cross-contamination.

The solution may be poured back into the bottle, tightly capped, and reused.

If you suspect the power of the sodium sulfite is beginning to deteriorate, note the phase degrees calculated during a zero-point calibration. If this number changes significantly on your next calibration, then the solution is probably old and weak, and should be replaced.

### DEGREES OF PHASE ANGLE

The phase (degrees) values calculated during calibration of the RDO sensor can be expected to fall within these ranges:

Oxygen Saturation	25 – 35 degrees
Zero Oxygen	50 – 70 degrees

### 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 ( $\mu\text{g/L}$ ).
- Oxygen concentration in microMolar ( $\mu\text{mol/L}$ ), =  $\text{mg/L} \times 31.25$
- 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 9000'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.

### DEPLOYMENT 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 9000 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 deploy the instrument in the mountains, you should perform a recalibration at the new altitude.

The bleaching effect of sunlight on the sensing foil is minimal with the opaque optical isolation layer. However, the frequent application of strong blue light will eventually have a bleaching effect on the foil. Therefore, the sampling interval should be set to the longest practicable interval while still capturing the necessary D.O. measurements. Laboratory tests have shown that the sensor can measure for more than a year at 2-second intervals, which translates to 5 years at 10-second intervals. Exposure to direct sunlight will also excite/bleach the foil over time but this effect is minimal with the protection provided by the opaque optical isolation layer.

The sensor exhibits a small linear pressure effect with increasing depth. It reads 1% lower for each 250 m of water depth. Since the maximum depth to which an MP TROLL 9000 can safely be submerged is 246 m (350 PSI = 246 m, 807 ft), this means that at 246 m you will have to multiply your readings by 1.01 to get the correct absolute values.

Please note that this compensation is not performed by the MP TROLL 9000, and the MP TROLL 9000 is depth limited by the PSI rating of the pressure sensor installed in the unit. Overall unit pressure rating without a pressure or turbidity sensor installed is 350 PSI (246 m, 807 ft).



- Wipe foil gently with a damp cloth or swab
- Clean body with a brush & clean water

### SENSOR CARE AND HANDLING

The RDO sensor requires very little maintenance. The only user-serviceable part of the sensor is the foil. The foil can last for up to five years if it is not damaged. The foil disc is protected by a robust black optical isolation coating. If it gets badly scratched (through cleaning or biofouling) it may need to be replaced.

### 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 from a month to a year depending on the required accuracy and the fouling condition at the site.

### CLEANING

Examine the visible area of the optical window—what you are seeing is the protective black optical isolation coating over the sensing foil. If it appears dirty, clean it as follows:

- Rinse with clean water from a squirt bottle or spray bottle.
- Or gently wipe with a clean wet cloth or cotton swab.
- If algal growth is present, clean gently with a soft brush.



**TIP:** Cleaning should be done with caution so that the protective coating is not removed. If badly damaged, the sensing foil should be replaced.

Calcareous fouling can normally be dissolved with household vinegar. If needed, remove the sensor from the MP TROLL 9000 and submerge it in vinegar overnight, or longer. If the marine growth remains, use clean cotton swabs to gently wipe it off after it has been softened by soaking in vinegar. After cleaning the sensor it should be thoroughly rinsed in clean tap water before storing or reuse.



**Do not use organic solvents (e.g., acetone, chloroform, toluene) since they will damage the foil.**

When cleaning, check to be sure the securing plate is firm and tight. If it is loose, and the foil has required heavy cleaning, it is prudent to remove the securing plate and clean the optical window. See instructions for replacing the sensing foil, below.

### FOIL CHECK

The foil may continue to work even when quite heavily damaged. As long as sufficient fluorophore remains on the foil the sensor will measure correctly. If heavily damaged, we recommend the following steps:

1. Recalibrate the sensor with a standard two-point calibration.
2. Check the sensor reading in an air-bubbled water solution.
  - a. If the sensor behaves normally (showing 100% saturation) the foil should function properly.
  - b. If the sensor is not reading 100% saturation, replace the foil, update the foil coefficients, and perform a new two-point calibration.

### REPLACING THE FOIL

1. Remove the two hex screws with the hex wrench supplied, remove the securing plate, and remove the sensing foil. It should not be necessary to remove the screws underneath the securing plate.
2. Check for foreign materials on the optical window, and clean it if necessary with a clean damp cloth or swab.
3. Center the new foil over the optical window, black side up. Replace the securing plate, and replace the hex screws. Be careful not to overtighten.
4. Update the foil coefficients, as described next.

### UPDATING THE FOIL COEFFICIENTS

It is very important to update the foil coefficients in the sensor after the sensing foil is changed. Win-Situ can do this automatically provided the manufacturing batch number of the foil is known. If the new foil is from the same batch as your previous foil, you do not need to change the coefficients, but a new two-point calibration should be done.

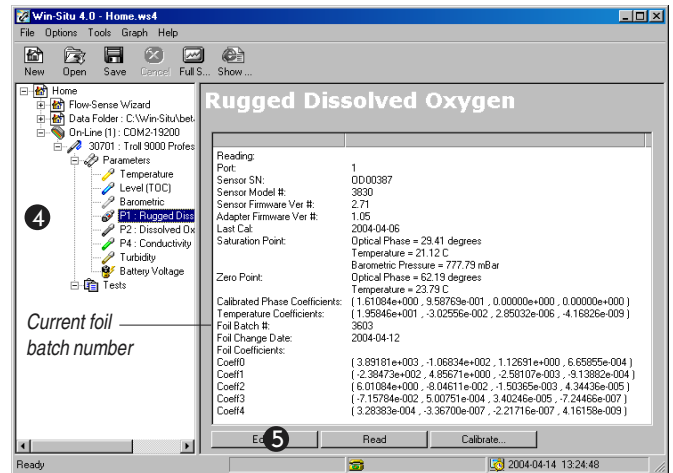


*Data collected when the wrong coefficients are loaded cannot be post-corrected.*



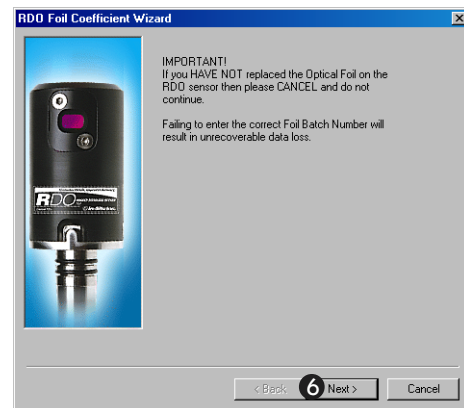
**TIP:** Before beginning the update procedure, locate the foil batch number in the sensing foil replacement kit. Also, ensure that you are using the latest release of Win-Situ (always available in the Download area of the In-Situ website at [www.In-Situ.com](http://www.In-Situ.com)).

1. Connect the MP TROLL 9000 to a PC and establish a connection in Win-Situ or Pocket-Situ.
3. Select the MP TROLL 9000 in the Navigation tree. The software will automatically detect and display the installed sensors.
4. Select Rugged Dissolved Oxygen in the Parameters list.



5. Select **Edit**.

An information screen like this will be displayed.

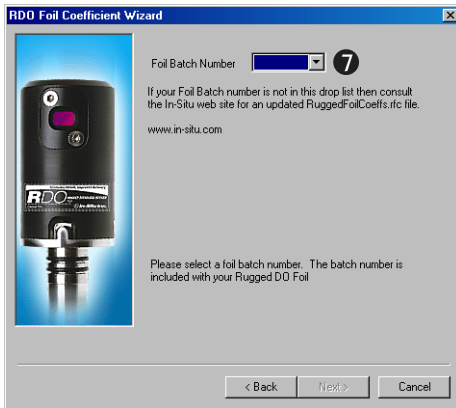


*If you have not replaced the sensing foil, or if the new foil is from the same batch as the previous foil, you do not need to edit the foil coefficients. Select Cancel.*

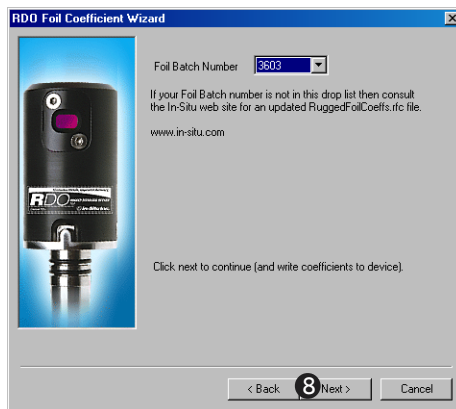
6. Do one of the following:
  - If you have not replaced the sensing foil, you do not need to edit the foil coefficients. Select **Cancel**.
  - If you know the batch number of the new foil, select **Next** and continue with step 7.

- If you do not know the batch number of the new foil, select **Cancel** and locate the batch number.

7. Select the foil batch number from the drop-down list.



8. After selecting the batch number . . .



. . . click **Next**.

9. In the Final screen, select **Finish** to update the foil coefficients. You also have the option to launch the calibration wizard after the coefficients are updated. **This choice is highly recommended.**



*Be sure to recalibrate the sensor after replacing the foil and updating the foil coefficients. If the new foil is from the same batch as the old foil, the coefficients do not need to be updated, but a new two-point calibration should be performed.*

**SPECIFICATIONS**

Wetted Materials	Acetal, Viton®, 316L stainless steel, PVC, polyurethane, titanium, Teflon®
Temperature Range	
Operating	0°C to 40°C (32°F to 104°F)
Transport	-40°C to 70°C (-40°F to 158°F)
Storage	Room temperature recommended
Measuring Range	0-20 mg/L
Resolution	0.01 mg/L
Accuracy	± 0.1 mg/L @ 0-10 mg/L ± 0.2 mg/L @ 10-20 mg/L

## Sensor response time to changing oxygen levels

	Oxygen level increasing	Oxygen level decreasing
T63	6 seconds	13 seconds
T90	16 seconds	45 seconds
T95	20 seconds	57 seconds

**Dimensions**

Sensor	36 mm (1.42 in) diameter, 86 mm (3.4 in) long
Adapter/Restrictor/Nose cone assembly	88.4 mm (3.48 in) diameter, 20.3 cm (8 in) long
MP TROLL 9000 with RDO installed	88.4 mm (3.48 in) diameter, 48.3 cm (19 in) long
MP TROLL 9000E with RDO installed	88.4 mm (3.48 in) diameter, 61 cm (24 in) long
Power Options	Lithium D cells (see lifetime estimates in the chart below) 4 alkaline D cells (estimated lifetime: 6 months) or 9 VDC external power using cable with external power jack
Recommended Calibration	
Frequency	2-point calibration annually
Life of Sensing Foil	5 years

Battery Life Estimates for MP TROLL 9000 (sensors: RDO, pressure, temperature, barometric pressure, pH, conductivity, turbidity [no wiper]), lithium batteries, various sampling intervals

Sampling Interval			Average Current	Battery Life		
seconds	minutes	hours	mA	hours	days	months
20			25	1050.00	43.73	1.46
30			17.67	1485.75	61.88	2.06
60	1		10.33	2540.25	105.83	3.53
120	2		6.67	3937.50	164.10	5.47
300	5		4.47	5877.00	244.88	8.16
600	10		3.73	7031.25	292.95	9.77
900	15		3.49	7524.00	313.50	10.44
1200	20		3.37	7797.00	324.90	10.83
1800	30		3.24	8091.00	337.13	11.24
3600	60	1	3.12	8407.50	350.33	11.68
7200	120	2	3.06	8575.50	357.30	11.91
14400	240	4	3.03	8661.75	360.90	12.03
21600	360	6	3.02	8691.00	362.10	12.07
28800	480	8	3.02	8706.00	362.70	12.09
43200	720	12	3.01	8720.25	363.38	12.11
86400	1440	24	3.01	8735.25	363.98	12.14

### RDO Optical Dissolved Oxygen Sensor Summary

- Provide sufficient power to the RDO sensor. Lithium D-size batteries are recommended.



*Please exercise great care in handling, deploying, and shipping lithium batteries. Refer to the instructions, cautions and MSDS packed with the batteries.*

- A yearly recalibration of the RDO sensor is recommended. Calibration is software-assisted. To do this, select the RDO sensor in the Navigation tree and click or tap **Calibrate**.
- The foil coefficients need to be updated only when the foil is changed. To change the coefficients, you will need to know the foil's batch number. Win-Situ can enter the coefficients automatically. To do this, select the RDO sensor in the Navigation tree and click or tap **Edit**. *Data collected when the wrong coefficients are loaded cannot be post-corrected.*
- Recalibrate the sensor after changing the sensing foil and updating the foil coefficients.
- Recalibrate the sensor if you move the foil.
- When measuring turbidity with RDO installed, be sure to use the wide black nose cone to control the ambient light.
- When a turbidity wiper is installed, be sure to pull the slack in the RDO adapter cable back against the TROLL 9000 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 Optical Dissolved Oxygen sensor will work properly only in port 1 or 3 of the MP TROLL 9000. 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, ORP) may be stored in the cal cup insert with a moist sponge 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 9000 Cal Cup with a moist sponge in the bottom.





## 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.

Typical ORP values

Fluid	ORP (mV)
Properly chlorinated swimming pool	> 700
Salt water aquarium	~ 350
Harmful to aquatic life	> 400

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<sub>3</sub>) to nitrites (NO<sub>2</sub><sup>-</sup>) and nitrates (NO<sub>3</sub><sup>-</sup>). Ammonia levels as low as 0.002 mg/l can be harmful to some fish species.

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<sub>2</sub><sup>+</sup>, Fe<sub>3</sub><sup>+</sup>) 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 ORP SENSOR

The operation of the ORP sensor is very similar to that of the pH sensor. A two-electrode system is used to make a potentiometric measurement. The ORP electrode serves as an electron donor or electron acceptor depending upon the test solution. A reference electrode is used to supply a constant stable output for comparison. Electrical contact is made with the solution using a saturated potassium chloride (KCl) solution. The electrode behavior is described by the Nernst equation:

$$E_m = E_o - (RT/nF) \ln \{ [ox] / [red] \}$$

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 the ORP sensor. The ORP sensor then gives a calibrated response in mV when placed in a sample.

## SENSOR INSTALLATION

The MP TROLL 9000 may be shipped with an ORP or combination pH/ORP sensor installed. If installation is necessary, unpack, pre-soak, and install the sensor in the MP TROLL 9000 as follows.



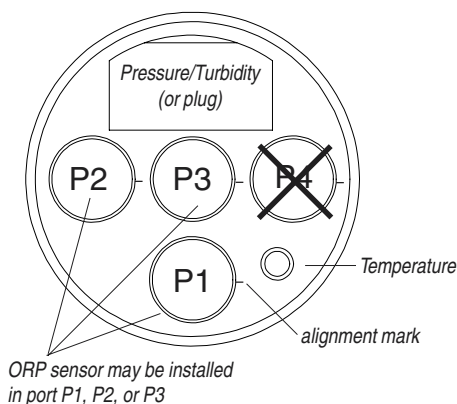
The combination pH/ORP sensor will work properly only in port P1. The ORP sensor may be installed in port P1, P2, or P3.



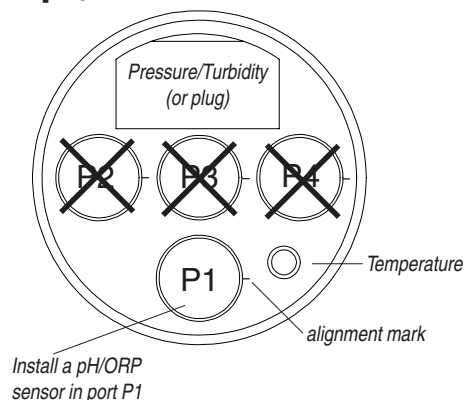
**TIP:** Remember that a polarographic D.O. sensor (if present) will operate properly only in P2, and a turbidity wiper accessory only in P3.

1. Remove the restrictor from the front end of the MP TROLL 9000. This allows access to the sensor block shown 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.

### ORP Sensor Positions

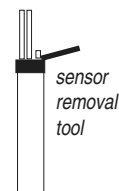


### pH/ORP Sensor Position



**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 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. Press the sensor firmly 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

A one-point calibration in a solution with a known potential at a given temperature is sufficient to calibrate the ORP sensor or the pH/ORP combination sensor. Several options are available for ORP calibration.

- **Quick Cal:** Calibrates all basic sensors (pH, ORP, DO, conductivity) at one time with one solution. ORP calibration is automatic.
- **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. 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 sensors are relatively new.

### 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

Only one solution is required for ORP calibration. ZoBell's solution is recommended and available from In-Situ Inc. for calibrating ORP.

The pH/ORP Calibration Kit includes solutions for calibrating both pH and ORP.



**TIP:** Most solutions are usable beyond their stated expiration date, depending on storage conditions; however, the results cannot be guaranteed. Store ZoBell's solution in accordance with recommendations on the bottle.

### Calibrating with Other Solutions

A custom solution may be used if its milliVolt value at the calibration temperature is known.

### RECOMMENDED CALIBRATION FREQUENCY

Your own experience is the best guide to how often the ORP 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."

### ORP QUICK CAL

The procedure to Quick Cal the ORP sensor, along with other sensors in the Basic Sensor Set, may be found in Section 3, Getting Started. The Quick Cal procedure produces excellent results for ORP so long as the solution is stored as recommended and used before its expiration date.

To perform a traditional calibration with a dedicated ORP calibration solution, use the following procedure.



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

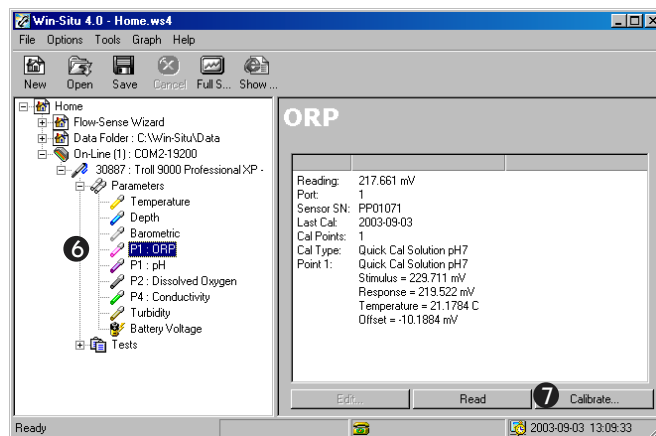
### TRADITIONAL ORP CALIBRATION PROCEDURE

1. With an ORP or combination pH/ORP sensor installed and plugs or sensors in the other ports, rinse the front end of the MP TROLL 9000 in clean water.
2. Insure the black PVC base is attached to the Cal Cup, and fill the Cal Cup to the line with the selected ORP calibration solution.
  - With a full complement of sensors installed, use the lower line as a guide.
  - With 1 or 2 sensors installed, fill to the upper line.
3. Insert the front end of the MP TROLL 9000 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.



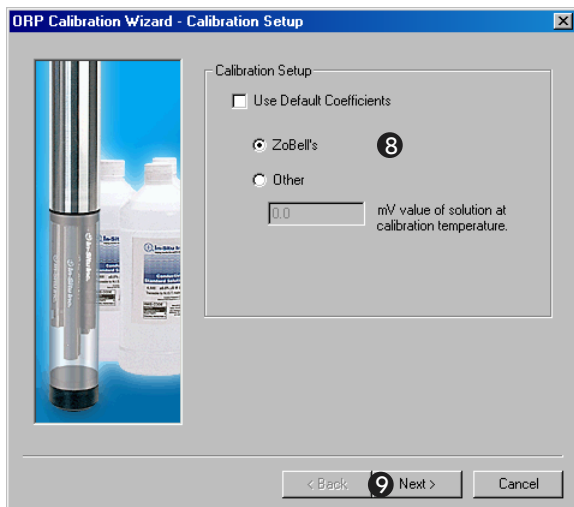
To stabilize the instrument, you may wish to use a calibration stand or other support.

4. Connect the MP TROLL 9000 to a PC and establish a connection in Win-Situ or Pocket-Situ. 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 9000 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 ORP in the Parameters list. The sensor serial number (SN) and recent calibration information is displayed.

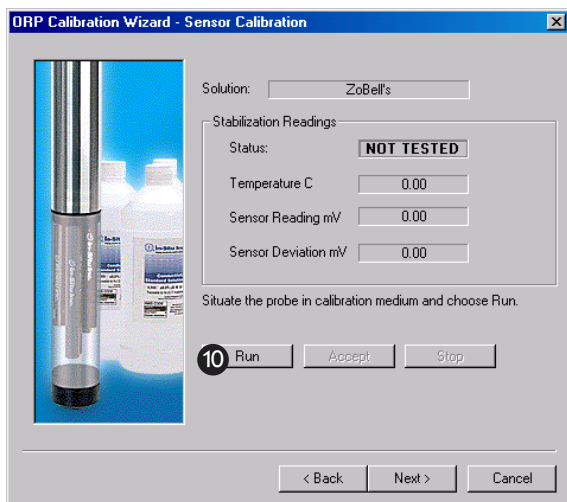


7. Select **Calibrate**.

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



8. Select the calibration 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.

- 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 is displayed for your information.
- Sensor Reading: The current sensor response in milliVolts.
- Sensor Deviation: Change in sensor response between the last two readings.



**TIP:** Most sensors stabilize within 1 to 3 minutes if the sensor is properly hydrated before calibration. To minimize stabilization times, do not handle the instrument during the time the sensor is taking readings in the solution.

11. The final screen shows the calculated sensor offset.



12. Select **Finish** to program the sensor with the newly calculated calibration coefficient.

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 until deployment:

- If the instrument will be deployed 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 of the Cal Cup, or add a little water (deionized, distilled, or tap)—just enough to create a moist environment. Return the probe to the Cal Cup for transport to the field site.
- For longer storage, remove the sensor from the instrument and place in the electrode storage bottle (located in the sensor kit) in the conditioning solution in which it was shipped, or with a sponge moistened with pH4 buffer to avoid depleting the reference solution. For longer-term storage, see the section on Sensor Care and Handling at the end of this chapter.

### RESETTING DEFAULT COEFFICIENTS

The sensor’s calibration may be reset back to factory defaults at any time. This option is most effective when the sensor is new.

1. With an ORP or combination pH/ORP sensor installed, establish a connection to the instrument in Win-Situ or Pocket-Situ.
2. Select ORP 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.

### UNITS AND CALCULATED MEASUREMENTS

Readings from the ORP channel may be displayed in Volts or millivolts. No calculated measurements are available.

#### Normalization to Standard Hydrogen Electrode Values

ORP values are dependent on solution composition, temperature, and the type of sensor used. 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 ( $\pm 50$  mV).

$$\text{ORP}_{\text{SHE}} = \text{ORP}_{\text{observed}} + \{215.81 - T_c * [0.77942 + T_c * 0.001934]\}$$

where

$\text{ORP}_{\text{SHE}}$  is the sample potential relative to the standard hydrogen electrode

$\text{ORP}_{\text{observed}}$  is the sample potential relative to the In-Situ reference electrode

$T_c$  is the sample temperature in  $^{\circ}\text{C}$

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 ORP sensor may give unstable readings in solutions containing chromous, vanadous, titanous, and other ions that are stronger reducing agents than hydrogen or platinum.

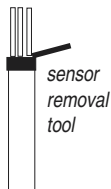
### DEPLOYMENT RECOMMENDATIONS AND CAUTIONS

- ORP calibration is not absolutely necessary if the sensor is in good working condition. If it is, then the sensor “deviation” reported during calibration is usually less than the sensor’s accuracy specification.
- 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,  $\text{H}^+$ .
- The pH/ORP sensor is designed for optimal operation at an angle of  $30^{\circ}$  or more from horizontal.
- The ORP sensor may be operated horizontally.

## 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

If the platinum band (ORP sensor) or button (combination pH/ORP sensor) appears dull or fouled, it may be cleaned with a swab dipped in alcohol. Rub gently until the platinum appears shiny.

### STORAGE

#### Short-Term Storage (up to a week)

Immerse the sensor tip in pH 4 buffer using the electrode storage bottle (located in the sensor kit). Tighten the cap to prevent drying. Alternatively, pH 7 buffer can be used for up to a few days.

#### Long-Term Storage (up to several weeks)

The electrode storage bottle should be moist with pH 4 buffer but not filled. Prior to use the sensor must be conditioned by rinsing with deionized water and subsequently soaked in pH 4 buffer for 1-2 hours.



**TIP:** If the MP TROLL 9000 was shipped with the sensor installed, you will find the electrode storage bottle in the sensor kit.

After long-term storage, be sure to recondition the sensor by rinsing in deionized water then soaking in pH 4 buffer for an hour or two.

### REFERENCES

Eaton, A.D., L.S. Clesceri, and A.E. Greenberg, eds., *Standard Methods for the Examination of Water and Wastewater*, 19th edition, Washington, D.C.: American Public Health Association, American Water Works Association, and Water Environment Federation, 1995. Section 2580, Oxidation-Reduction Potential.



# 15 AMMONIUM

## WHAT IS AMMONIUM ?

Ammonium ( $\text{NH}_4^+$ ) is the ionized form of ammonia ( $\text{NH}_3$ ). 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 ( $\text{NH}_3$ ) is highly toxic to aquatic life, while ammonium, the ionized form ( $\text{NH}_4^+$ ), 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 AMMONIUM SENSOR

The In-Situ sensor is an ion-selective electrode (ISE) that is selective for the ammonium ion ( $\text{NH}_4^+$ ). 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).

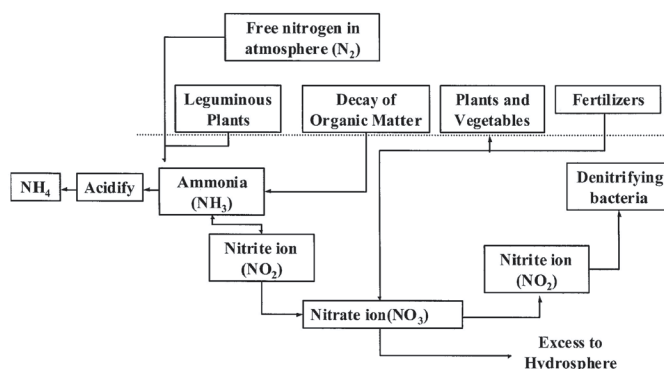
## SENSOR PREPARATION

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.

## THE NITROGEN CYCLE

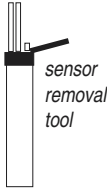


## SENSOR INSTALLATION

Unpack the ammonium sensor, hydrate it as above, and install in port P1, P2, or P3 in the sensor block at the front end of the MP TROLL 9000 as follows.



**TIP:** Remember that a polarographic D.O. sensor (if present) will operate properly only in P2 and a turbidity wiper accessory only in P3.

1. Remove the restrictor from the front end of the MP TROLL 9000. 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.

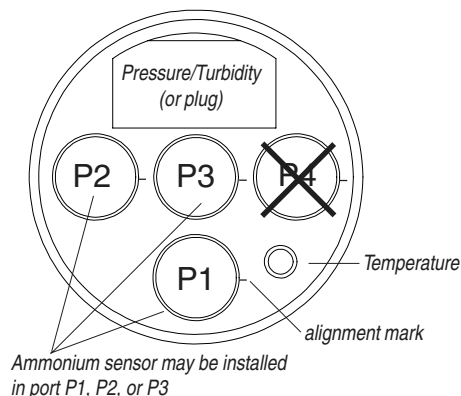


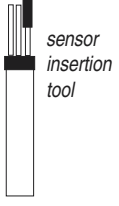
**TIP:** The sensor o-rings require generous lubrication before installation. New sensors will be lubricated at the factory. If the o-rings appear dry, apply a silicone lubricant before installation.

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 deployment 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 deployment 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 deployed. 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<sub>4</sub>Cl) 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 9000 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 during deployment—for example, if the instrument will be installed 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 9000 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 9000 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.

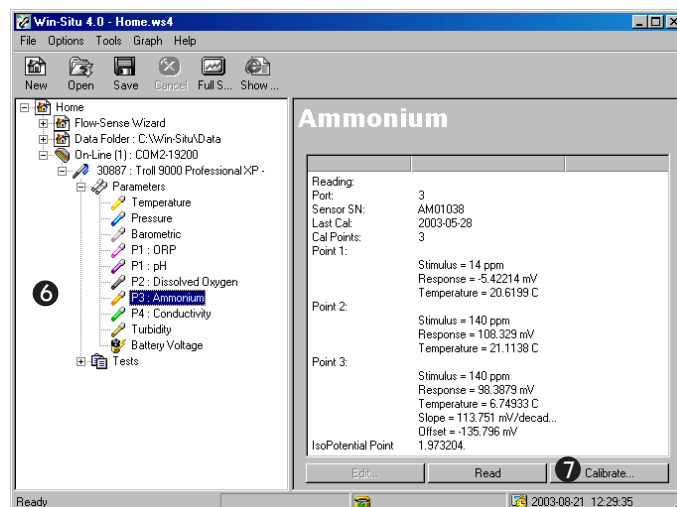
To stabilize the instrument, you may wish to use a calibration stand or other support.

4. Connect the MP TROLL 9000 to a PC and establish a connection in Win-Situ or Pocket-Situ. 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 9000 in the Navigation tree.

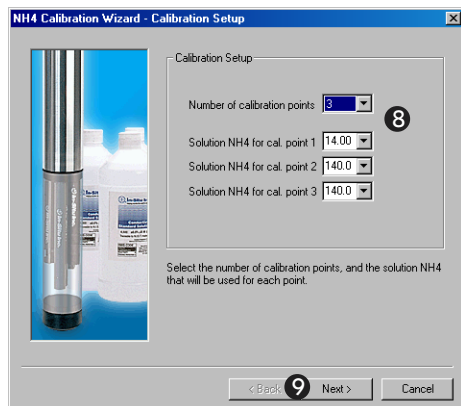
The software will automatically detect and display the installed sensors. If one or more sensors is installed in the wrong port, an error message will be displayed. Simply remove the sensor and install it in the correct position, then “refresh” the device before continuing.

6. Select Ammonium in the Parameters list. The sensor serial number (SN) and recent calibration information is displayed.



7. Select **Calibrate**.

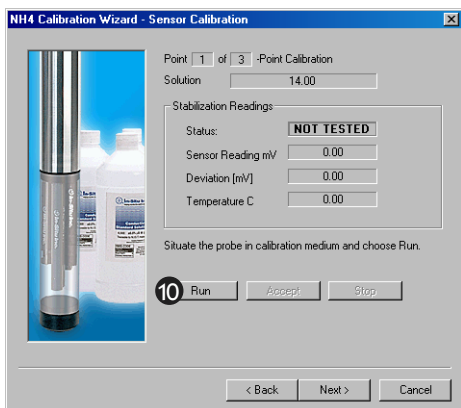
The Ammonium Calibration Wizard starts. A screen like this is displayed.



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).

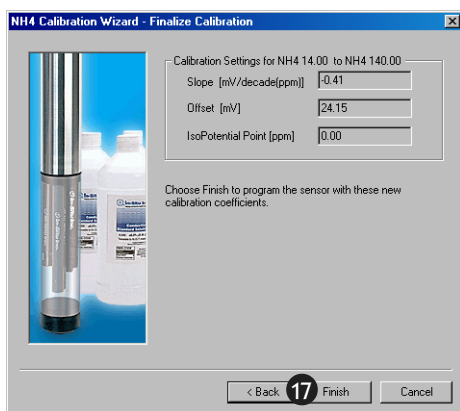
Again wait for Stable status (or click Accept when Nominal is indicated).

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 until deployment:

The ammonium sensor should be deployed as soon after calibration as possible. For storage, 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 ( $\pm 2$ ) 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.

#### DEPLOYMENT RECOMMENDATIONS AND CAUTIONS

Ammonium Sensor	
Operating Temperature	-5°C to 40°C (23°F to 104°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 deploy 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  $\mu\text{S}/\text{cm}$  or higher), the presence of interfering ions such as sodium or potassium may limit the usability of the ammonium sensor.

#### POTENTIAL INTERFERENCES

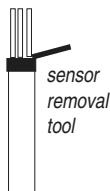
The following table lists concentrations of possible interfering ions that cause 10% error at various levels of  $\text{NH}_4^+$ .

Ion	100 ppm $\text{NH}_4^+$	10 ppm $\text{NH}_4^+$	1 ppm $\text{NH}_4^+$
Cs <sup>+</sup>	100	10	1
K <sup>+</sup>	270	27	2.7
Tl <sup>+</sup>	3100	310	31
H <sup>+</sup>	pH 1.6	pH 2.6	pH 3.6
Ag <sup>+</sup>	270,000	27,000	2700
Li <sup>+</sup>	35,000	3500	350
Na <sup>+</sup>	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

- Clesceri, L.S., A.E. Greenberg, and A.D. Eaton, eds., *Standard Methods for the Examination of Water and Wastewater*, 20th edition, Washington, D.C.: American Public Health Association, American Water Works Association, and Water Environment Federation, 1998. Section 4500-NH<sub>3</sub> 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](http://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 ( $\text{Cl}^-$ ) 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  $\text{Cl}^-$ . Some waters with as little as 250 ppm  $\text{Cl}^-$  will taste salty to sensitive individuals, especially if the sodium cation ( $\text{Na}^+$ ) 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  $\text{Cl}^-$  as a maximum for water used for irrigation, while 250 ppm  $\text{Cl}^-$  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 ( $\text{Cl}^-$ ). It is a double-junction combination ISE with a

Typical Chloride values

Fresh water	< 10 ppm $\text{Cl}^-$
Sea water	20,000 ppm $\text{Cl}^-$
Irrigation water standard (WHO)	100 ppm $\text{Cl}^-$
Drinking water standard (WHO)	250 ppm $\text{Cl}^-$

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  $\text{Cl}^-$ ).

### 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.

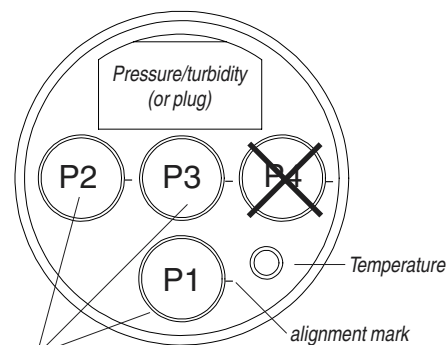
### SENSOR INSTALLATION

Unpack the chloride sensor, hydrate it as described above, and install in port P1, P2, or P3 in the sensor block at the front end of the MP TROLL 9000 as follows.



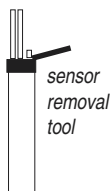
**TIP:** Remember that a polarographic D.O. sensor (if present) will operate properly only in P2, and a turbidity wiper accessory only in P3.

1. Remove the restrictor from the front end of the MP TROLL 9000. This allows access to the sensor block depicted in the drawing below.



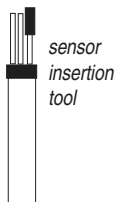
Chloride sensor may be installed in port P1, P2, or P3

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 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 deployment 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 deployment 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 deployed. 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<sub>4</sub>Cl) solutions certified to N.I.S.T. standards are supplied in the In-Situ Chloride Calibration Kits:

35.5 ppm Cl<sup>-</sup>  
 355 ppm Cl<sup>-</sup>  
 3545 ppm Cl<sup>-</sup>

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 9000 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 during deployment—for example, if the instrument will be installed 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 9000 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 9000 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.

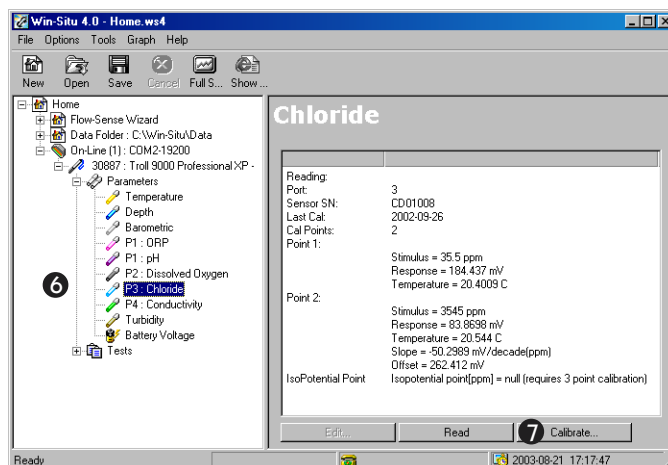
4. Connect the MP TROLL 9000 to a PC and establish a connection in Win-Situ or Pocket-Situ. Win-Situ screens are illustrated here. The Pocket-Situ interface is similar, with the Navigation tree at the top of the screen and the Information pane below it.

5. Select the MP TROLL 9000 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.

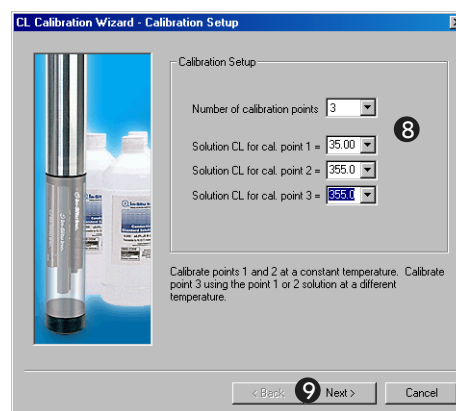


6. Select Chloride in the Parameters list. The sensor serial number (S/N) and recent calibration information is displayed.



7. Select **Calibrate**.

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

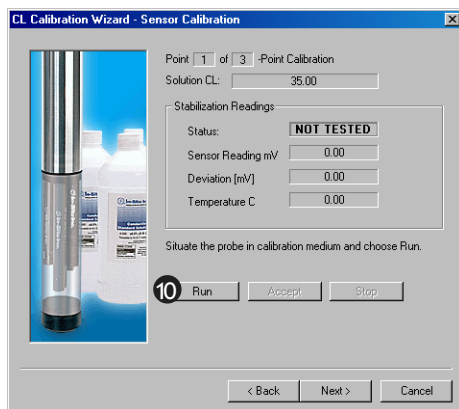


8. Select the number of calibration points for this calibration, and the concentration (ppm) of the calibration solution for each point.

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 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 to rinse the sensors 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).

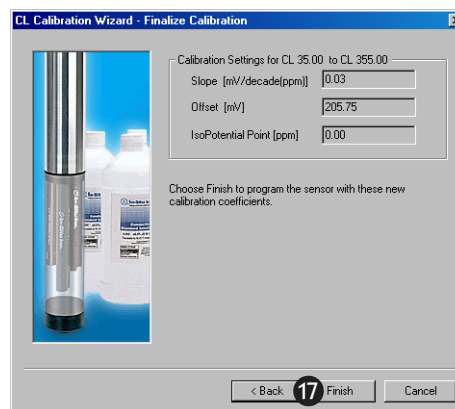
Again wait for Stable status (or click Accept when Nominal is indicated).

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 until deployment:

The chloride sensor should be deployed as soon after calibration as possible. For storage, 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 ( $\pm 2$ ) 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.

#### DEPLOYMENT 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

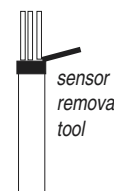
The table on this page lists possible interfering ions that cause 10% error at various levels of Cl<sup>-</sup>.

Ion	100 ppm Cl <sup>-</sup>	10 ppm Cl <sup>-</sup>	1 ppm Cl <sup>-</sup>
OH <sup>-</sup>	8000	800	80
NH <sub>3</sub>	12	1.2	0.12
S <sub>2</sub> O <sub>3</sub> <sup>2-</sup>	1	0.1	0.01
Br <sup>-</sup>	0.3	0.03	0.003
S <sup>2-</sup>	10 <sup>-4</sup>	10 <sup>-5</sup>	10 <sup>-6</sup>
I <sup>-</sup>	5x10 <sup>-5</sup>	5x10 <sup>-6</sup>	5x10 <sup>-7</sup>
CN <sup>-</sup>	2x10 <sup>-5</sup>	2x10 <sup>-6</sup>	2x10 <sup>-7</sup>
Complexes with Bi <sup>3+</sup> , Cd <sup>2+</sup> , Mn <sup>2+</sup> , Pb <sup>2+</sup> , Sn <sup>2+</sup> , Tl <sup>3+</sup> 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 ( $\text{NO}_3^-$ ) 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.

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.

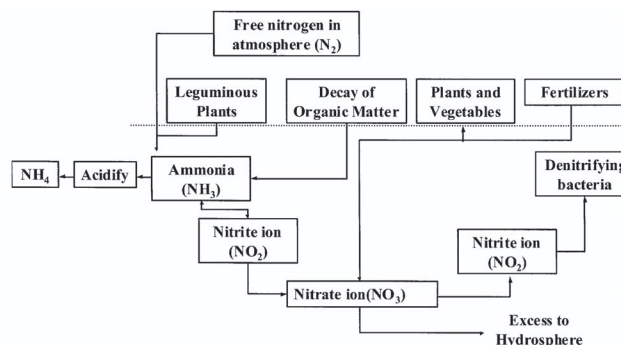
## THE NITRATE SENSOR

The In-Situ sensor is an ion-selective electrode (ISE) that is selective for the nitrate ion ( $\text{NO}_3^-$ ). 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).

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

## 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.

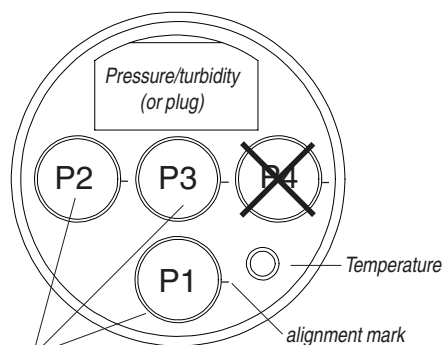
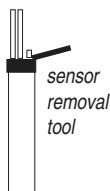
## SENSOR INSTALLATION

Unpack the nitrate sensor, hydrate it as above, and install in port P1, P2, or P3 in the sensor block at the front end of the MP TROLL 9000 as follows.



**TIP:** Remember that a polarographic D.O. sensor (if present) will operate properly only in P2, and a turbidity wiper accessory only in P3.

1. Remove the restrictor from the front end of the MP TROLL 9000. 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.



Nitrate sensor may be installed in port P1, P2, or P3

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



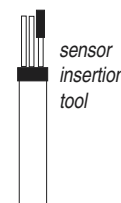
**TIP:** The sensor o-rings require generous lubrication before installation. New sensors will be lubricated at the factory. If the o-rings appear dry, apply a silicone lubricant before installation.

6. 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 deployment 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 deployment 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 deployed. 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 nitrate ( $\text{NaNO}_3$ ) 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 9000 with the hydrated nitrate sensor installed and sensors or 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 during deployment—for example, if the instrument will be installed 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 9000 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 9000 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.

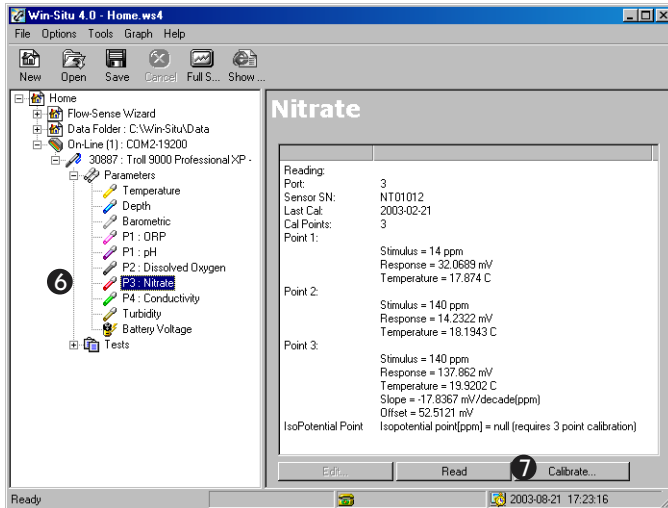
To stabilize the instrument, you may wish to use a calibration stand or other support.

4. Connect the MP TROLL 9000 to a PC and establish a connection in Win-Situ or Pocket-Situ. 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 9000 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.

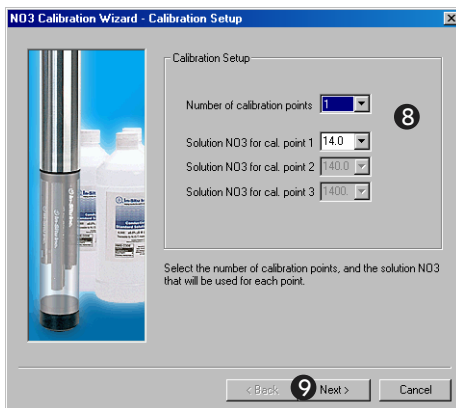


6. Select Nitrate in the Parameters list. The sensor serial number (SN) and recent calibration information is displayed.



7. Select **Calibrate**.

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

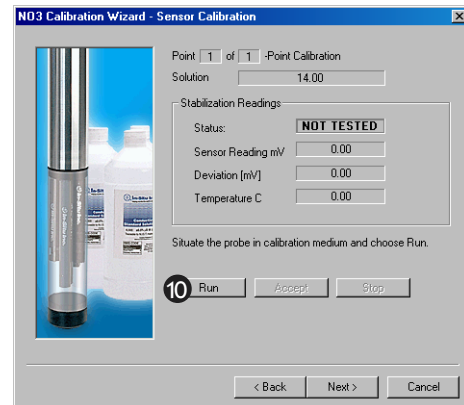


8. Select the number of calibration points for this calibration, and the concentration (ppm) of the calibration solution for each point.

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).

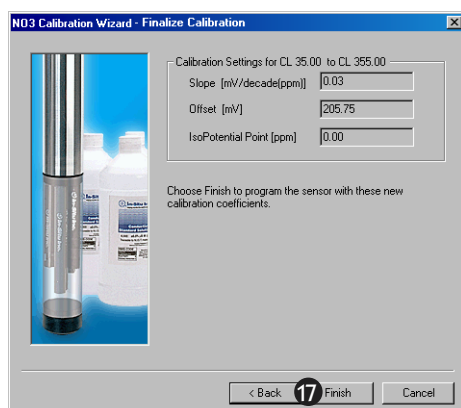
If doing a two-point calibration, go to step 16.

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 until deployment:

The nitrate sensor should be deployed as soon after calibration as possible. For storage, 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 ( $\pm 2$ ) 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.

#### DEPLOYMENT RECOMMENDATIONS AND CAUTIONS

Nitrate Sensor

Operating Temperature -5°C to 40°C (23°F to 104°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.

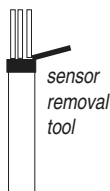
**POTENTIAL INTERFERENCES**

The following table shows concentrations of possible interfering ions that cause 10% error at various levels of  $\text{NO}_3^-$ .

Ion	100 ppm $\text{NO}_3^-$	10 ppm $\text{NO}_3^-$	1 ppm $\text{NO}_3^-$
$\text{ClO}_4^-$	0.01	0.001	0.0001
$\text{I}^-$	0.5	0.05	0.005
$\text{ClO}_3^-$	5	0.5	0.05
$\text{CN}^-$	10	1	0.1
$\text{Br}^-$	70	7	0.7
$\text{NO}_2^-$	70	7	0.7
$\text{HS}^-$	100	10	1
$\text{HCO}_3^-$	1000	100	10
$\text{CO}_3^{2-}$	2000	200	20
$\text{Cl}^-$	3000	300	30
$\text{H}_2\text{PO}_4^-$	5000	500	50
$\text{HPO}_4^{2-}$	5000	500	50
$\text{PO}_4^{3-}$	5000	500	50
$\text{AcO}^-$	20,000	2000	200
$\text{F}^-$	60,000	6000	600
$\text{SO}_4^{2-}$	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 140 or 1400 ppm N solution, depending on usage requirements, rather than dry or in DI water.

**REFERENCES**

Clesceri, L.S., A.E. Greenberg, and A.D. Eaton, eds., *Standard Methods for the Examination of Water and Wastewater*, 20th edition, Washington, D.C.: American Public Health Association, American Water Works Association, and Water Environment Federation, 1998. Section 4500- $\text{NO}_3^-$  D. Nitrate 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](http://www.nico2000.net)



# 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* (Clesceri and others, 1998) 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



\* Contains an assembly, US Pat. No. 6,842,243



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 9000 is permanently-installed and factory-calibrated. It may be a turbidity sensor alone or a pressure/turbidity sensor combination. If your MP TROLL 9000 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 P3 of the MP TROLL 9000 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, as shown in the table below.*

Instrument	Estimated Battery Life		
	At 60 min. sample intervals	At 15 min. sample intervals	At continuous sample intervals
MP TROLL 9000 (2 alkaline D cells)			
With Turbidity & Wiper	63 Days	52 Days	10 Days
No Wiper	75 Days	70 Days	11 Days
No Turbidity	76 Days	73 Days	
MP TROLL 9000E (4 alkaline D cells)			
With Turbidity & Wiper	137 Days	117 Days	24 Days
No Wiper	204 Days	193 Days	35 Days
No Turbidity	206 Days	198 Days	

## WIPER INSTALLATION

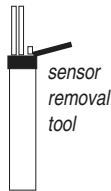
The MP TROLL 9000 may be shipped with the optional wiper already installed in port P3, as shown on the drawing below. If installation is necessary, unpack and install the wiper in port P3 as follows.



*The turbidity wiper will function properly only when installed in **port P3**.*

1. Remove the restrictor from the front end of the MP TROLL 9000. 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 P3. Retain the plug for future use. For best access to port P3, you may need to remove sensors or plugs from other ports as well.

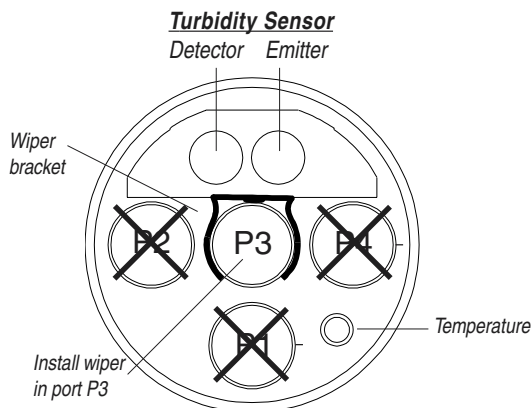


3. Check lubrication of the o-rings on the connector end of the wiper.



*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 a silicone lubricant before installation.*

4. Visually align the connector on the wiper with the connector at the bottom of port P3.
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-term deployments (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 P4. 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 allotted for a wipe cycle. This time is generous to allow for slower wiper movement at very low temperatures.*

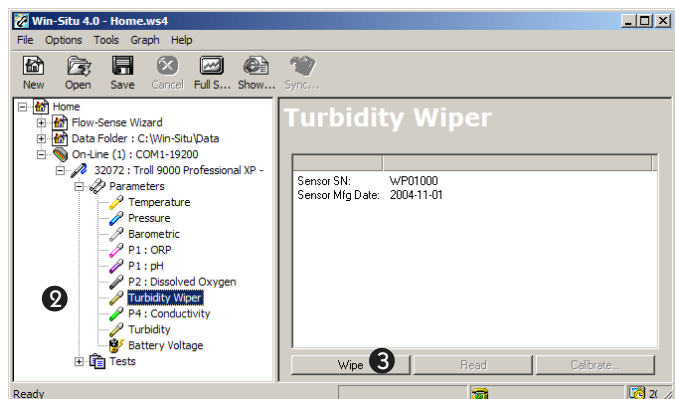
*If readings—test, calibration, profiling—are more than 15 seconds apart, the turbidity sensor will be wiped automatically before each reading. If readings are less than 15 seconds apart, the wiper will wipe the windows just once, before the first reading.*



## MANUAL WIPE

To wipe the turbidity sensor optics manually:

1. With the wiper installed in port P3, connect the MP TROLL 9000 to a PC and establish a connection in Win-Situ or Pocket-Situ.
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  $\pm 5\%$  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 9000'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.



**Why do I need to calibrate the turbidity sensor if it has been calibrated in the factory?**



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 in deployment.

### 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 the condition of the optical windows, which in turn depends on the environment in which the sensor is deployed. 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 9000 changes the reflective properties of the device.

### TURBIDITY CALIBRATION PROCEDURE

You will need:

- MP TROLL 9000 with turbidity sensor (wiper optional), plugs in any unused sensor ports.
- The restrictor, nose cone, and removable sensors (if any) that will be deployed in the field.
- 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.

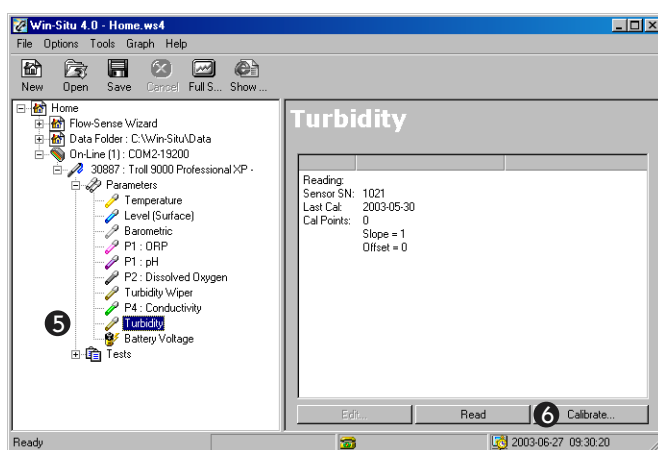
1. Rinse the front end of the MP TROLL 9000 with clean water. Shake well to remove the rinse water; dry external surfaces (not the optical windows) with a clean tissue.
2. Pour the selected calibration standard into the beaker and insert the MP TROLL 9000 into the solution.

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.

- Connect the MP TROLL 9000 to a PC and establish a connection in Win-Situ or Pocket-Situ. 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.
- Select the MP TROLL 9000 in the Navigation tree.

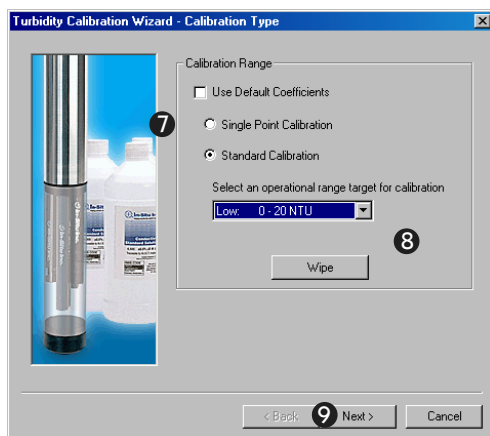
The installed sensors will be displayed—including the turbidity wiper, if installed in port P3.

- Click to select Turbidity in the Parameters list. The sensor serial number (S/N) and recent calibration information is displayed.



- Select **Calibrate**.

The Turbidity Calibration Wizard starts. A screen like the one below is displayed.

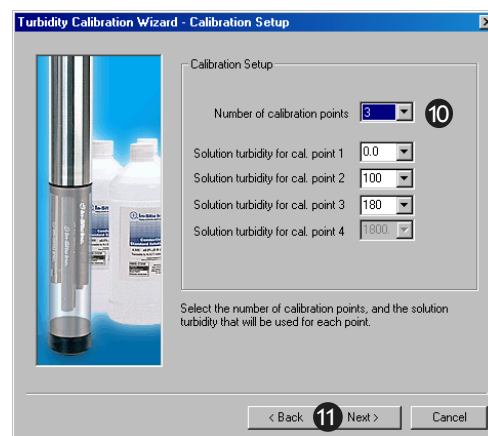


- Select the type of calibration you wish to do:
  - Use Default Coefficients resets the factory defaults. If you select this option, click **Next** and proceed to step 17.

- Single-Point Calibration. Click **Next** and go to step 12.
  - Standard Calibration (default).
- 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.

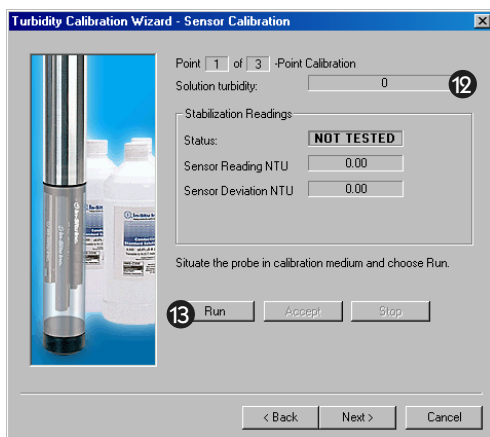
- Select **Next** to continue.
- In the next screen, select the number of calibration points for this calibration, and the turbidity value (in NTU) of the calibration solution for each point. One to four points (solutions) may be selected for any operational range target selected in the previous screen.



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.

- Select **Next** to continue.

A screen similar to the one shown below is displayed.



12. If you are 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

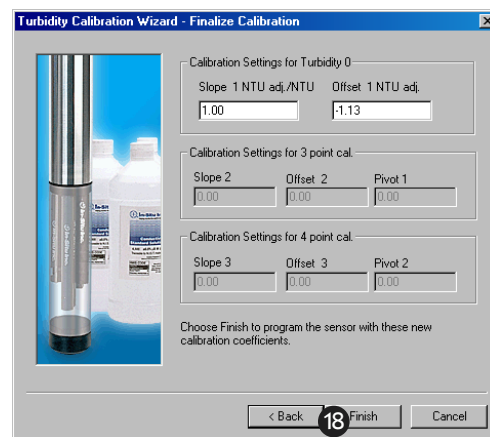
14. If doing a one-point calibration, go to step 17.

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 9000 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 ( $\pm 5\%$  or 2 NTU).

1. Establish a connection to the instrument in Win-Situ or Pocket-Situ.
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

Readings from the turbidity channel are displayed in NTUs (Nephelometric Turbidity Units). No calculated or derived units are available.

### DEPLOYMENT RECOMMENDATIONS AND CAUTIONS



*The operational pressure rating of the turbidity 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-compensated.

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.

### LONG-TERM MONITORING OF TURBIDITY

The wiper is activated automatically before turbidity readings in long-term tests, so long as the readings are 15 seconds or more apart. To prolong battery life when running a wiper in long-term tests, we recommend the use of external power or two internal lithium D-cells installed in the MP TROLL 9000.

### 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 deployed 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 P3.

Replacement pads and wiper heads are available from In-Situ Inc. or your local distributor.

### Removing the Wiper Head

With the wiper parked over port P4, loosen the set screw on the wiper head until you can grasp the wiper head and gently pull it out.



*To remove the wiper head, use the supplied hex wrench to loosen the set screw*

### 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.
4. Position the head on the motor shaft with the pad facing down toward the sensors. The silver 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.

### REFERENCES

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U.S. Geological Survey, Methods for Analysis of Inorganic Substances in Water and Fluvial Sediments, U.S. Department of the Interior, Techniques of Water-Resources Investigations of the U.S. Geological Survey, I-3860-85.





## 19 INSTRUMENT NETWORKS

### NETWORK DESCRIPTION

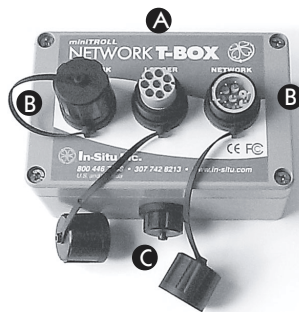
Multi-Parameter TROLLs and miniTROLLs can be installed in a network of up to 32 instruments, each directly connected via its submersible cable to a network box. Network boxes provides power and venting to the instruments, and are connected to each other by network cable. A network may include up to 4000 ft of cable.

### NETWORK BOXES

#### NETWORK T-BOX, NTB-100

A 4-function environmental enclosure that accommodates one MP TROLL 9000 or miniTROLL. Each T-box has:

- A** one connector for the instrument's submersible cable (center)
- B** two connectors for network interconnect cables (left and right)
- C** vent port with dust cap containing hydrophobic membrane and indicating desiccant
- an internal DC to DC converter to change externally-supplied 12 VDC to 6 VDC to power the attached instrument. In order to provide full power across the network interconnect cables with a small gauge wire, a higher voltage is required for a lower current (and to allow for voltage drops within the cable).
- three capacitors to provide extra current in cases when all instruments on the network "wake up" at the same time
- lightning suppression



#### NETWORK QUAD BOX, NTB-400

Provides all the features of the T-Box and accommodates up to four MP TROLLs or miniTROLLs.

#### NETWORK MID-LINE TAP BOX, MLT-100

Environmental enclosure for connecting an instrument network to a PC, power, or telemetry from a point within the network. Permits the network to extend in both directions from the MLT Box.

### CABLES

Network cable is designed to lie flat on the ground or to be installed in on-site conduit. It is not submersible, not weight-bearing, not vented. Venting is provided by network boxes. Gray network cable does not mate with yellow or blue vented cables.



*The total length of all cable in a network must not exceed 1219 m (4000 ft). When calculating this total include all Network Interconnect Cable, all Submersible Cable, and all Network Extension Cable (if used).*

#### NETWORK COMMUNICATION CABLE

Non-vented PVC cable (1.8 m, 6 ft), connects a network of TROLLs to a host computer for programming and downloading. Includes an RS485/RS232 converter, and can be wired to an external 12 VDC network power supply.

#### SMART DEVICE NETWORK COMMUNICATION CABLE

Non-vented PVC cable (1.8 m, 6 ft), connects a network of instruments to a "smart device" such as a modem or relay controller.

#### NETWORK INTERCONNECT CABLE

Non-vented PVC cable (custom length), links network boxes; connects the last box in a network to a network communication cable for programming and external 12 VDC input.

**NETWORK EXTENSION CABLE**

Non-vented PVC cable (custom length), can be used to extend a length of network interconnect cable to cover a longer distance than originally planned on either side of a network box.

**POWER**

Three regulated 12 VDC network power supplies are available:

- North American (120 VAC, 0° to 50° C)
- Universal (95-250 VAC, 0° to 40° C)
- Universal Environmental (100-120, 200-240 VAC, -10° to 60° C)

Alternatively, a 12 VDC automotive or marine battery may be used to power an instrument network.

**SYSTEM REQUIREMENTS**

A network of up to 32 Multi-Parameter TROLLs or miniTROLLs requires the following components:

- Quick-Connect Submersible Cables: one per instrument
- Network Boxes: one T-Box per instrument or one Quad Box per 4 instruments
- Network Interconnect Cables (*variable length*): one per network box
- Network Communication Cable (for communications and external power input): one per network
- Network power source: 12 VDC power supply and available AC line power source; or a 12 VDC automotive or marine battery

**INSTALLATION PROCEDURE**

1. Install individual instruments, on submersible cable, in their field monitoring sites.
2. Attach a T-Box (center connector) to the surface connector of each instrument's submersible cable.

Alternatively, attach a Quad Box to the surface connectors of as many as 4 instruments.



**TIP:** Protective enclosures are recommended for complete water-resistance.

3. Connect the network boxes using Network Interconnect Cable.

4. Connect Network Communication Cable to the interconnect cable on the last T-Box or Quad Box in the network.
5. To power the network, wire a 12 VDC network power supply to the Network Communication Cable (red=12V, black=ground). Alternatively, any 12 VDC automotive or marine battery may be used.



**TIP:** External power may be applied at a network mid-point using a Network Mid-Line Tap Box, rather than at the end with a Network T-Box. The MLT Box has 3 connectors for network interconnect cable; power is applied via the center connector.

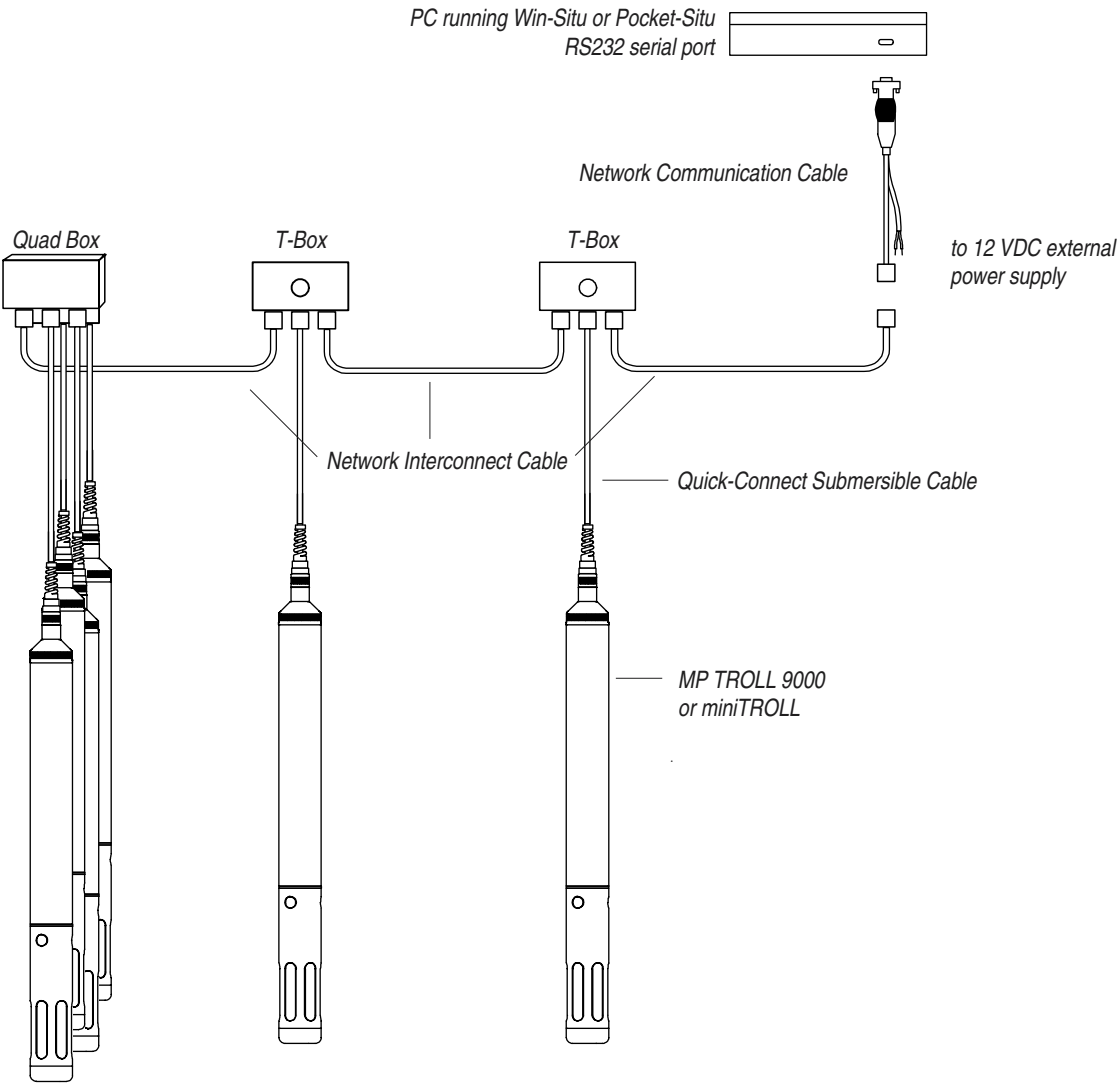
**GUIDELINES & PRECAUTIONS**

- Remove and replace the vented cap on the T-Box vent when the indicating desiccant loses its blue color. Replacement dust caps and connector o-rings are also available.
- Screw the dust caps together to prevent loss or damage.

**TELEMETRY**

Many possibilities are available for transmitting data from the MP TROLL 9000 in the field to an office computer or Internet site, automatically at regular intervals or on demand. In-Situ telemetry system options include North American analog cell modem, spread-spectrum radio modem (902-928 MHz), and 1200 baud line modem. Power supply options include solar panels with storage battery and AC line power (85-265V 50/60 Hz). Enclosures can be fabricated from low-cost fiberglass or high-security steel.

**Schematic diagram of network connections**





## 20 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 9000's sensor measurements by a standard SDI-12 data recorder.

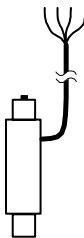
### SDI-12 REQUIREMENTS

- SDI-12 ready MP TROLL 9000 (firmware 1.21 or later)
- SDI-12 Adapter (for proper power management)
- SDI-12 data recorder (customer-supplied)

### WIRING

Connect the 3 pigtails from the SDI-12 Adapter to the terminal block of an SDI-12 data recorder (or to an SDI-12 network) as follows.

- serial data line (white)
- ground line (black)
- 12-volt supply line (red)



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.

### MP TROLL INSTALLATION

Minimum voltage supplied per the SDI-12 specification (9.6V) is sufficient to power a TROLL 9000 on 170 ft (52 m) of submersible cable. 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 on this page lists power requirements for specific submersible cable lengths.

1. Attach the surface connector on the MP TROLL 9000's submersible cable 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.

Submersible cable length		Power supply requirement
feet	meters	
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

2. Install the instrument as usual.

### SDI-12 SUPPORT

The SDI-12-ready MP TROLL 9000 supports all SDI-12 Version 1.3 commands. Data loggers that support SDI-12 Version 1.3 can usually send the standard 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.



*Calibration of the water-quality sensors will need to be done through Win-Situ as SDI-12 protocols do not support calibration.*

## SENSOR IDENTIFICATION

In response to the “send identification” command, the MP TROLL 9000 will respond as follows:

013IN-SITU WQP100121030452

013	IN-SITU	WQP100121030452
		Serial number
		Firmware version
		Sensor (MP TROLL 9000) model
		Manufacturer (In-Situ Inc.)
		SDI-12 compatibility (version 1.3)
		Sensor address

The default sensor address for an SDI-12 MP TROLL 9000 is 0. The device supports software-changeable addresses.

The following will be reported in response to the “start verification” command: + 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)

## MAKING SDI-12 MEASUREMENTS



*TIP: SDI-12 protocols use the term “sensor” for a single SDI-12 device with an address. In this usage, the MP TROLL 9000 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.*

When measurements are made they will be taken on all sensors installed in the MP TROLL 9000. One measurement will be reported

**SDI-12 Parameter Reporting (Default Order)**

Reporting 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	D.O. (Optical)	mg/L

per sensor. “Derived” or calculated measurements will not be reported. For example, the conductivity sensor will report Actual Conductivity, not salinity, TDS, or specific conductance (derived measurements available in Win-Situ).

The default order in which parameters are reported, and the units for each parameter, are listed in the table on this page.



*TIP: You can change the default order of parameters reported in Win-Situ or Pocket-Situ like this:*

1. Select the MP TROLL 9000 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 9000 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. It differs from the Start Measurement command in bus timing issues.
- 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. If a unit has duplicate transducers we will report only one, 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.

If a sensor port is empty, the unit will report readings with values of 0.0.

If a sensor is reading out of its range, the following values will be reported:

Pressure	-9999.999
Temperature	-99.99999
Barometric Pressure	-99.99999
Turbidity	-9999.999
pH	-99.99999
ORP	-9999.999
Conductivity (Actual)	-999999.9

Dissolved Oxygen (polarographic)	-99.99999
Battery Voltage	-99.99999
Nitrate	-99999.99
Ammonium	-99999.99
Chloride	-99999.99
Dissolved Oxygen (optical)	-99.99999

### REDUNDANT LOGGING (WIN-SITU AND SDI-12)

If your MP TROLL 9000 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 9000 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 9000 data can be retrieved using Win-Situ.
- \* if the SDI-12 recorder ceases to function due to power loss, the MP TROLL 9000 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.”*

### NETWORKING CONSIDERATIONS

A special version of In-Situ's SDI-12 Adapter may be used for a network of SDI-12 TROLLs. Contact In-Situ Inc. or your regional sales representative.

### 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](http://www.sdi-12.org).

**SDI-12 VERSION 1.3 COMMANDS**

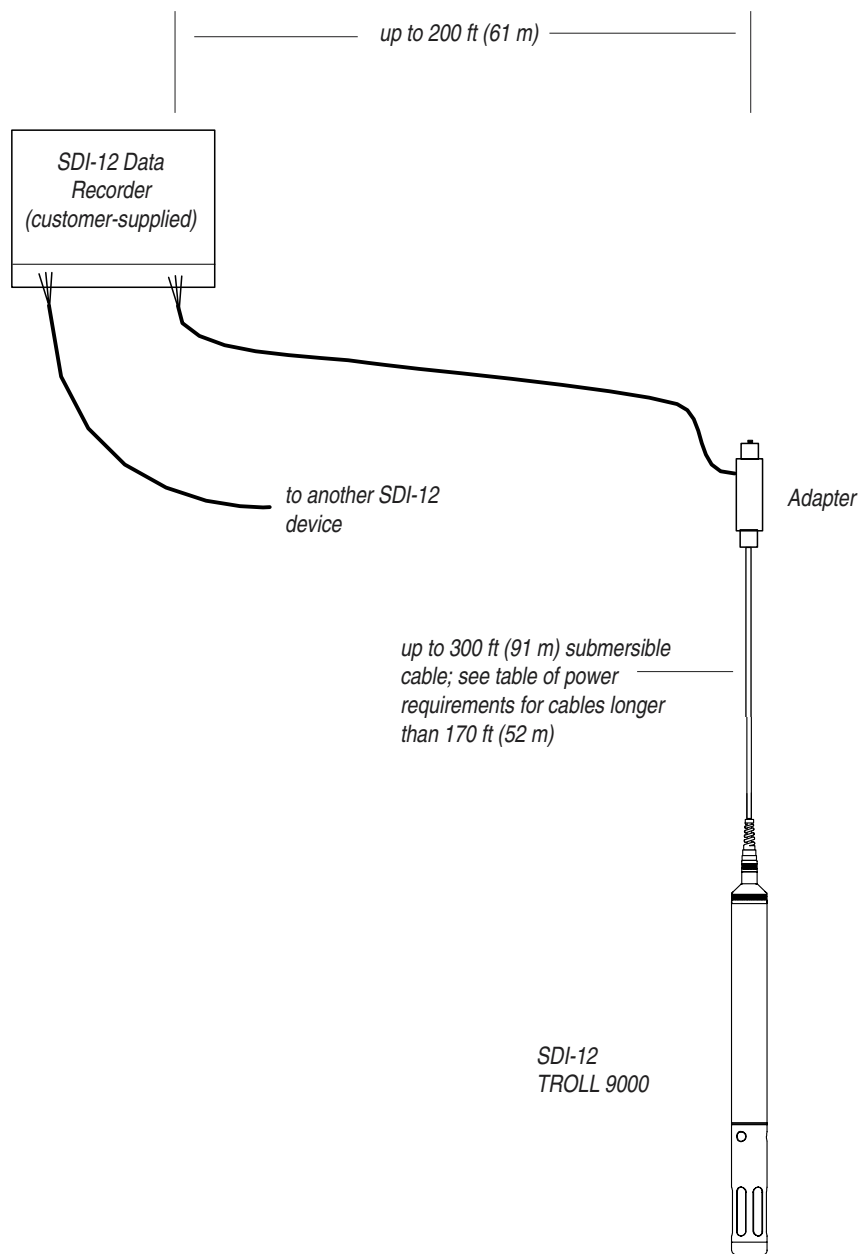
<b>NAME</b>	<b>COMMAND</b>	<b>RESPONSE</b>
Break	Continuous spacing for at least 12 milliseconds	None
Acknowledge Active	a!	a<CR><LF>
Send Identification	a!	allccccccmmmmmmvvvxxx...xx<CR><LF>
Change Address	aAb!	b<CR><LF>
Address Query	?!	a<CR><LF>
Start Measurement*	aM!	atttn<CR><LF>
Start Measurement and Request CRC*	aMC!	atttn<CR><LF>
Send Data	aD0! . . . aD9!	a<values><CR><LF> or a<values><CRC><CR><LF>
Additional Measurements*	aM1! . . . aM9!	atttn<CR><LF>
Additional Measurements and Request CRC*	aMC1! ... aMC9!	atttn<CR><LF>
Start Verification*	aV!	atttn<CR><LF>
Start Concurrent Measurement	aC!	atttnn<CR><LF>
Start Concurrent Measurement and Request CRC	aCC!	atttnn<CR><LF>
Additional Concurrent Measurements	aC1! . . . aC9!	atttnn<CR><LF>
Additional Concurrent Measurements and Request CRC	aCC1! ... aCC9!	atttnn<CR><LF>
Continuous Measurements	aR0! ... aR9!	a<values><CR><LF> (same as the D commands)
Continuous Measurements and Request CRC	aRC0! ... aRC9!	<values><CRC><CR><LF> (same as the D commands)

\* 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

ll (2-character SDI-12 version number), ccccccc (8-character vendor identification), mmmmmm (6-character sensor model), vvv (3-character sensor version), xxx...xx (optional up to 13 characters used for specific sensor info)

### SDI-12 Schematic Installation Diagram







## 21 FIELD INSTALLATION

### LONG-TERM MONITORING INSTALLATIONS

Lower the MP TROLL 9000 gently to approximately the desired depth. When measuring water levels, position the instrument below the lowest anticipated water level, but not so low that its range might be exceeded at the highest anticipated level.

### CHECK THE INSTRUMENT'S LOCATION

At this point, if convenient, it is a good idea to connect the MP TROLL to a PC and take a reading. If the instrument is at the desired depth, secure it in position as suggested below. If not, reposition the MP TROLL as necessary.

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

For long-term installations, check the surface connector:

- Be sure the desiccant in the cap is still active (blue)
- Insure the surface connector is tightly capped
- The connector at the surface end of the submersible cable is water-resistant but not completely waterproof. It is not designed for submersion.

Water Quality Sensor Pressure Ratings

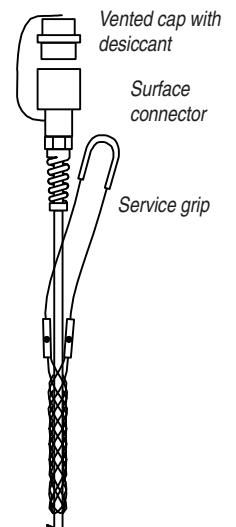
Sensor	Pressure Rating	Usable Depth	
	PSI	Meters	Feet
pH	350	246	807
ORP	350	246	807
pH/ORP	350	246	807
Cond.	350	246	807
DO*	350	246	807
Turbidity	150	105	346
Chloride	100	70	231
Ammonium	20	14	46
Nitrate	20	14	46

\* Deployment and retrieval at up to 4 feet per second.

### SECURING THE CABLE

The cable has a handy device called a service 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 service grip to properly tighten it and keep it from slipping.

Use the loop of the service 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. For long-term installation, especially when monitoring water levels, insure the cable is secured to prevent the instrument moving while data is being logged.



### INSTALLATION TIPS FOR LONG-TERM PRESSURE/LEVEL 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), and other sensors.
- When monitoring pressure, 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 9000 and the pump.

### 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, especially in long-term tests. 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.

### INSTALLATION CHECKLIST

- ✓ Can you communicate with the instrument?
- ✓ Is instrument programmed to collect data?
- ✓ Does it have sufficient power?
- ✓ Are the water quality sensors installed and calibrated?
- ✓ Is the instrument at the proper depth? within its operating temperature & pressure range?
- ✓ Is the cable securely attached to a stationary object so the instrument does not move while taking measurements?
- ✓ Is the surface connector capped?

### BACKSHELL HANGER INSTALLATIONS

#### (ABSOLUTE PRESSURE SENSOR)

The non-vented backshell accessory can be used to suspend a pre-programmed MP TROLL 9000 with an absolute pressure sensor in a well or other site while taking data.



The backshell 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.

1. Program the MP TROLL 9000 before attaching the non-vented backshell: Use Win-Situ or Pocket-Situ to add a manual or scheduled test. If a manual test, start it before removing the communication cable. (You cannot communicate with the device after attaching the non-vented backshell).
2. Remove the cable used for programming and attach the non-vented backshell.
3. Barometric compensation of absolute pressure measurements, if required, may be accomplished either manually or in software. See “Correcting Absolute Pressure Readings for Barometric Pressure” in Section 7 for more information.

## 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.

### Starting the Stirrer

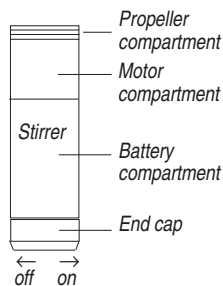
The stirrer is powered by two alkaline D-cells (installed). To start the motor, tighten the end cap.

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.

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



**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.



### Attaching the Stirrer for Deployment

The stirrer accessory is easily installed on the MP TROLL 9000 before deployment as follows:

1. Remove the nose cone from the MP TROLL 9000. 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.

The instrument is ready for deployment in stagnant water.





## 22 APPLICATIONS AND TECHNICAL NOTES

The Multi-Parameter TROLL 9000 is a multi-application instrument designed for use in a wide range of surface and groundwater applications. This section describes just a few of the possible uses of the instrument. Additional Application Notes and Technical Notes are in development.

### MONITORING BACKGROUND LEVELS

Prior to remediation or cleanup operations, the MP TROLL 9000 can be used to collect and record data on background water levels and the presence of contaminants. Individual parameter data may be logged in the form of tests (see Section 6) or profiling (see Section 5).

### LONG-TERM WATER QUALITY MONITORING

To meet regulatory requirements, take advantage of the MP TROLL 9000's generous memory, battery life, and data-logging capabilities to track and record changes in water level and water quality.

### PRESSURE TESTING

A pressure-sensor-equipped MP TROLL 9000 can be used to measure and record drawdown and recovery during aquifer testing. In a pumping test, for example, the water level in a well is artificially drawn down through pumping and then permitted to recover under conditions of natural groundwater flow. Water level is measured and recorded on a logarithmic time scale to capture early-time data during drawdown and recovery. The effects of pumping and the rate of recovery may be monitored in the pumped well alone, or in the pumped well and in nearby monitoring wells.

Similarly, a slug test raises the water level by "slugging" a well and monitors the recovery to pre-slug conditions.

One way to set up data logging for a pumping test is to program a log test with a manual start for the instrument in the pumping well, and a scheduled start for the monitoring wells.

Set up the pressure channel in the pumped well in Level (Top of Casing) mode so that drawdown is measured directly. Enter your elevation and latitude for the most accurate conversion from pressure to level. Select a scheduled test if a referenced starting level is to be used.

As the programmed start time in the observation-well instruments approaches, get ready to turn the pump on and start the test in the pumping well to begin the drawdown phase of the test.

You can view the data at any time to monitor the progress of the test using the *Extract* function.

### MONITORING STORMWATER RUNOFF

The Multi-Parameter TROLL's "event" test schedule is ideal for detecting an event like stormwater runoff that results in a sudden dramatic change in water level. The instrument may be programmed in advance to take and store data on a sparse linear schedule, for example once an hour, or even once a day. Designate the pressure/level channel as the "event" channel, and select a "delta" value such that a change in level will be detected and recorded in the instrument memory.

This test paradigm is readily adapted to detecting an "event" on any channel. For more specific information on setting up this type of test, refer to the discussion of Event tests in Section 6 above.

### ARTESIAN (SEALED-WELL) APPLICATIONS

With a custom adaptation, an MP TROLL 9000 may be installed into a sealed well where the seal is made around the cable. A "dome" compression fitting makes a water- and air-tight seal around the cable. Contact In-Situ Inc. or your distributor for additional details on hardware for artesian well applications.

## LOW-FLOW MONITORING WITH FLOW-SENSE

Groundwater that has sat in 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 water-quality parameters of interest. 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 and Pocket-Situ 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 automatically calculates the volume of the In-Situ flow cell and the 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.

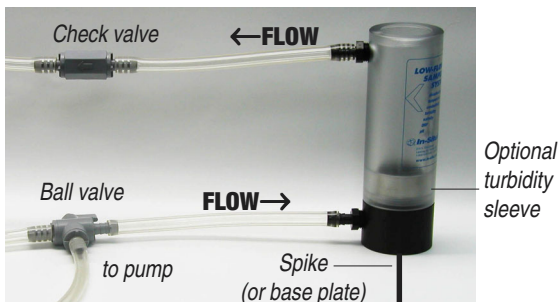
### PREPARATION

- Install Win-Situ from the CD supplied
- Install and calibrate the water-quality sensors
- Insert the MP TROLL 9000 into the Low-Flow Flowcell and connect the valves and tubing. Connect the tubing to the pump.



**TIP:** For turbidity measurement, ensure the stainless steel sleeve is positioned in the bottom of the flow cell.

- Start the pump and determine optimum final pumping rate.
- Have the following site information ready to enter in the software:
  - Well diameter
  - Total well depth
  - Depth to water level, top of screen and placement of pump intake, referenced to a benchmark



- Screen length
- Pump model & type
- Tubing type, inner diameter & length
- Final pumping rate (in mL/min)
- Final stabilized drawdown from static water level, measured with a tape or other measurement device after the final pumping rate has been established
- Connect the MP TROLL 9000 to the PC's COM port
- Install Microsoft® ActiveSync™ on a desktop or laptop PC to enable transfer of files to and from a Pocket PC. ActiveSync must be installed before connecting the computers for the first time.

### OPTIONAL PREPARATION

- Text entry on a PDA in the field can be tedious. To simplify the task, you may wish to run the Flow-Sense Wizard from Win-Situ on a full-sized PC in the office to prime the software with representative values. Then use ActiveSync to copy the “templates” created in this way to the PDA. See “Hints and Tips” at the end of this section.

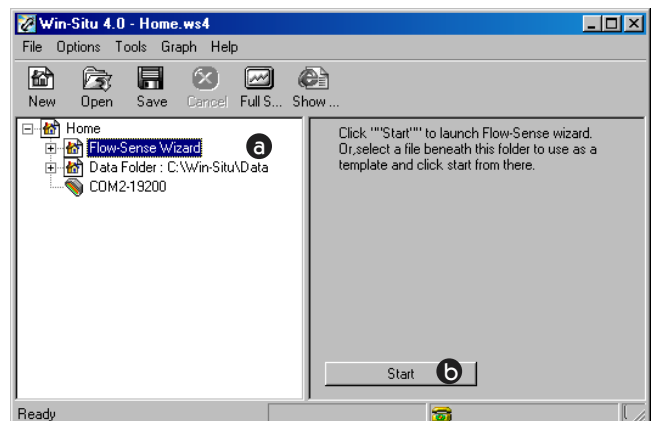
### START THE SOFTWARE

Launch Win-Situ or Pocket-Situ.

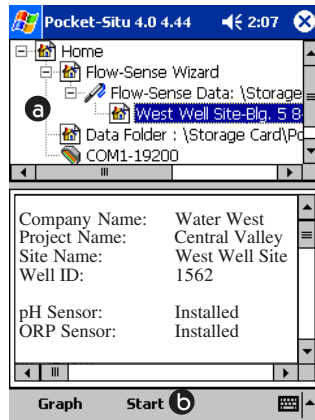
If you have not used the software before, take a moment to specify a connection type, COM port, and baud rate. Refer to Software Setup in Section 3 (Getting Started) of this manual for specifics.

### 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 in. For more on “template” files, see “Hints and Tips” at the end of this section.



### 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.

- 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.

- In the next screen, enter information about the well. This information will be included in the output report. The Well I.D. 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).

Click or tap **Next** to continue.

The next screen requests pumping information

4. **Final pumping rate:** Enter in milliliters per minute.
5. **Total volume—Auto Calculated Value:** This is the software-calculated volume of the cup (In-Situ Low-Flow Flowcell) and tubing, less the displacement of installed sensors.

To specify a different volume, clear the “Auto” check box, and enter the new volume (milliliters).

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)

Click or tap **Next** to continue.

8. The final screen displays the Low Flow parameters. Choose the parameters to monitor and the target stability range for each parameter. *(continued on next page)*

The percentage range is calculated by the formula:

$$\frac{\text{max} - \text{min of last 3 readings}}{\text{last reading}} \times 100\%$$

If no percentage ranges are entered, the software will monitor absolute values to determine stabilization. If any percentage range is entered, the software will monitor percentage change.

9. Click the **Notes** button to add comments, if you want. They will be included in the output report.
10. Ensure the pump is on, then click or tap **Start** to begin the stabilization readings.

### STABILIZATION READINGS

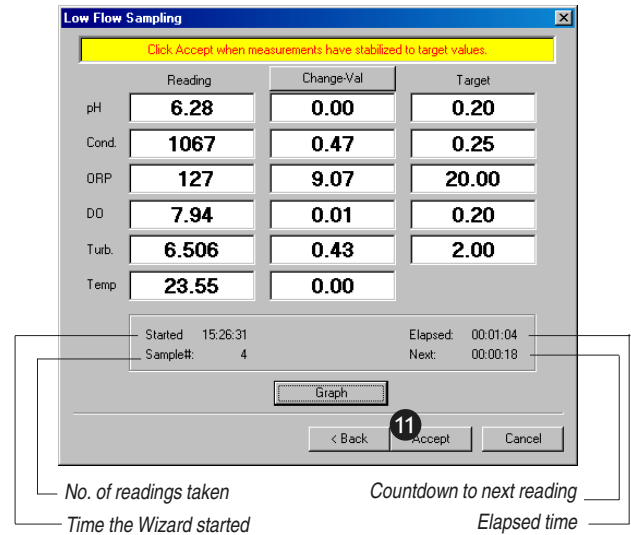
The next screen shows for each parameter:

- **Reading:** the current reading
- **Change - Val:** difference between the maximum and minimum over the last 3 readings OR
- **Change - %:** difference between the current reading and the third reading back (two readings ago) 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. The range finder on the right may be dragged up or down, or the stability region may be expanded to zoom in on the readings.

The most recent readings are shown on the right of the graph, with earlier readings on the left. 0 designates 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 and displayed with each reading.

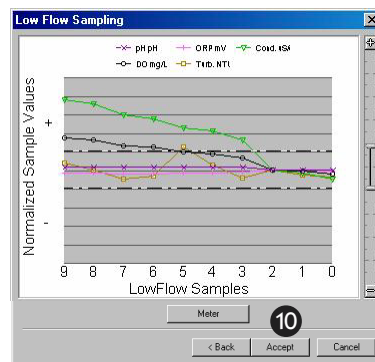
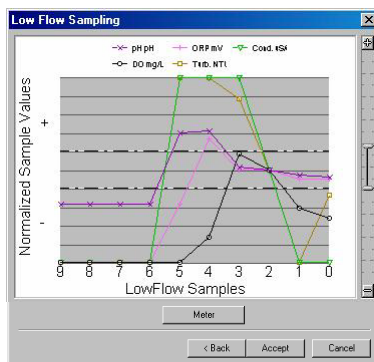
The **Meter** button returns to the previous screen.

11. When you are ready to save the data and exit the software, click or tap **Accept**.

### SAVING THE LOW FLOW DATA

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 or Pocket-Situ.

The file may be displayed in report format or as a graph in both Win-Situ and Pocket-Situ. (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 (desktop/laptop PC).

- 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-1562-3-10-2004.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

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 Low Flow 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.
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.

## HINTS AND TIPS

### PRIMING THE FLOW-SENSE WIZARD IN THE OFFICE

To reduce the need for input on a PDA in the field, you may want to use the following procedure to prepare the majority of Low Flow information on your desktop PC ahead of time.

#### On the Desktop PC

1. Connect the TROLL 9000 you will use in the field to your desktop PC.
2. Create .FLO “template” files on desktop PC in preparation for going out into the field, as follows:

For each well you need to sample, execute the Wizard and enter reporting information. You may click Finish immediately (the sampled data is unimportant), but be sure to run the Wizard for each well you intend to visit and enter that well’s information.

When the Wizard asks if you want to save the file, give each one a meaningful name, for example:

“Well abc template.flo”

“Well xyz template.flo”

3. On your next ActiveSync connection, In-Situ’s synchronization utility PocketSync will prompt you for Low Flow templates you wish to transfer to the PDA.



**TIP:** If Pocket Sync does not prompt for this, click Send Low Flow Files on the PocketSync File menu.

#### In the Field

4. Connect the TROLL 9000 to the PDA, launch Pocket-Situ, and navigate to the Flow-Sense Wizard/Flow-Sense Data branch of the tree. Locate the template file you created for the well you are sampling. Highlight that file in the tree and tap **Start from Template**. The highlighted file will be used to initialize the Wizard so that you don’t have to type as much on the PDA.

5. Verify that Pocket-Situ's settings for units used in low flow sampling are the same as those of Win-Situ. These include "Low Flow units" and units for sensors used.
6. Note that you will need to adjust Final Pumping Rate and other variables. Let the Wizard run to stabilization.
7. Save this file (with real data) under a different name than the template file you created on your PC. The Wizard's default file name consists of the Project name, Site name, Well I.D., and date, but you can rename the file any way you like.

**In the Office**

8. Connect the computers in ActiveSync and the PocketSync utility will automatically copy the resultant .FLO files back to the PC.



**TIP:** If Pocket Sync does not prompt for this, click Get Files on the PocketSync File menu.

Note: In future visits to the same well you can re-use files from last time.

		<b>Troll 9000</b> 04/23/04	<b>Low-Flow System</b> <b>ISI Low-Flow Log</b>				
<b>Project Information:</b>		<b>Pump Information:</b>					
Operator Name	TCR	Pump Model/Type	Bladder				
Company Name	Princeton	Tubing Type	PVC				
Project Name	AAA	Tubing Diameter	0.8 [cm]				
Site Name	Code3	Tubing Length	29.99 [m]				
		Pump placement from TOC	12.01 [m]				
<b>Well Information:</b>		<b>Pumping information:</b>					
Well Id	Percentage	Final pumping rate	200 [mL/min]				
Well diameter	5 [cm]	Flowcell volume	132.07 [mL]				
Well total depth	50 [m]	Calculated Sample Rate	40 [sec]				
Depth to top of screen	8.01 [m]	Sample rate	10 [sec]				
Screen length	16.5 [cm]	Stabilized drawdown	12 [cm]				
Depth to Water	4.49 [m]						
<b>Low-Flow Sampling Stabilization Summary</b>							
	Time	Temp [C]	pH [pH]	Cond [uS/cm]	Turb [NTU]	DO [mg/L]	ORP [mV]
<b>Stabilization Settings</b>			+/-1	+/-0.14	+/-1	+/-0.2	+/-10
			+/-10 %	+/-20 %	+/-5 %	+/-15 %	+/-10 %
Last 5 Readings	15:05:49	19.83	7.77	1.34	1.23	-3.18	141.63
	15:06:00	19.83	6.75	1.34	1.23	-3.18	-297.05
	15:06:09	19.83	4.99	1.34	1.23	-3.18	371.14
	15:06:19	19.83	2.98	1.34	1.21	-3.17	646.73
	15:06:30	19.85	-0.48	1.34	1.20	-3.17	717.62
Variance in last 3 readings	15:06:09	0.00	-1.75	0.00	0.00	0.00	668.19
	15:06:19	0.00	-2.02	0.00	-0.02	0.00	275.60
	15:06:30	0.01	-3.46	0.00	-0.01	0.00	70.89
<b>Notes:</b>	ORP is all over the place						

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



## 23 CARE & MAINTENANCE

### REPLACING BATTERIES

#### MP TROLL 9000 batteries

- 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 replacement lithium batteries supplied by In-Situ. Use of any other lithium battery will void the product warranty.

#### MP TROLL 9000E batteries

- 4 standard 1.5V alkaline D cells



Do not use any other type of battery as this may damage the MP TROLL 9000E. Rechargeable batteries are not recommended.

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 will report that the TROLL 9000 is operating on external power.

To replace batteries:

1. Unscrew and remove the knurled back end of the instrument. This is a tight fit with the o-ring seals, so be gentle but persistent. The cable may be detached to simplify the back end removal.
2. The round flat “battery contact” will pop out slightly to allow access to the batteries. This is attached to a flexible circuit that extends through the instrument body.
3. Remove the used batteries.
4. Insert the new batteries according to the diagram on the inside of the flex circuit.



**CAUTION:** The flex circuit is a ribbonlike strip that extends from the battery contact through the instrument body to the circuit board in the sensor end. Treat it with care when installing and removing batteries.

*DON'T tug on it to get the batteries out. It's an electronic circuit, not a battery removal device. Let it slide out on its own only as far as necessary to remove and replace the batteries.*

*DON'T twist it. The battery diagram should face the batteries.*

*DON'T bend the battery contact backwards. It should remain at a 90° angle to the flex circuit.*

5. Center the battery contact over the top battery and replace the back end.
6. Hand-tighten to compress the o-rings and create a waterproof seal. When properly assembled, the o-rings will not be visible.
7. In the software, 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 9000 and other submersible In-Situ instruments are crucial to insure the integrity of the water-tight seal. We recommend that you inspect them each time they are stressed (insertion/removal of sensors, attachment/removal of the restrictor, 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.

When lubricating the sensor o-rings, take special 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.

Similarly, when replacing o-rings on the backshell, try to avoid transferring grease from your fingers to the circular PCB inside the backshell.

## REPLACEMENT

If the o-rings become damaged to the extent that no longer provide an effective seal, they should be replaced. If in 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.

Replacement o-rings are available from In-Situ Inc. or your distributor. The kits include o-ring lubricant.

## GENERAL CLEANING

Rinse the instrument body well, especially if it has been deployed in contaminated media. Air-dry or wipe with a lint-free tissue.

## STORAGE

If the sensors are removed for storage, place plugs in the dry sensor ports as protection from dust and dirt.

### Sensor Storage

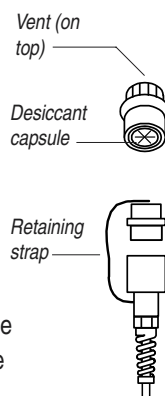
For long-term storage, return the water-quality sensors to their original packaging. Protect the lubricated o-rings from dust and dirt.

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.

## VENT CAP DESICCANT

The vented cap of the cable surface connector contains desiccant to protect the instrument's electronics against damage from moisture and condensation. The silica gel desiccant is blue when active. When the gel appears colorless, the desiccant has adsorbed all the moisture it can hold. The desiccant capsule or the entire cap should be removed and replaced.

- To remove a cap: Pull the retaining strap out of the slot on the connector body. Dispose of the used cap properly.
- To attach a cap: Insert the retaining strap into the slot on the connector body. Screw the cap to the connector.

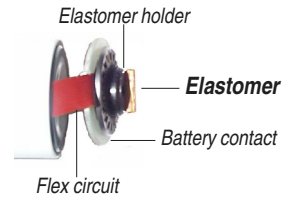


- Protect new caps from moisture until ready to use.

Replacement caps with desiccant are available from In-Situ Inc. Desiccant is also available in a pack of 10 capsules (no caps).

## ELASTOMER

An elastomeric connector ("elastomer" for short) in the back of the MP TROLL body transmits signals from the instrument to the cable. Each time the cable is attached or detached, the elastomer undergoes wear from contact with the backshell. The elastomer may become "smashed" or compressed so that it no longer contacts the round circuit board in the backshell.



We recommend you clean the elastomer with an alcohol wipe each time you attach or remove the cable and at each battery replacement. For best results, also clean the round circuit board in the instrument backshell at the end of the cable. If you have problems communicating with the instrument after cleaning the elastomer, replace it. Replacement elastomers are available from In-Situ Inc.

## CONSUMABLES

A variety of replaceable items are available for operation and maintenance of your MP TROLL 9000 system. The following is a partial list. Contact your In-Situ sales representative or your local distributor for prices and ordering information.

### Vented Cap with Hydrophobic Membrane & Indicating Desiccant

Desiccant is blue when active. When the desiccant appears colorless, the entire cap should be removed and replaced. A pack of 10 desiccant capsules (no caps) with o-rings is also available.

### Internal Batteries

Alkaline D-cells, 1.5V (2)

### Dust Caps & O-Rings

### Elastomer Kit

Pack of 5

### TROLL 9000 Maintenance Kit

Elastomers, o-rings, desiccant capsules



## 24 TROUBLESHOOTING

### TROUBLESHOOTING CONNECTIONS

**Problem:** Win-Situ or Pocket-Situ cannot “find” (connect to) the MP TROLL 9000. 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
- the elastomer looks clean and shiny, and “tall” enough to contact the round circuit board in the backshell (see [Section 24](#))
- 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



*The MP TROLL 9000 rolled out of the back of my truck and hit the ground pretty hard. It still talks. Is it OK to use?*



*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

## BOXCAR FILTERING

Software boxcar filtering is a weighted running average of the 5 most recent measurement results. The “boxcar” is the moving window on the data set. These five raw readings are averaged and presented in a filtered version as a single data point. When averages are computed for successive data points, the newest data point is added to the window and the oldest data point is removed.

The default weighting is even across all 5 readings but can be optionally changed to the user’s weighting preference, for example an exponential decay. The following algorithm is used:

$$\text{New Result}_n = (M_n \cdot 4 \cdot a + M_{n-3} \cdot b + M_{n-2} \cdot c + M_{n-1} \cdot d + M_n \cdot e) / (a+b+c+d+e)$$

where:

New Result<sub>n</sub> = the reported value after the filtering

M<sub>n</sub> = Raw Measurement n, the most recent raw measurement

M<sub>n-1</sub> = the next most recent raw measurement

a, b, c, d, and e are the weighting coefficients (default value = all set to 1.00)

At the beginning of the data set there will be less than 5 raw data points available to fill the boxcar; the average will be computed with all available points.

## ELECTRONIC DRIFT AND DEVICE RECALIBRATION

The electronics of the Multi-Parameter TROLL 9000 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 below.

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 9000 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  $\pm 0.0005$ .

### 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 ( $\rho$ ) in  $\text{g/cm}^3$  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  $\text{m/s}^2$ .  $P$  must be in PSI units and  $L$  must be in meters. If using a tape measure calibrated in feet,  $1 \text{ ft} = 0.3048 \text{ m}$  (exactly).



*An error of 0.001 m (1 mm) in the depth measurement translates into an error of 0.00085  $\text{g/cm}^3$  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.
- 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.
- 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<sub>3</sub>):** A toxic, colorless gas with a pungent odor, highly water-soluble.
- Ammonium (NH<sub>4</sub><sup>+</sup>):** Solvated ammonium cation produced when ammonia gas is dissolved in water.
- Ammonium chloride (NH<sub>4</sub>Cl):** A salt used to make ammonium and chloride calibration standards.
- Anion:** Negatively charged ion (e.g., Cl<sup>-</sup>, NO<sub>3</sub><sup>-</sup>).
- Atmospheric pressure:** Pressure due to the atmosphere, altitude-dependent.
- Backshell:** Threaded stainless steel “quick-connect” end of quick-connect submersible or direct-read cable; closes the back end of the MP TROLL 9000 and provides electrical connection and venting.
- Backshell, non-vented:** Combination backshell cap and hanger without venting or communication capabilities; allows use of inexpensive hanging cable while taking absolute (non-vented) pressure data with a preprogrammed instrument.
- 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, conductivity, dissolved oxygen, and ORP; pH and ORP may be single-parameter sensors or a combined sensor; *compare* Extended sensor set.
- Boxcar filtering:** A smoothing scheme that looks at the 5 most recent data points.
- Cable,** *see* Communication cable, Direct-read cable, Network cable, Quick-connect cable, Submersible cable, 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 9000 directly from the box, with factory-supplied calibration coefficients. Sensors should be calibrated after they are deployed 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 9000 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.,  $\text{NH}_4^+$ ,  $\text{Na}^+$ ).
- Cell constant:** A value that describes a conductivity cell which is determined by electrode area and electrode separation.
- Chloride ( $\text{Cl}^-$ ):** 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.
- Comm cable,** *see* Communication cable
- Communication cable:** Vented polyurethane cable that connects the MP TROLL 9000's quick-connect submersible cable to a PC. Includes external power input and RS485/RS232 converter.
- ComIT:** Vented RS485/RS232 converter with a short length of cable attached; connects the MP TROLL 9000's quick-connect submersible cable to a PC.
- 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,  $\text{g/cm}^3$ ). Water is most dense at 4° Celsius.
- Depth:** The distance between the water surface and the pressure sensor of the MP TROLL 9000. 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 9000.
- Digital DO:** Proprietary method of powering the dissolved oxygen sensor; digital pulsing eliminates the need to stir the sample to avoid oxygen depletion.
- Direct-read cable:** Quick-connect cable that combines the functions of a submersible cable and a communication cable; connects the MP TROLL 9000 directly to the serial port of a PC. Includes external power input and RS485/RS232 converter.
- Dissolved oxygen (DO):** The amount of oxygen present in water and available for respiration.
- DO:** Dissolved Oxygen.
- Downhole cable,** *see* Submersible cable
- Drift:** Gradual change in sensor response with time.
- DSP:** Digital signal processor.
- Elastomer:** Connector in the back end of the MP TROLL 9000, made of a rubberlike synthetic polymer, wrapped with flexible circuit material; completes a circuit when compressed by the quick-connect backshell.
- 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 chlorophyll sensors; *compare* Basic sensor set.
- Extract: Copy test data from the MP TROLL 9000 memory to a host PC. Initiated by the **Extract** button when a test is selected in the Navigation tree.
- FEP: Fluorinated ethylene propylene; the generic equivalent of DuPont Teflon®.
- Firmware: Software program that resides in the memory of the MP TROLL 9000; firmware can be field-upgraded.
- Flow cell: Clear PVC vessel with input and output ports for routing flow past the sensors of the MP TROLL 9000; alternative to in-situ deployment 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.
- 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 9000 via comm cable or 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.
- 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<sub>3</sub>: Sodium nitrate.

- 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.
- Network: Instrument network consists of Multi-Parameter TROLL 9000 (up to 32) with submersible cable connected to a network box, connected to additional network boxes via network cable, 12 V power supplied by externally applied AC line power.
- Network box (T-box, Quad box, Mid-line tap box): Vented environmental enclosure with a regulated power supply and lightning suppression; ties multiple MP TROLLs into an instrument network.
- Network cable: Insulated non-vented PVC cable for connecting networks of MP TROLL 9000s or other instruments.
- NH<sub>4</sub>Cl: 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<sub>3</sub><sup>-</sup>): 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 9000.
- 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<sup>+</sup>) in the solution.
- Pocket PC: A type of PDA with an ARM processor and Pocket PC operating system.
- Pocket-Situ: Win-Situ 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 9000 model containing memory; able to log data; accommodates the Basic sensor set.
- Professional XP: MP TROLL 9000 model with all features of the Professional model and in addition allows use of the Extended sensor set.
- Profiler: MP TROLL 9000 model without memory; must be used with a PC or PDA; accommodates the Basic sensor set.
- Profiler XP: MP TROLL 9000 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.
- Programming cable, *see* Direct-read cable
- 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 9000 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).
- Quick-connect cable: Submersible or direct-read cable that includes the instrument backshell.
- 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 9000 between the nose cone and the body; protects the sensors and allows free circulation of environmental fluid.
- 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  $\Omega$  at 0°C.
- S, *see* Siemens
- Salinity: A measure of the amount of salts dissolved 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.
- 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 9000.

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 ( $\text{NaNO}_3$ ): 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 deployment of the MP TROLL 9000 in stagnant waters.

Submersible cable: Waterproof, quick-connect cable designed for submersion; carries power and communication signals; provides strain relief and a means to anchor the instrument to a stationary object. 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

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.

Turbidity: A measure of the transparency of water.

Units: Measurement units; user-selectable in software interface.

Vented cable: Quick-connect submersible cable with a vent tube that runs from the surface connector to the pressure sensor; 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: 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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