Meeteetse Conservation District

SURFACE WATER SAMPLING AND ANALYSIS PLAN

For

***E. coli* and Chemical Sampling**

Within the Meeteetse Conservation District

June, 2014

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Analytical Services Laboratory, Wyoming Department of Agriculture Date

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I. INTRODUCTION

This Sampling and Analysis Plan (SAP) is written to meet the Quality Assurance/Quality Control (QA/QC) requirements of the Wyoming Department of Environmental Quality (DEQ), Water Quality Division (WQD), Watershed Program for the State of Wyoming grants to Conservation Districts for water quality monitoring, to satisfy the requirements of the State of Wyoming Statute (W.S.) 35-11-103(b) and (c) and W.S. 35-11-302, known as the Credible Data Law, and to meet the DEQ QA/QC requirements for volunteer water quality monitoring under the Credible Data Law.

The SAP is intended as a field guide for personnel who will be conducting the water quality monitoring activities for this project, as a QA/QC plan, and as a data management plan. Supplemental watershed information not essential to field operations may be found in "Greybull River Watershed Information", variously dated, compiled by the Meeteetse Conservation District (as amended), incorporated by reference in this SAP, and in other documents kept on file in the MCD office.

Samples are to be collected using the methods, procedures and/or protocols described in Appendix B of this SAP from the Manual of Standard Operating Procedures for Sample Collection and Analysis, WDEQ/WQD, Water Quality Division, 2011, and the methods, procedures and/or protocols in the Natural Resources Conservation Service National Handbook of Water Quality Monitoring, USDA, 2003, both incorporated by reference into this SAP. Variances or deviations from referenced methods, procedures, protocols, and SOP's are noted by referencing them as "modified" SOP's, methods, procedures, etc. and by providing an explanation in Appendix B, "SOP's and Methods, Deviations from DEQ SOP, and Reasons For".

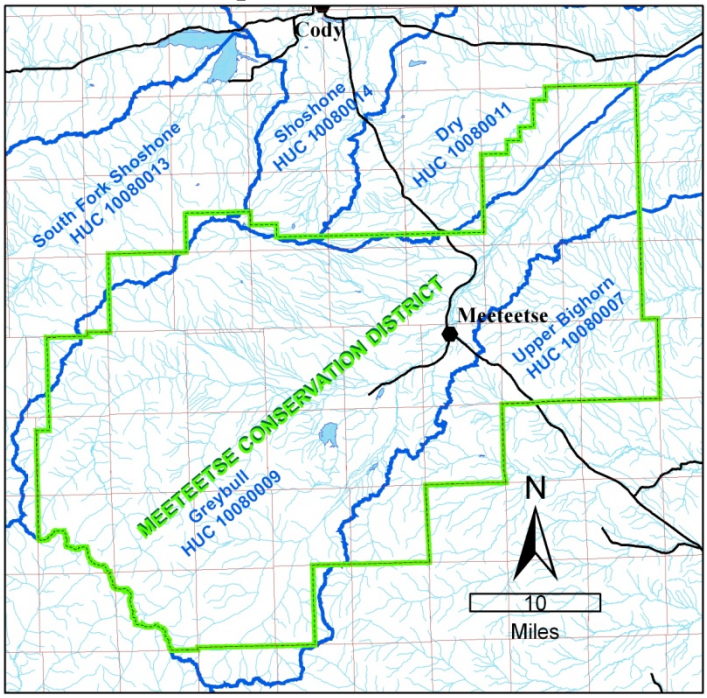
Within this SAP, the standard definitions of the terms shall, must, should and may, are used:

- shall, must - when the element is required and deviation from the specification will constitute nonconformance with the standard; conformance is measured by completion or implementation of the action specified.
- should - when the element is recommended.
- may - when the element is optional.

Background

The Meeteetse Conservation District (MCD) encompasses most of the Greybull River watershed within Park County (Fig. 1). This is approximately the western ¾ of HUC 10080009. That portion of the Greybull watershed, easterly and downstream of the MCD, within Big Horn County and the South Big Horn Conservation District is referred to as the lower Greybull. Minor headwaters portions of the watershed lie outside of the MCD. Minor portions of the Gooseberry Creek and Fifteenmile watersheds (HUC 10080007) lie within the southerly portion of the MCD, and some of the Dry Creek watershed (HUC10080011) lies within the northeasterly portion of the MCD.

Figure 1 - Location map



The 2006 Wyoming 305(b) State Water Quality Assessment Report states. "Headwaters of the Greybull Sub-basin are in the Absaroka Range within the Shoshone National Forest. The foothills portions of the sub-basin are a mix of BLM, state, and private lands, and the basin portions are primarily BLM, with private lands adjacent to streams. The sub-basin has three major irrigation reservoir projects. Summer flows in the Greybull River at the confluence with the Big Horn River are reportedly almost entirely irrigation return water and at sometimes there may be minimal to no flow, due to appropriations on the river (RPO, 1979). Livestock grazing and areas of oil and gas extraction are major land uses, with irrigated agriculture nearby and adjacent to the major tributary streams. The Greybull River is on Table A of the 303(d) List because exceedences of the criteria for fecal coliform bacteria at Greybull indicate it is not meeting its use for contact recreation. Although high fecal bacteria counts have been occasionally recorded as far upstream as Meeteetse, samples were collected too infrequently to develop a valid geometric mean to compare with criteria. Meeteetse and South Big Horn Conservation Districts have monitored on the Greybull River. Analysis of their data sets indicates that the impairment may not extend above the Sheets Flat Bridge, below Meeteetse. High water temperatures recorded during the recent drought raise concerns about the river's ability to support its use as a cold water fishery during low flows in summer. Future monitoring is required to better understand the temperature regime and to determine sources of fecal bacteria. The populace of the MCD is dependent on the Greybull watershed and its water primarily for domestic and industrial purposes, recreation, agricultural production, for intangible values such as those derived from scenic beauty and wildlife, and for its effects on local custom and culture. In response to concerns of individuals, governmental agencies, and non-governmental organizations (NGO's), MCD proactively initiated qualitative water quality monitoring in the fall of 1995. MCD's continuing water quality monitoring operations evolved from that beginning.

As stated in the MCD Plan of Work, 2011, hereby incorporated by reference, "…MCD remains committed to maintaining and improving the water quality of groundwater, streams, rivers, reservoirs and lakes within the boundaries of the District."

Purpose and Objective

MCD's overall purpose, as stated in the MCD Plan of Work, 2011, is to continue to provide an effective water quality/watershed management and improvement program. MCD will continue to use proper science to merge the wise management and use of natural resources with the District's custom, culture, and socioeconomic needs in order to provide for the integrated and comprehensive management of our natural resources. MCD's commitment to this purpose is ongoing and will continue in the future. The water quality/watershed management and improvement program will itself be monitored and revised through time. The surface water quality monitoring conducted under this SAP will provide credible surface water quality data that will be a key component of our continuing water quality/watershed management and improvement program and will be carried out through the following objectives:

1. A database of credible data acquired over a long period of time is critical to defining and understanding natural processes and their effects on the surface water quality of the Greybull River watershed. Acquiring the database is therefore a significant part of the overall objective.
2. The results of systematic long-term data collection will be used to address the contact recreational use impairment listed on the DEQ 303(d) list.
3. The results of the surface water monitoring program will be used to develop cost-effective and functional best management practices (BMPs) that can be implemented by all users of the watershed and the water resource, preventing needless regulation and unachievable goal-setting.
4. MCD seeks to assist DEQ in achieving the goal of all of the statewide Watershed Program monitoring: to produce comparable data of known and documented quality.
5. The MCD seeks to work cooperatively with other Conservation Districts, on a watershed basis, to address mutual concerns.

This Sampling and Analysis Plan is covered by the Wyoming Department of Environmental Quality, Water Quality Division, Watershed Program Monitoring Quality Assurance Project Plan (QAPP), 2001. This water quality monitoring complies with state law, Wyoming Statute (W.S.) 35-11-103(b) and (c) and W.S. 35-11-302.

Updates

Analytic and sampling methods change frequently. Either entire SOP's or individual pages may be revised. Variances or deviations from referenced methods, procedures, protocols, and SOP's are noted in the body of this SAP by reference in an explanation in Appendix B, SOP's and Methods, "Deviations from DEQ SOP, And Reasons for". Original Document pages are dated December, 2011 on the lower left hand side of the page. Revised pages will say Revised (date). From time to time, there may be a need for additional SOP's. New SOP's will have a date different from December, 2011. The Distribution List herein will be used to coordinate the delivery of any revisions. Both this SAP and the revisions will be available electronically on the MCD's web site (http://meeteetsecd-wy.gov) and/or revised pages will be printed and distributed. Persons who need to know whether a revision is in progress on an SOP or a new SOP has not yet been released should contact the MCD Resource Specialist using the information on the cover page. Persons, groups or organizations which collect data on behalf of the MCD for the WYDEQ-WQD, Watershed Program, under contracts, assistance agreements (cooperative agreements, grants), or interagency agreements, in response to statutory or regulatory requirements are responsible for knowing and applying the information this manual contains, and for maintaining an up to date manual.

Disclaimer

This document has been reviewed, approved and released in compliance with Wyoming Department of Environmental Quality, Water Quality Division, Watershed Protection Program policy. Reference to any specific commercial product, process or service by trade name, trademark or manufacturer does not necessarily constitute or imply its endorsement, recommendation or favoring by the Meeteetse Conservation District. Every reasonable effort is made to accurately describe the actual technical and administrative activities and to check for errors in the descriptions, methods and chemical reagents. However, users should read each SOP carefully and question any possible errors. The Meeteetse Conservation District does not claim that this document is free of mistakes.

II. PERSONNEL

Steffen Cornell and Blaise Allen are Resource Specialists that report to the MCD Board of Supervisors and have primary responsibility for all operations under this SAP. Other personnel or contract services may be utilized as necessary.

Table 1. Qualifications and Training	**Cornell**	**Allen**
Bachelor of Science Degree	Environmental Science and Wildlife Biology	Agroecology
Previous Field Experience	Yes	Yes
Watershed 101 (WACD/ University of Wyoming)	Yes (2012)	Yes (2013)
Water Quality 101 (WACD/ University of Wyoming)	Yes (2012)	Yes (2013)
Module II Training (WACD/University of Wyoming)	Yes (2012)	Yes (2014)
Module III Training (WACD/DEQ/University of Wy)	Yes (2012)	Yes (2013)

III. Sampling Locations and Timing

Designated Primary Sampling Sites

The locations shown in Table 2 are the designated primary sampling sites for the Greybull River watershed. Private property access requires permission from landowners at all sites except GR33. Permissions are on record in the MCD office, as stated in Appendix D of this SAP. If for some reason a sample cannot be collected at the designated site, a notation will be made on the data sheet and/or the Field Log Book. See Appendix A for site maps.

Table 2. Surface Water Sampling Sites, Greybull River Watershed, HUC10080009

I.D.	*Primary Sampling Site Name*	*Legal Description (6th P.M.)*	*Latitude*	*Longitude*	*Land Ownership*
WR8	Wood River	NE/4 SE/4 Sec. 30 -T47N - R101W	44° 0.536	-109° 1.109	Private
GR46	Greybull River in Meeteetse	SE/4 SE/4 Sec. 5 – T48N - R100W	44° 9.334	-108° 52.586	Private
GR30	Greybull River at Road 3LE	SW/4 NW/4 Sec.28- T51N - R98W	44° 21.771	-108° 39.018	Private
GR60	Upper Greybull River above Wood River	SW/4 NW/4 Sec. 30 -T48N- R102W	44° 6.205	-109° 8.582	Private
GR33	Greybull River at Sheets Flat Road 3SL	SE/4 NW/4 Sec. 6 -T50N - R98W	44° 20.307	-108° 41.175	BLM

Additional Sampling Sites

The MCD's sampling program would best be described as using a trend based sampling methodology and may be modified based on interpretation of the acquired data. MCD may conduct additional sampling in cooperation with other Conservation Districts and/or as requested by Cooperators within the District. Single and replicate samples may be collected throughout the watershed to provide additional information as needed.

For addition or deletion of primary sampling sites refer to "QA/QC - Corrective Actions".

Timing

Samples may be taken in months shown in Table 3. Blanked months indicate sampling is not currently planned: Due to spring flows and other circumstances, the MCD sampling schedule will shift from year to year. For the 2014 sampling season we will start on May 9th, 2014 and will 5 samples in 60 days, 10 days apart (Wyoming's Methods for Determining Surface Water Quality Condition and TMDL Prioritization, 2014 – pp. 13-14) through the end of September.

Table 3 – Sampling Timing Matrix

				Primary Sampling Season								
					Contact Recreation Season							
Parameter	***J***	***F***	***M***	***A***	***M***	***J***	***J***	***A***	***S***	***O***	***N***	***D***
Chemical												
Temperature				**X**	**X**	**X**	**X**	**X**	**X**	**X**		

pH				X	X	X	X	X	X	X		
Conductivity				X	X	X	X	X	X	X		
Dissolved Oxygen												
E. coli				X	X	X	X	X	X	X		
Turbidity				X	X	X	X	X	X	X		

- *E. coli* and turbidity samples – Three multiple-sample sets (a minimum of five water samples taken at least ten days apart within 60 days) suitable for determination of the geometric mean (pg. 75, WDEQ SOP, 2011) should be taken within the primary sampling season. Two of those sets should be taken within the contact recreation season. Additional samples or sample sets may be collected throughout the watershed as needed at any time.
- Physical and chemical measurements (Temperature, pH, and conductivity) – Should be made whenever *E. coli* or chemical samples are taken, and at a minimum should be made six (6) times per year, including five (5) times in the primary sampling season and four (4) times in the contact recreation season.
- Chemical samples - Should be taken quarterly, once each in spring, summer, and fall. A winter sample should be taken if time and conditions permit.
- Data collected using InSitu Troll® 9500 multiprobe with appropriate sensors is not currently utilized, but may be in the future.

IV. Sampling and Analysis

Safety & Water Velocity

Watershed Program safety precautions define any stream depth greater than 2.5 feet AND with a current velocity greater than 3.3 feet per second as NOT wadeable. Pools, if the current velocity is less than or equal to 0.6 feet per second, are defined as wadeable to chest height. In any other circumstances, wadeable conditions are at the discretion of the individual sampler, but in no case are samplers to enter any waters, which in their best professional judgment may present a hazard to human health and/or safety. Samplers are required to observe all safety precautions.

If a stream is determined to be not wadeable at its mid-channel, then, **based on the sampler's safety and only if the sampler believes that the sample will properly represent the stream**, a sample may be collected "from well-mixed sections of the channel below the water surface" (DEQ SOP "Coliform Bacteria Sampling Procedure"). Field notes should document and describe that this protocol was used and that the sample was not collected at mid-channel.

MCD maintains a file containing Material Safety Data Sheets (MSDS) for the chemicals, materials, and/or substances used under this SAP. The MSDS file is always available to personnel.

Table 4-Emergency Contact information

Name and Title	*Agency*	*Contact Information*
Steffen Cornell Resource Specialist	Meeteetse Conservation District	1906 State St. Meeteetse, Wy 82433 Phone: 307-868-2484 Mobile: 269-274-0905 Email: mcdrstctwest.net
Blaise Allen Resource Specialist	Meeteetse Conservation District	1906 State St. Meeteetse, Wy 82433 Phone: 307-868-2484

		Mobile: 307-272-7265 Email: mcdrs2tctwest.net
West Park Hospital	Nearest Hospital	707 Sheridan Ave, Cody, WY 82414 (307) 527-7501

Sample and Data Collection

General:

- The field log book will be maintained according to page 227 of WDEQ SOP, 2011 and 2007 QAQC Checklist.
- Field data sheets shall be maintained and reviewed according to page 11 of WDEQ SOP, 2011 and 2007 QAQC Checklist.
- Photographic documentation shall be maintained according to page 235 of WDEQ SOP, 2011.

E. coli Samples:

"Coliform Bacteria Sampling Procedure" (pg. 59, WDEQ SOP, 2011): Samples will be taken from as nearly as possible to the middle of the moving stream or its primary channel just below the water surface.

Samples should be collected as follows using sterile Whirl-Pak™ bags, labeled in the field at the sampling location with, date time, unique sample I.D., parameter, and the sampler's official three initials documented in the field log as described in Section V, "Sample Identification" (if transfer to an incubation vessel is to be made immediately upon leaving the stream, the Whirl-Pak™ bag may be considered a sterile transfer container and complete labeling shall not be required):

- Using the aseptic technique, tear off top of plastic bag at perforation and pull tape tabs outward to open bag. Bag is held by ends of wire closure with both hands to collect sample.
- Sample shall be collected immediately after breaking the sterile seal of the Whirl-Pak™ bags.
- Facing upstream, dip bag into water as far out in front of sampler as possible with both hands holding wire ends, quickly plunge opened bag below water surface. Sample should be collected in one swift motion to prevent loss of thiosulfate tablet (if required).
- Avoid contact with stream bed or bank to prevent fouling water. In streams with slow currents, sampler may have to wait for suspended sediment disturbed from channel bottom to clear from sampling location.
- If water level in bag is above fill line, dispense water from bag until appropriate sample volume is contained. An ample amount of airspace is needed to facilitate mixing by shaking once bag is closed.
- Pull wire ends to close bag. Holding wire ends firmly with both hands, whirl or spin bag three (3) revolutions. Bend ends of wire closure inward and opposite of bag fold. Twist wire ends together to secure.

Samples shall be:

- Decanted into the incubation vessels as soon as possible (using aseptic technique) and labeled at the time of transfer - maintaining the original sampling date and time - with date, time, unique sample I.D., parameter, and the sampler's official three initials documented in the field log as described in Section V, "Sample Identification".
- Immediately packed carefully into iced cooler. **Samples must be iced immediately and kept at a temperature of 1-4°C until initiation of analyses and sample containers cannot be immersed in water (e.g. melted ice water) during transit or storage.**

- Transported to the MCD office (or an entity authorized under this SAP) for processing.
- **Processed within 6 hours of collection.** (DEQ SOP "*Escherichia coli* & Total Coliform Bacteria").

Relevant sample information data must be recorded on the sample Field Data Sheet (FDS) or in the log book. Appropriate site information shall be entered into the Field Log Book prior to leaving the site. (pg. 227, WDEQ SOP, 2011). Site Photos must be taken.

A trip blank must be used and a minimum of one duplicate will be collected per sampling trip. Additional duplicates will be taken as necessary to provide at least one duplicate for every ten samples collected. A field blank must also be used and minimum of one duplicate will be collected per sampling trip.

Water sample remaining in the Whirl-Pak™ after the *E. coli* sample is decanted may be retained for other testing purposes based on the presence or absence of Na-thiosulfate.

Sampling for *E. coli* to provide credible data will consist of collecting a minimum of five samples within a 60-day period at least ten days apart. The sampling objective is to provide a minimum of five samples from the sampling period passing QA/QC protocols and providing validated data suitable for deriving a geometric mean for the period.

E. coli Analysis:

Samples will be analyzed for *E. coli* using the Colilert® method ("*Escherichia coli* & Total Coliform Bacteria"; pg. 63, WDEQ SOP, 2011).

- The analysis will be performed by the RS according to Modified SOP specific to the Colilert® method.
- A laboratory blank must be run for each processing session.
- Allow 24 hours for incubator temperature to stabilize prior to use.
- Incubation will be at 35°C± 0.5°C for 26 ± 2 hours in a calibrated and monitored incubator.
- Samples will be analyzed immediately upon removal from incubator.

Physical and Chemical Measurements:

- Equipment used must be calibrated per this SAP and in proper operating condition.
- Air temperature should be measured at each site using the conductivity probe and recorded on the FDS prior to making subsequent field measurements.
- Conductivity, pH, and water temperature measurements should be made at each of the sampling locations as nearly as possible to the middle of the stream or main channel and recorded on the Field Data Sheet. Dissolved Oxygen may also be measured.
- Measurements should be made at the same location that *E. coli* samples are collected.

Turbidity Grab Samples:

- Should be collected any time an *E. coli* or chemical sample is taken, or that physical and chemical measurements are made.
- Should be preferentially collected as closely as possible in time to the *E. coli* sample and at the same point and depth in the stream.
- May utilize water remaining in the Whirl-Pak™ bag after decanting the *E. coli* sample.

Multiprobe Monitoring: MCD has the capability of using their multiprobe monitoring, but is not currently using them. If used in the future this SAP will be amended and the following will be

completed. For long-term data logging, the MCD has installed InSitu Troll® 9500 multiprobes at locations WR2 (Wood River at GVID Diversion), GR 4 (Greybull River at GVID Greybull River Dam), and GR7 (Greybull River at GVID Diversion), as shown on Table 1. The current configuration of multiprobe sensors is for conductivity, oxidation-reduction potential (ORP), pH, temperature, and turbidity.

Sample interval may be adjusted to meet needs as determined by operational experience. Readings may be logged as frequently as every 5 minutes, but it is expected that experience will lead to a 10 to 30 minute sample interval.

The Troll® 9500 multiprobes will be calibrated according to manufacturer's recommendations:

- Conductivity - two to three months.
- ORP - one to two months.
- pH - two weeks to two months.
- Conductivity - two to three months.
- Temperature - not user calibrated.
- Turbidity - Permanently stored calibration referenced to AMCO-AEPA-1 Styrene Divinylbenzene copolymer primary standards, may be user-calibrated if desired.

Calibration of the multiprobe sensors may be checked with commercially available standards during data collection periods prior to calibration in order to determine appropriate calibration intervals within manufacturer's guidelines.

Physical and Chemical Measurement Analysis:

The MCD currently uses the Hach HQ40D Multiparameter Meter to measure electrical conductivity, pH, and temperature.

- Its environmental requirements are: 0-50 °C (32-122 °F) at 85% non-condensing relative humidity.
- The meter must be kept within its 0-50 °C operational range during winter operation.
- The meter is waterproof, chemical-resistant, dust proof, and will float.
- Calibration is addressed in Section V of this SAP.

Dissolved Oxygen (DO). MCD does not currently measure DO, however we have the equipment and capability if need be. If it were measured, MCD would be using a Hach HQ40D Meter and DO probe (or equivalent). The meter would be calibrated daily prior to sampling. Calibration would be field-checked during the sampling period at intervals not exceeding 4 hours and at the end of the sampling day. (Water-saturated air with re-calibration performed if water-saturated air reading is not within 97%-103%.) Water flow across the probe must be 20 cm/sec (0.66 ft/sec) or greater.

pH will be measured using a Hach HQ40D Meter and pH probe (or equivalent). The meter will be calibrated daily prior to sampling.

Specific Conductivity will be measured using a Hach HQ40D Meter and conductivity probe (or equivalent). The calibration will be checked using a standard calibration solution in the range of 1000 to 1500 µS daily prior to sampling. The meter will be recalibrated with a known standard if the check readings are not within 5% of the check standard.

Streamflow data from the USGS "GREYBULL RIVER AT MEETEETSE, WY" station 06279500 and other sources may be used where appropriate. The USGS Meeteetse data is available at: http://wy.water.usgs.gov/data.htm#Streamflow and http://waterdata.usgs.gov/wy/nwis/uv/?site_no=06276500.

Water velocity may be measured in conjunction with samples and measurements taken under this SAP. If a current meter is not used, then the travel time for a floating object to traverse a measured distance of at least ten feet in the area in which the samples or measurements are taken, and representing the velocity of the water sampled, may be used to calculate the water velocity (Modified SOP "Current Velocity, Measuring for Monitoring"). Highly buoyant objects such as ping-pong balls will not be used. The distance and time will be recorded in the field notes.

Temperature of water will be measured using a Hach HQ40D Meter and conductivity probe (or equivalent) in conjunction with the conductivity measurement(s). The probe does not require thermal calibration but will be checked for thermal accuracy against a reference thermometer on at least an annual basis.

Temperature of air at the sample site may be measured using the Hach HQ40D Meter and conductivity probe prior to the water measurements.

Turbidity will be measured using a HACH Portable 2100P Turbidimeter either in the field or at the MCD office. Its environmental requirements are: 0-50 °C (32-122 °FC). **The meter must be kept within its 0-50 °C operational range during winter operation.** The calibration will be checked daily prior to testing using Gelex® secondary standards or Hach StablCal® Stabilized Formazin turbidity standards. The meter will be recalibrated according to manufacturer's instructions if standard readings vary from known values by more than 5%.

Chemical Grab Samples:

Meeteetse Conservation District does not currently collect chemical analysis data. However, the district intends to in the future, as it has in the past. District staff will follow the following procedures if/when chemical analysis data is needed. Laboratory personnel will have prepared and shipped the appropriate sample containers before the sampling season begins. These bottles, vials and/or Whirl-Paks contain the correct preservatives. **DO NOT RINSE THESE BOTTLES PRIOR TO FILLING**. Depending on the parameters to be determined, the number of bottles supplied will vary. If more than one site is to be sampled, it will be necessary to separate the bottles into sets. The label on each bottle will identify the set and the preservative (e.g. Site No. 1, Plain; Site No. 1, HNO3; Site No. 1, H2SO4; Site No. 2, Plain; Site No. 2, HNO3; etc.)

- Samples should be taken as nearly as possible to the middle of the stream or main channel with a clean transfer container at a depth of 0.6 times the total water depth.
- Remove the caps from the bottles, one at a time, fill, recap, fill out the label, cool to 4 °C (40 °F) as soon after collection as possible, and return the samples to the laboratory for analysis.
- In order to conform to E.P.A. sampling practices the collected samples should be returned to the laboratory in the same cooler in which the bottles were shipped. Before shipping the samples to the lab, it will be necessary to freeze the ice packs that were shipped with the sample bottles.
- Samples in the sealed cooler will be shipped to Analytical Services, Wyoming Dept. of Agriculture or other approved laboratory in time to meet SOP holding time requirements. UPS Next Day Air from Cody, Monday through Wednesday, is currently recommended.
- Duplicate samples shall be collected at an interval not fewer than one in ten sites consecutively sampled.
- Duplicate samples should be collected at random times during the day, week, and sampling season to provide a meaningful evaluation of sampling precision.
- Field blank samples should also be taken, per Blanks SOP (p. 191).

Chemical Grab Sample Analysis:

Meeteetse Conservation District does not currently collect chemical analysis data. However, the district intends to in the future, as it has in the past. District staff will follow the following procedures if/when chemical analysis data is needed. Chemical analysis under this SAP will be performed by Analytical Services, Wyoming Dept. of Agriculture, Laramie, Wyoming, according to the Modified SOP "Chemical Analytical Methods". Analysis basics are referenced in Appendix B3 "Inorganic Water Chemistry Methods used by the Wyoming Department of Agriculture Analytical Services Laboratory".

Analytes are: Ca, Mg, Na, K, Se, TDS (ROE 180), TSS, pH, Conductivity, Turbidity, COD, TOC, Carbonate, Bicarbonate, Fluoride, Chloride, Nitrate as N, Nitrite as N, Ortho Phosphate, sulfate, Total Phosphate, Ammonia as N, and Hardness as CaCO3. A QA balance check will be performed.

The suite of analytes may be modified to suit the needs of the MCD program and other analytical laboratories may be used as referenced in the Corrective Actions section.

V. QUALITY ASSURANCE/QUALITY CONTROL

General:

- Quality assurance will be achieved by following the Wyoming Department of Environmental Quality Manual of Standard Operating Procedures for Sample Collection and Analysis that are applicable to this Plan (listed in Appendix B).
- Deviations from referenced methods, procedures, protocols, and SOP's are noted in the body of this SAP by the use of the term "Modified SOP". An explanation is provided in Appendix B, "SOP's and Methods, Deviations from DEQ SOP, And Reasons for".
- A copy of this SAP will be taken to the field.
- This SAP and a copy of the DEQ Manual of Standard Operating Procedures for Sample Collection and Analysis will be maintained in the district office for reference.
- Calibration of equipment will be according to the manufacturer's guidelines.
- Calibrations will be recorded in the calibration logbook.
- Calibration materials and standards will be used in accordance with manufacturer's recommendations.
- Samples for outside lab analysis will be collected following the Wyoming Department of Environmental Quality Manual of Standard Operating Procedures for Sample Collection and Analysis, as modified in this SAP.
- Analytical Laboratory instructions for storage and transportation will be followed.
- Blank and replicate samples will be used as referenced in this SAP and the incorporated SOP's to provide data validation.

The Wyoming Association of Conservation Districts provides training for district personnel in water quality monitoring.

- The MCD will emphasize continuing education and support DEQ and WACD educational efforts.
- The MCD will provide as much education and training for its personnel as is reasonably possible.

Field Log Book

A Field Log Book will be kept by sampling personnel. Field conditions, field observations, sampling location information and narrative information concerning any special circumstances or corrective action will be recorded in the Field Log Book, signed and initialed according to Modified SOP. The senior MCD staff member present shall determine who is responsible for data entry.
The Field Log Book will remain in the District's office when not in use.

A copy of the Field Log Book will be made and kept updated within one working day.

Sample Identification (Modified SOP)

The sample identification will be recorded on the sample container, on the Chain of Custody form, on the lab's analytical report, and in the Field Log Book.
Sample labeling must identify seven elements in this order:

1. Sample Date in the format yyyy-mm-dd
2. Time of sample 24 hr. clock format hh:mm
3. Code for normal (NL), duplicate (D*n*), replicate (R*n*), split (S*n*), spike (SK), combined (CO), or blank sample (BK) where *n* is an integer or letter unique to that sample.
4. Sample Site I.D. code
5. 4-character Parameter Code. (chem, coli, turb, *othr*), defined in SAP and in the Field Log Book, and where *othr* may be any relevant four character (maximum) code.
6. The sampler's three initials documented in the Field Log Book on the inside front cover
7. The name or chemical formula of any preservative or additive used ("NaT" may be used as an abbreviation for sodium thiosulfate), blank if none.

Items 1 through 5 make up the unique Sample I.D. used by MCD, to be entered in the Sample ID Code field on the Chain of Custody form, and which should agree with the Sample I.D in the Field Log Book.

Example: **2014-10-15-13:24-R3-G46-coli-JBD** is the 3rd replicate *E. coli* sample taken October 15, 2014, at 1:24 PM from the Greybull River at Meeteetse by John B. Doe. No preservative or additive was used. This sample would become **2014-10-15-13:24-R3-G46-coli-JBD-NaT** when transferred to the 120 ml. incubation vessel (IDEXX) containing sodium thiosulfate.

Chain of Custody

Forms provided by the WDA Analytical Services Laboratory serve as chain of custody forms. The forms include sample ID, date, time and the signature of the sampler. Employees of the lab record the date and time when the sample is received and assign the sample a lab ID. Analysts at the lab record the time at which procedures are started and the time when the sample is read. The laboratory manager signs off on the completed data sheet. Hard copies of these records remain in the laboratory office and a copy is sent electronically to the MCD office. Two hard copies will be kept on file and electronic copies will be maintained as specified in the Data Management section of this SAP.

Forms used by MCD for reporting Colilert® analysis serve as chain of custody forms. The forms include sample ID, date, time and the signature of the sampler and record the date and time when the sample arrives at the MCD office. The sample I.D is used as the analysis I.D. The MCD analyst(s) records the time at which procedures are started and the time when the sample is read. The RS shall sign the completed data sheet. The original handwritten and at least one copy shall be kept on file in the MCD office.

Equipment Calibration

The following equipment used and maintained by the MCD requires calibration:

Cole Parmer 39060-10 Incubator. S/N: 0300104
HACH HQ40D Portable Multiparameter Meter. S/N: 140400102693
HACH Portable 2100P Turbidimeter.S/N: 020800027428

All equipment will be calibrated according to the manufacturers' recommendations. A calibration log will be kept with the equipment to record calibrations completed. The log will include the dates of

calibration, calibration solutions, expiration dates, other pertinent information, and initials of the person performing the calibrations.

The MCD does not currently use the InSitu Troll® 9500 Multiprobe, but if this SAP is amended for the use of this instrument, Resource Specialists will calibrate to the the manufacturers' recommendations. The InSitu Troll® 9500 Multiprobe calibration log will be kept at the MCD office when not in use.

InSitu Troll® 9500 Multiprobe components: Prior to annual deployment, all probes requiring calibration will be calibrated..

Probe	**Standard Calibration**	**Optional Calibration**	**Maximum Run Interval**
Conductivity	*InSitu "Quick Cal"	1000 to 1500µS/cm standard solution	3 months
ORP	InSitu "Quick Cal"	n/a	2 months
pH	InSitu "Quick Cal"	2 or 3-point (4.0, 6.8 or 7.0, & 10.0 buffers)	2 months
Temperature	** n/a	n/a	n/a
Turbidity	*** n/a	Up to 4 points	2 months

* At 25°C: pH=7.00, ORP=224 mV, Conductivity=8000µS/cm
** pre-deployment check against certified thermometer ± 0.5 °C

Dissolved Oxygen may be measured using a HACH HQ40D Meter and dissolved oxygen probe. Calibration will be performed in water-saturated air daily prior to sampling. The internal barometer should be checked against the MCD weather station barometer when calibrating at the MCD office. The meter will be field-checked (water-saturated air) during the sampling period at intervals not exceeding 4 hours and re-calibrated if the reading is not within 97%-103%.

Incubation temperature of the Cole Parmer Model 39060-10 incubator will be checked prior to and during use with a certified thermometer to insure incubation at ± 0.5 °C for Colilert® *E. coli* and Total Coliform Analysis. The Incubator digital controller will be recalibrated to keep thermal variation centered on the 35°C set point.

pH meter will be calibrated daily (two point-method) with standard pH 6.8 or 7.0 and pH 10.0 buffers prior to sampling. If sample pH values lower than 6.8 are anticipated then three-point calibration will be used with an additional buffer of pH 4.0. Note: the HACH HQ40D Meter has automatic calibration temperature compensation from 0 to 60 °C .

Specific Conductivity will be measured using a HACH HQ40D Meter and conductivity probe (or equivalent). The calibration will be checked using a standard calibration solution in the range of 1000 to 1500 µS daily prior to sampling. The meter will be recalibrated with a known standard if the check readings are not within 5% of the check standard.

Turbidity will be measured using a HACH Portable 2100P Turbidimeter either in the field or at the MCD office. The calibration will be checked daily prior to testing using Gelex® secondary standards or Hach StablCal® Stabilized Formazin turbidity standards. Recalibration will be performed using Hach StablCal® Stabilized Formazin turbidity standards if standard readings vary from known values by more than 5%.

Data Quality Objectives

Data quality objectives in terms of accuracy, precision and completeness are outlined in Table 5.

Table 5– Data Quality Objectives

Parameter	Precision from Duplicates	Accuracy	Resolution	Completeness	Method Reference
Temperature	± 10%	± 0.5°C	0.1°C	90%	EPA 170.1
pH	± 5%	± 0.02pH	0.01pH	90%	EPA 150.1
Conductivity	± 10%	± 1% full scale, excluding probe error	0 to 1999µS/cm	90%	EPA 120.1
Dissolved Oxygen	± 10%	± 1% full scale, excluding probe error	0.1% mg/L	90%	EPA 360.1
Turbidity	± 20%	± 2% of reading plus stray light from 0 to 1,000 NTU	0.01 NTU on lowest range	90%	EPA 180.1
E. coli	*40%	**	1 cfu/100mL	80%	WDEQ *E. coli* SOP
Conductivity (Multiprobe)	n.a.	0.5% or 2µS/cm	1µS/cm	70%	EPA 120.1
ORP (Multiprobe)	n.a.	± 4.0mV	1.0mV	70%	Std. Methods 2580
pH (Multiprobe)	n.a.	± 0.1pH	0.1pH	70%	EPA 150.2
Temperature (Multiprobe)	n.a.	± 0.1°C	0.1°C	70%	EPA 170.1
Turbidity (Multiprobe)	n.a.	± 5% or 2 NTU/FNU	1NTU	70%	ISO 7027

*Relative % difference between two different samples.
**Duplicate counts of the number of positive wells identified from a Quanti-Tray® sample for the same analyst should agree within 5% and those between two different analysts within 10%.

Corrective Actions

In order to identify any problem(s), the MCD Resource Specialist will conduct an assessment of the data sampling and analysis at least once per year. If a major problem exists, corrective action will be taken immediately and documented. In those situations where independent expertise is needed to assess a certain aspect of the project, the district should request technical assistance from the Wyoming Department of Environmental Quality (DEQ), the Wyoming Department of Agriculture, or other appropriate entities.

Analytical Laboratories.

Analytical Services Lab
174 Snowy Range Road
Laramie, WY 82070
Phone: (307) 742-2984
Fax: (307) 742-2156

This SAP may be amended to include additional analytical laboratories.

Audits. The Wyoming DEQ Project Officer or other third party entity may at any time request a technical audit in order to evaluate compliance with this SAP. One week or more advance notice shall be given, as is appropriate for the circumstances.

A technical audit can consist of site visits to evaluate sample collection and/or laboratory activities, a technical review, and/or an evaluation of performance. This includes assessments of any contractor or sub-contractor performing sampling, analysis, or any other activity directly related to the program. If any major problems are identified, MCD should request technical assistance from an appropriate source.

***E. coli* data.** The MCD Resource Specialist will verify that:

- Holding times do not exceed 6 hours and
- All data fields are completed on all forms used.
- Blanks and replicate samples were properly used and identified.

Chemical data. The MCD personnel will work cooperatively with the analytical laboratory to verify that all requirements are met. MCD has a copy of the lab's QAPP available at the MCD office. If chemical data is questionable or values seem odd, the cause will be investigated and appropriate remedial measures employed.

The MCD may modify the list of analytes to suit the purposes of the monitoring program.

Primary Sampling Sites may be added or deleted under this SAP. A log of those changes will be maintained in Section III "Sampling Locations and Timing, Designated Primary Sampling Sites".

VI. DATA MANAGEMENT

Data Validation

The Resource Specialists will be responsible for maintaining the data inventory, the data sheets, Field Log Book, and laboratory notebooks. The Resource Specialists will crosscheck each other's work, checking for errors in identification, decimal placement, dates, times, units reported, and comments.

Once data are generated, they will be compiled in a digital file, and a paper copy will be kept as well. Transferred data will be reviewed and verified in accordance with data quality objectives.

Digital data will be printed out in lists and/or as graphs with lists and checked against original data sheets. The Resource Specialist will be responsible for correcting data entry errors. It is the responsibility of the Resource Specialist to evaluate the raw data generated by the contract laboratory for appropriate numeric reduction, data quality, and accuracy. All data will be reviewed and reported in units specified at the detection level of the analytical methods used.

Sample results will be evaluated individually by performing appropriate mathematical analysis for precision or accuracy for each sample, where appropriate.

Data will be reported in standard units, customary for the specific parameters and those units will be stated. For example, Colilert® *E. coli* data will be reported in units specific to that method, such as Most Probable Number (MPN), conductivity will be reported in μS/cm or μmhos/cm, turbidity will be reported in NTU, and most concentrations as mg/l or percent. Scientific notation will be used if

necessary. Significant figures should correlate with detection levels. Tables, graphs, charts, and narrative discussion, may be used where appropriate.

Data from quality assurance and quality control samples will be compared to established data quality objectives. Sampling data that does not meet data quality objectives will be evaluated on a case-by-case basis to determine if the data may be useful for watershed planning or may provide useful provisional information relative to water quality objectives. Unqualified or provisional data may, or may not, be released by the MCD at the discretion of the MCD Board of Supervisors as specified in section "*Data Availability*".

The Resource Specialist will evaluate completeness, accuracy, precision, and comparability. If the data quality objectives have not or cannot be met, the problem will be addressed either by correcting errors in the system, or by adjusting the objectives.

Data Storage

Data will be maintained and kept on file at Meeteetse Conservation District, 1906 State St., Meeteetse, WY. The primary electronic copies of raw data sheets, geometric means and compiled data will be kept on the MCD computer.

- A backup copy shall be made on portable digital media and stored in a safe deposit box at a local bank or as otherwise directed by the MCD Board of Supervisors.

Data Availability

- The Resource Specialists shall have access to data.
- MCD shall provide copies of validated, credible data to the DEQ after completion of all QA/QC review and review by the MCD Board of Supervisors.
- All data submitted to DEQ will be accompanied by MCD quality control information.
- Data submitted to DEQ may be submitted to WACD.
- Data will be released to MCD cooperators according to relevant agreements or contracts.
- Authorization by the MCD Board of Supervisors is required for release of any data.
- A letter of transmittal signed by the MCD Resource Specialist will be used to verify authenticity of data released as part of the QA/QC of this SAP.

Reports

"Reporting" under this SAP means "the transfer of data to the DEQ".

- When duplicate or replicate samples are taken, the individual values of those samples will be preserved in the raw data set.
- Data reporting will include calculation of geometric means for E. coli data according to the DEQ SOP "Geometric Means" and the update found in the (April 2014) WDEQ methodology: Wyoming's Methods for Determining Surface Water Quality Condition and TMDL Prioritization, 2014 – pp. 13-14.
- An appropriate statistical representation of a set of duplicate or replicate samples, such as the arithmetic mean, may be used as the reported data point for that sample set.
- A means of qualifying out of range data, including analysis values less than or equal to detection limits, will be adopted if necessary. Methods used to properly represent out of range data i.e. "censored data" or "nondetects" are currently being evaluated. (U.S. Geological Survey, Statistical Methods in Water Resources)
- Data will be organized in spreadsheet format. Charts and/or graphs may be generated for illustrative purposes.

The Resource Specialist will be allowed to submit data and/or reports as specified in "*Data Availability*", subject to MCD Board of Supervisors' approval. Interim reports may be written and provisional data may be cited with the approval of the MCD Board of Supervisors.

The Meeteetse Conservation District may use water quality data acquired under this SAP in any of its plans, projects, or reports. As stated in the Introduction, the data will be a key component of continuing water quality and watershed management or improvement. It is anticipated that water quality data will strongly influence the Annual Plan of Work and Long Range Plan submitted to the Wyoming Department of Agriculture and to The Wyoming Association of Conservation Districts.

VII. ABBREVIATIONS AND ACRONYMS

DEQ	Wyoming Department of Environmental Quality
FDS	Field Data Sheet
MCD	Meeteetse Conservation District
NIR	Near infrared
QAPP	Quality Analysis Project Plan
QC/QA	Quality Control/Quality Analysis
RS	Resource Specialist
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
NaT	Sodium Thiosulfate
USDA	United States Department of Agriculture
WDEQ	Wyoming Department of Environmental Quality
WYDEQ	Wyoming Department of Environmental Quality
WACD	Wyoming Association of Conservation Districts

VIII. REFERENCES

HACH, Dissolved Oxygen Probe Instruction Sheet

HACH, Model PHC30103 pH Electrode Instruction Manual

HACH, Portable Turbidimeter Model 2100P Instrument and Procedure Manual

HACH, Quick Reference Guide, HQ40D Portable Multiparameter Meter

HACH, HQ40D Portable Multiparameter Meter Manual

Helsel, D.R., and Hirsch, R.M., 1992, Statistical methods in water resources: New York, Elsevier

Meeteetse Conservation District, 2011, Meeteetse Conservation District Long Range Plan

Meeteetse Conservation District, 2011, Meeteetse Conservation District Plan of Work

Meeteetse Conservation District, variously dated, unpublished, "Greybull River Watershed Information"

U.S. Geological Survey, Statistical Methods in Water Resources, Techniques of Water-Resources Investigations Book 4, Chapter A3, by D.R. Helsel and R.M. Hirsch, http://pubs.usgs.gov/twri/twri4a3/html/pdf_new.html

U.S. Geological Survey, variously dated, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A1-A9, available online at http://pubs.water.usgs.gov/twri9A.

USDA, 2003, Natural Resources Conservation Service National Handbook of Water Quality Monitoring.

WDEQ/WQD. 2011. Manual of Standard Operating Procedures for Sample Collection and Analysis. Wyoming Department of Environmental Quality, Water Quality Division, Watershed Program, Cheyenne, WY.

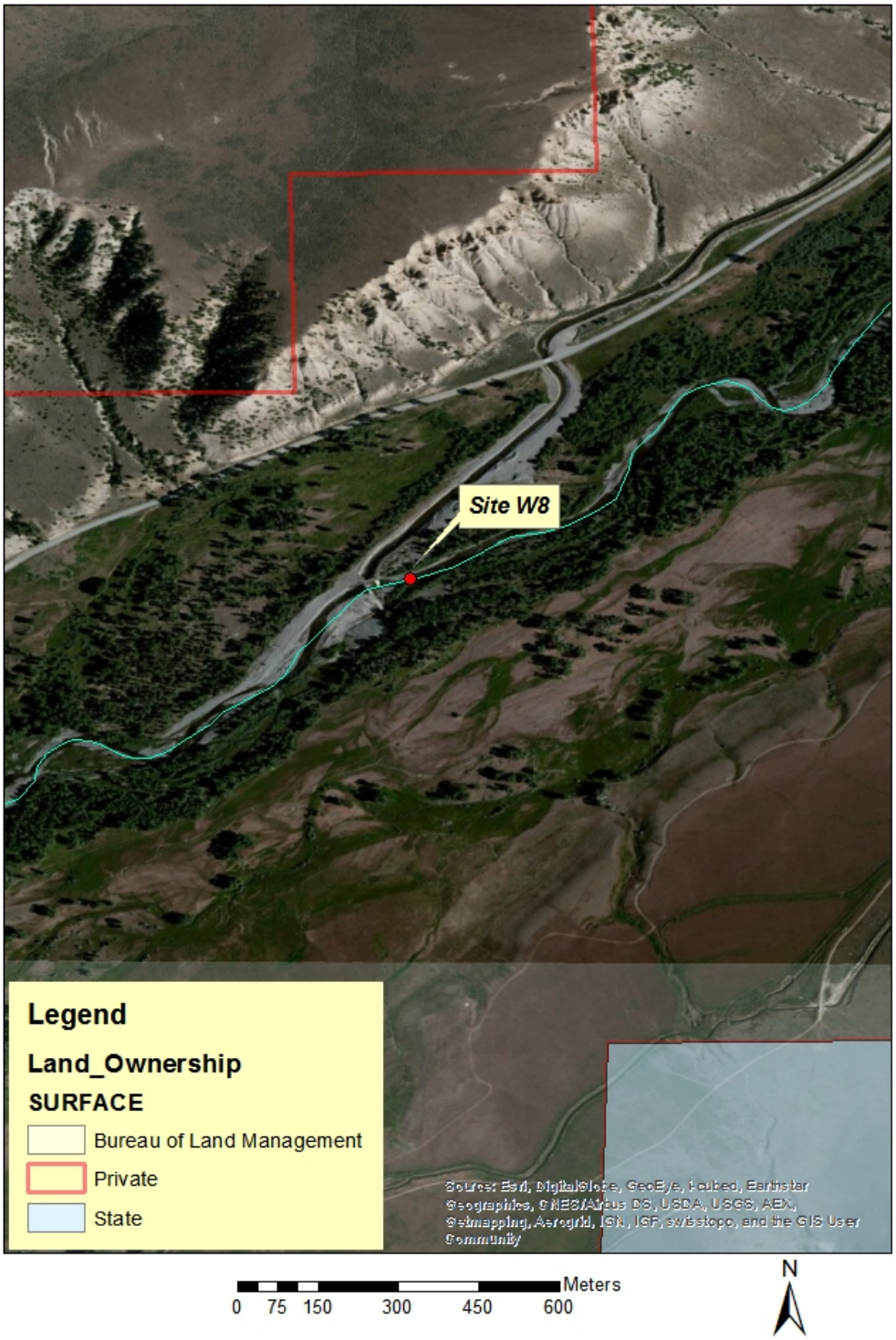
IX. DISTRIBUTION LIST

South Big Horn Conservation District.
Wyoming Association of Conservation Districts.
Wyoming Dept. of Agriculture, Analytical Services Laboratory
Wyoming Department of Environmental Quality, Water Quality Division, Watershed Program.

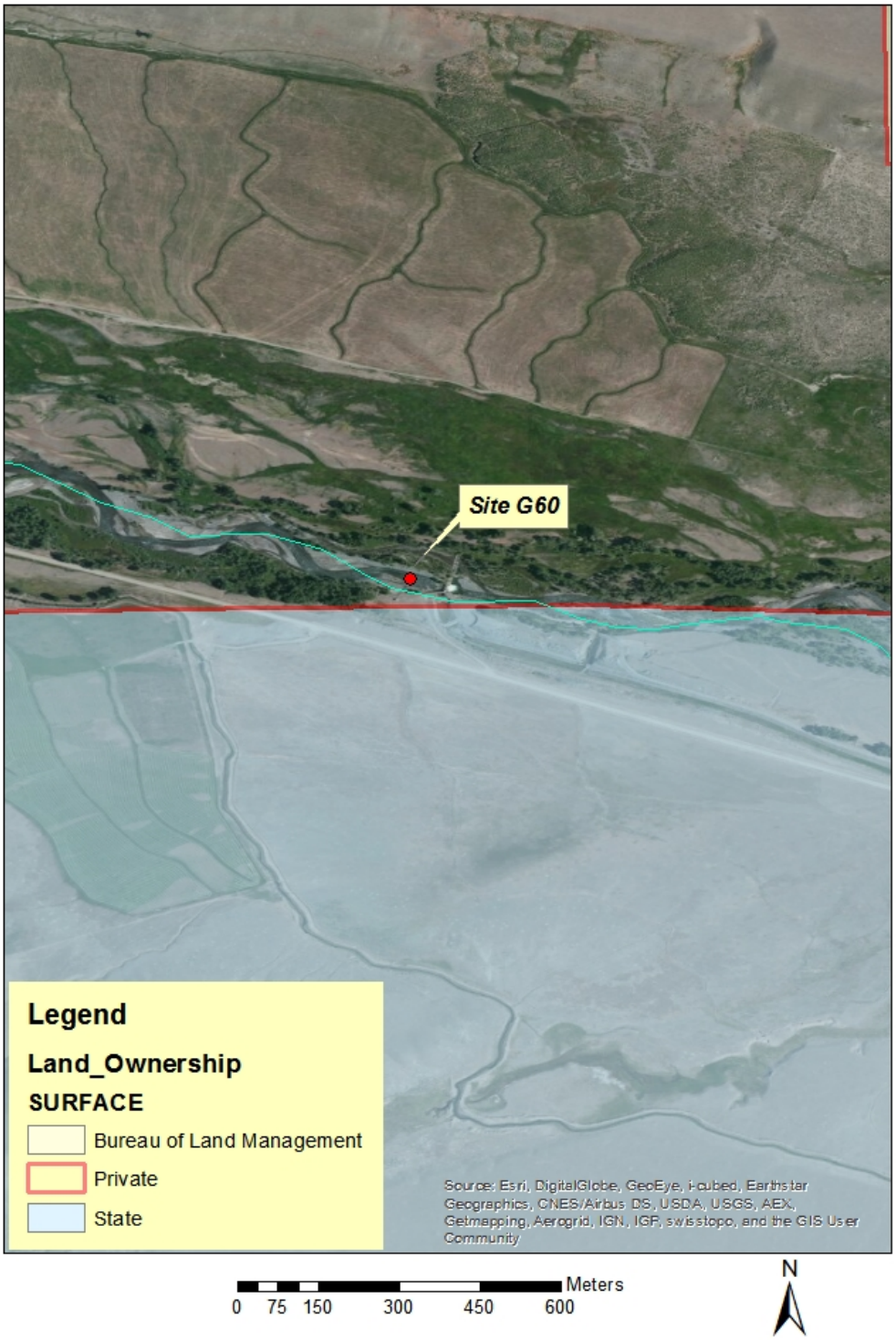
Appendices

A. Maps

Sampling Site W8

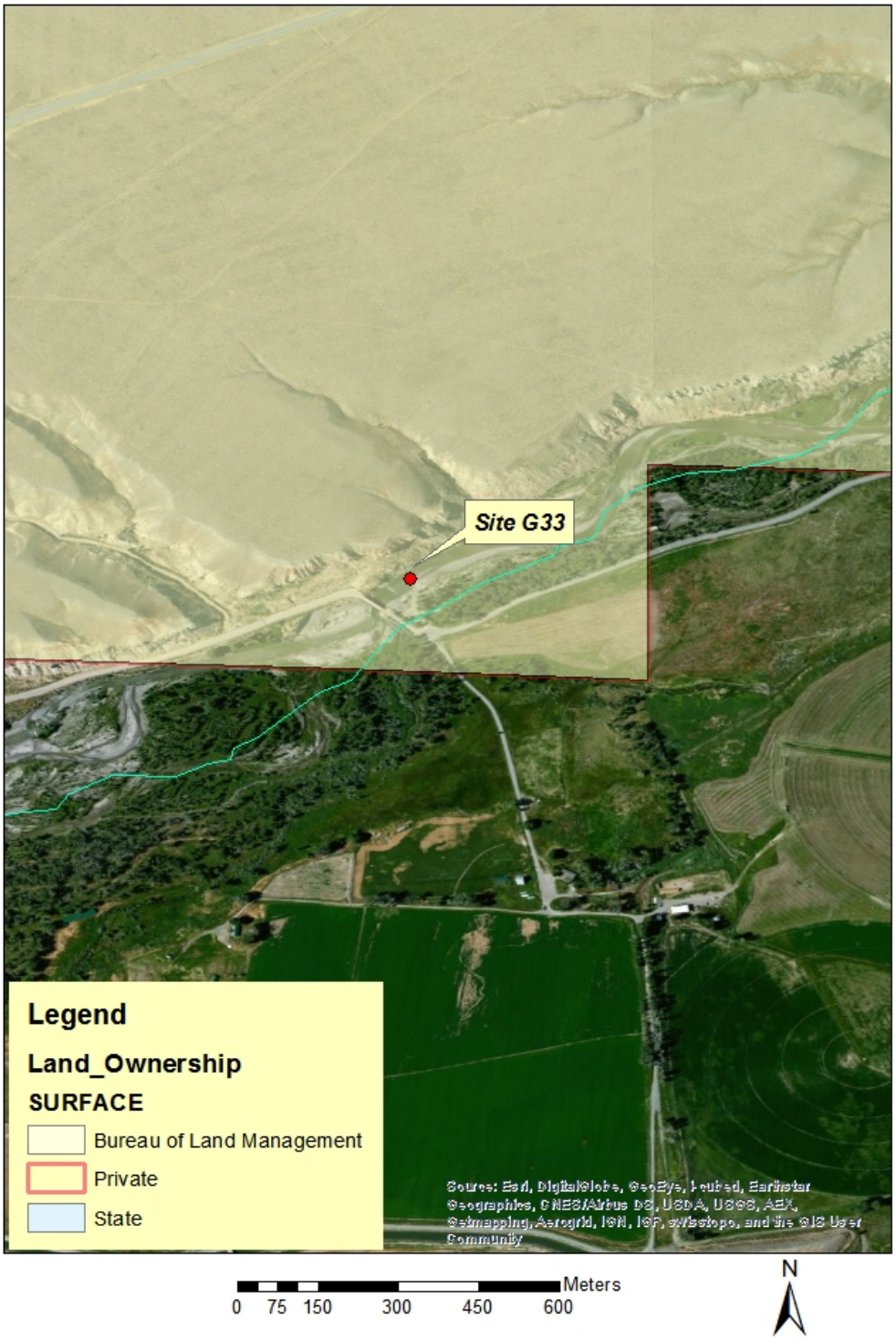


Sampling Site G60



Sampling Site G46

Sampling Site G33



Sampling Site G30

Travel Map

From the district office head west on US HWY 290 until it meets up with Wood River Road. Take Wood River Road for approximately eight miles where the Lower Sunshine canal bridge is located. Site W8 is located at the Wood River/Lower Sunshine Diversion. After sampling site W8, head back to HWY 290 and continue west. Follow that road for approximately nine miles to the Upper Sunshine diversion to get to site G60. After sampling G60, take HWY 290 back into Meeteetse and turn west on Colorado St. Site G46 is located at the USGS gage station. After sampling G46 take HWY 120 north of town until it meets up with county road 3LE. From here drive northeast until you meet up with road 3SL approximately 10 miles down the road. Site G33 is located at the Sheets Flat bridge. After completing sampling at G33 keep heading northwest on 3LE for 2.5 miles before turning east below the private ranch headquarters to get to site G30.

B. SOP,s and Methods

Many DEQ SOP's refer to "Each Field Office" DEQ job titles, and to resources available to the DEQ and not available to the MCD. Therefore, as used by the MCD, the term "Each Field Office" or other WDEQ offices in DEQ SOP shall be generally interpreted to mean the MCD, and the MCD may substitute alternative or equivalent resources to meet the intent of the DEQ SOP.

Critical DEQ SOP's from the Manual of Standard Operating Procedures for Sample Collection and Analysis, 2011 (* indicates Modified SOP):

PART 2 - BIOLOGICAL SAMPLING
- Coliform Bacteria Sampling Procedure
- **Escherichia coli* & Total Coliform Bacteria Colilert®-Defined Enzyme Substrate Method
- Geometric Mean, Calculating and Using

PART 3 - PHYSICAL SAMPLING
- *Current Velocity - Wadeable Streams and Rivers

PART 4 – CHEMICAL SAMPLING
- Conductance, Specific (Conductivity)
- Dissolved Oxygen (DO)
- pH

TurbidityPART 5 - QUALITY CONTROL, CUSTODY AND REPORTING
- Aseptic Technique
- Blanks
- Monitoring Electronic Data Entry
- Chain of Custody
- Completeness
- Data Archiving
- Data Validation
- Data Verification
- Duplicates
- *Field Log Books
- Instrument Calibration and Calibration Logs
- *Photographic Documentation
- Precision
- Quality Control Measures, Summary of
- Quality Control Report, Field
- Safety and Safety Equipment
- *Sample Collection
- *Sample Labeling
- Temperature Blank

Deviations from DEQ SOP, and reasons for:

<u>Sample Collection</u> - Samples may not always be taken from mid-channel: High water and reservoir releases may necessitate sampling when the stream is technically not wadable. Stream gradients are generally high with seasonal flow velocity commonly exceeding 3.3 ft/sec and depth at mid-channel in excess of 2.5 ft., precluding sampling at the stream channel midpoint. When the mid-channel is not wadable, the sample "should be collected from well-mixed sections of the channel below the water surface". (DEQ SOP "Coliform Bacteria Sampling Procedure".)

<u>Current Velocity</u>- Wadeable Streams and Rivers not calculated over a 10 ft. reach: Stream velocities in excess of 4 ft/sec make accurate timing using a floating object difficult on a 10 ft. reach. Timing through a 20 to 40 ft. reach should be more accurate.

Sample Labeling as defined in body of this SAP: The MCD sample I.D. system provides that the date code is part of the unique sample I.D., requiring less space for writing on the sample container and providing for use in Excel spreadsheets

Photographic Documentation: A minimum of three individual photographs of the sampling reach will be taken: looking upstream from the base of the reach, downstream from the top of the reach, and a photo taken at approximately the middle and perpendicular to the reach. A multi-photo panoramic set of photographs may be needed to properly capture details of the perpendicular view. Besides archiving as Photographic Documentation sheets, digital photos should be digitally archived in an unedited form.

Escherichia coli & Total Coliform Bacteria Colilert®-Defined Enzyme Substrate Method : To eliminate biohazard risk by locally available means, used IDEXX Quanti-Tray® and Quanti-Tray®/2000 will be sanitized by one of the following methods prior to disposal:

- Immersion for 1 hour in a chlorine bleach solution of 1 tablespoon bleach per gallon of water. All wells must be opened and exposed to the bleach solution.
- Exposure of the transparent side of the trays to UV light (strong sunlight or commercially available fluorescent U.V. source) for 2 hours.
- Immersion in a water bath having a minimum temperature of 60°C (140°F) for 30 minutes.

Field Log Book: This modified SOP ensures that information is in one location and in chronological order. A Field Log Book shall be maintained for all sampling done under this SAP.
The Field Log Book may differ from DEQ SOP in that:

- "Meeteetse Conservation District" and the District's current physical address and phone number shall be written on the outside front cover in the place of an individual sampler's name.
- Written or printed sampler's initials may be used.
- Field data recorded on a Field Data Sheet need not be entered into the Field Log Book.

This modified SOP may be used so long as (1) sampling is not funded by or performed on behalf of USEPA and (2) sampling is conducted in a linear chronological manner. At such time as criteria (1) or (2) cannot be met, then sampling personnel shall maintain individual Field Log Books under their name according to DEQ SOP.

WDA Analytical Services Laboratory Methods as of May 1st, 2014

Analytical Methods, Practical Detection Limits (PDL), Containers, Preservation, and Holding Times for Selected Analytes

The analytes listed in this table are frequently requested by Wyoming's Conservation Districts in their effort to determine whether or not surface water is impacted by agriculture or other activities in the drainage. The analytes requested depend on the water's beneficial uses and the type of activities potentially effecting its quality. This list is not all-inclusive; therefore the laboratory should be contacted during the design phases of a monitoring program.

Determination	1995 Std. Methods, 19th Ed.	EPA Method No.	PDL mg/L	Container	Preservation	Holding Time Max
Cations						
Ammonia	4500-NH_3 D		0.1	Plastic/Glass	H_2SO_4 to pH<2, Cool to 4°C	28 days
Calcium	3111B		0.1	Plastic/Glass	HNO_3 to pH<2	6 months
Magnesium	3111B		0.1	Plastic/Glass	HNO_3 to pH<2	6 months
Sodium	3111B		0.1	Plastic/Glass	HNO_3 to pH<2	6 months
Potassium	3111B		0.1	Plastic/Glass	HNO_3 to pH<2	6 months
Anions						
Alkalinity	2320B			Plastic/Glass	Cool to 4°C	14 days
Chloride	4110B, 4500-Cl-F	300.0	0.10	Plastic/Glass	Cool to 4°C	48 hours
Fluoride	4110B, 4500-F-F	300.0	0.10	Plastic/Glass	Cool to 4°C	48 hours
Nitrate	4110B, 4500-NO_3-F	300.0	0.10	Plastic/Glass	Cool to 4°C	48 hours
Nitrite	4110B, 4500-NO_2-F	300.0	0.10	Plastic/Glass	Cool to 4°C	48 hours
Phosphate, ortho		300.0	0.10	Plastic/Glass	Cool to 4°C	48 hours
Phosphorus, Total	4500-P B.5, 4500-P F.		0.020	Plastic/Glass	H_2SO_4 to pH<2	28 days
Sulfate	4110B, 4500-SO_4^{2-}-C	300.0	0.10	Plastic/Glass	Cool to 4°C	48 hours
Metals						
Selenium	3113B	200.9	0.005	Plastic/Glass	HNO_3 to pH<2	6 months
Other						
COD	5220D (Hach)		5	Plastic/Glass	H_2SO_4 to pH<2, Cool to 4°C	28 days
Conductivity	2510 B		1 uS/cm	Plastic/Glass	Cool to 4°C	28 days
pH	4500-H+ B	150.1		Plastic/Glass	None, Cool to 4°C	14 days
Solids, TDS	2540C	160.1	50	Plastic/Glass	Cool to 4°C	7 days
Solids, TSS	2540D	160.2	1.0	Plastic/Glass	Cool to 4°C	7 days
TOC	5310C	415.4		Plastic/Glass	H_2SO_4 to pH<2, Cool to 4°C	28 days
Turbidity	2130D	180.1	0.05 NTU	Plastic/Glass	Dark, Cool to 4°C	48 hours

C. Standard Forms

Meeteetse Conservation District

Total Coliform and E. coli Analysis Log (Colilert Quanti-Tray 2000)

Date(m/d/y): _____

Incubator: Cole Parmer Mod. 39060-10 S.N. 0300104

Incubator Temp: 35°C ± 0.5°C

Verified By: _____

Samples Received By: _____

Time [24 hr]: _____

Processed By:

Field Sampler(s):

Analyzed By:

Checked By:

Lab Sample ID # (yyyy-mm-dd-hh:mm-type-site-param-init-NaT)	Incubator In Date [m/d/y] Time [24 hr clock]	Incubator Out Date [m/d/y] Time [24 hr clock]	# Positive Wells: Total Coliform [yellow] # Large Wells	# Positive Wells: Total Coliform [yellow] # Small Wells	# Positive Wells: *E. coli* (fluorescence) # Large Wells	# Positive Wells: *E. coli* (fluorescence) # Small Wells	MPN/100 ml (Refer to MPN Table) Total Coliform	MPN/100 ml (Refer to MPN Table) Total E. coli	Sample Collection Date [m/d/y]	Sample Collection Time [24 hr clock]	Remarks Additional Information: Sample Site Locational Data [GPS, Narrative] and Analysis Information [blank, dupl., split, etc.] if not coded in sample ID

Remarks and Analytical Notes: (ST=sodium thiosulfate)
Incubation Temperature: 35°C ± 0.5°C. Maintaining incubator temperature is critical. If the temperature is not maintained for the entire test time, the test results are not valid and must be reported as "not valid" with the reason described in the Remarks section of this Form. Incubation time: 26 hours ± 2 hours (results definitive after 24 hours) Inoculated Colilert® samples must be placed in the incubator within 30 minutes after the reagent is mixed with the water sample. Sample dilutions must be processed within 30 minutes after preparation.

Field Data Sheet Water Quality Monitoring Program, Meeteetse CD Date:

Sampler: Notes: Photos:

Time	Site:	Temp (°C)	Conductivity (µS/cm)	TDS (Mg/L)	D.O (Mg/L) (%)	Barometer (hPa)	Flow (ft/sec)*	Comments
	Air		N/A	N/A	N/A	N/A	N/A	
	1							
	2							
	3							
	Site:							
	Air		N/A	N/A	N/A	N/A	N/A	
	1							
	2							
	3							
	Site:							
	Air		N/A	N/A	N/A	N/A	N/A	
	1							
	2							
	3							
	Site:							
	Air		N/A	N/A	N/A	N/A	N/A	
	1							
	2							
	3							
	Site:							
	Air		N/A	N/A	N/A	N/A	N/A	
	1							
	2							
	3							
	Site:							
	Air		N/A	N/A	N/A	N/A	N/A	
	1							
	2							
	3							

Office Review Initials: _____

D: Permissions

Of the five sites samples, four of them are on private land and one is on Bureau of Land Management. For the private landowners where the sample sites are located, as well as the access routes through other private property, permission forms were signed by the land owners and are on file at the MCD office. For the Bureau of Land Management no permission is required, however they were notified. The sampling site is accessed directly from the public road and no other properties are crossed.

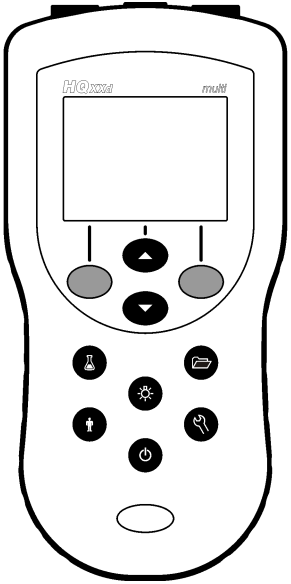
E. Equipment Manuals

DOC022.53.80017

HQd Portable Meter

06/2013, Edition 4

User Manual



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Specifications

Specifications are subject to change without notice.

Specification	Details
Dimensions	19.7 x 9.5 cm (7.75 x 3.75 in.)
Weight	335 g (0.75 lb) without batteries; 430 g (0.95 lb) with four AA alkaline batteries
Meter enclosure	IP67, waterproof to 1 meter for 30 minutes
Battery enclosure	Water resistant to 0.6 m (2 ft) for 15 seconds
Power requirements (internal)	AA Alkaline or rechargeable Nickel Metal Hydride (NiMH) batteries (4); battery life: up to 200 hours
Power requirements (external)	Class II, external power adapter: 100–240 VAC, 50/60 Hz input; 4.5 to 7.5 VDC (7 VA) output
Meter protection class	Class I
Storage temperature	–20 to +60 °C (–4 to +140 °F)
Operating temperature	0 to +60 °C (32 to 140 °F)
Operating humidity	90% (non-condensing)
5-pin input connector	M12 connector for IntelliCAL™ probes
8-pin input connector	The 8-pin connector enables USB and external AC power connectivity
USB/DC adapter	Peripheral and host
Data memory (internal)	500 results
Data storage	Automatic in Press to Read mode and Interval Mode. Manual in Continuous Read Mode.
Data export	USB connection to PC or USB storage device (limited to the storage device capacity). Transfer entire data log or as readings are taken.
Connections	Integrated USB type A (for USB flash memory device, printer, keyboard) and Integrated USB type B (for PC)
Temperature correction	Off, automatic and manual (parameter dependent)
Measurement display lock	Continuous measurement, Interval or Press to Read mode. Averaging function for LDO probes.
Keyboard	External PC keyboard connector via USB/DC adapter

General information

Revised editions are found on the manufacturer's website.

Safety information

NOTICE

The manufacturer is not responsible for any damages due to misapplication or misuse of this product including, without limitation, direct, incidental and consequential damages, and disclaims such damages to the full extent permitted under applicable law. The user is solely responsible to identify critical application risks and install appropriate mechanisms to protect processes during a possible equipment malfunction.

Please read this entire manual before unpacking, setting up or operating this equipment. Pay attention to all danger and caution statements. Failure to do so could result in serious injury to the operator or damage to the equipment.

Make sure that the protection provided by this equipment is not impaired. Do not use or install this equipment in any manner other than that specified in this manual.

Use of hazard information

⚠ DANGER

Indicates a potentially or imminently hazardous situation which, if not avoided, will result in death or serious injury.

⚠ WARNING
Indicates a potentially or imminently hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION
Indicates a potentially hazardous situation that may result in minor or moderate injury.

NOTICE
Indicates a situation which, if not avoided, may cause damage to the instrument. Information that requires special emphasis.

Precautionary labels

Read all labels and tags attached to the instrument. Personal injury or damage to the instrument could occur if not observed. A symbol on the instrument is referenced in the manual with a precautionary statement.

	This symbol, if noted on the instrument, references the instruction manual for operation and/or safety information.
	This symbol indicates that the marked item can be hot and should not be touched without care.
	Electrical equipment marked with this symbol may not be disposed of in European public disposal systems after 12 August of 2005. In conformity with European local and national regulations (EU Directive 2002/96/EC), European electrical equipment users must now return old or end-of-life equipment to the Producer for disposal at no charge to the user. ***Note:*** *For return for recycling, please contact the equipment producer or supplier for instructions on how to return end-of-life equipment, producer-supplied electrical accessories, and all auxiliary items for proper disposal.*

Product overview

The HQd series portable meters are used with digital IntelliCAL™ probes to measure various parameters in water. The meter automatically recognizes the type of probe that is connected to the meter.

Measurement data can be stored and transferred to a printer, PC or USB storage device.

The HQd series meters are available in 4 models:

- HQ11d—pH/mV/ORP
- HQ14d—conductivity, salinity, total dissolved solids (TDS), resistivity
- HQ30d—all IntelliCAL probes, 1 probe connector
- HQ40d—all IntelliCAL probes, 2 probe connectors

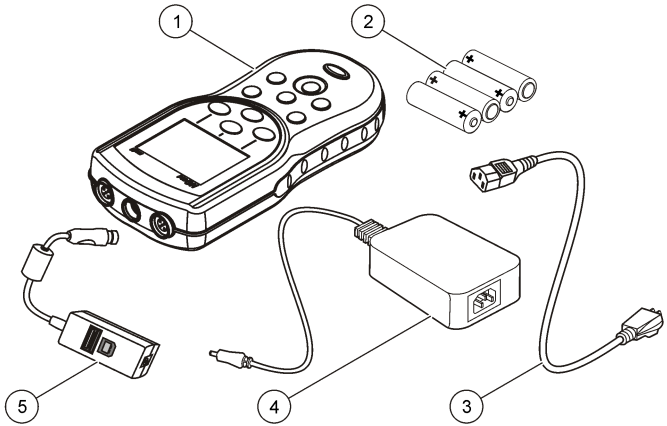
Features common to all models:

- Automatic probe and parameter recognition
- Instrument guided calibration procedures
- Calibration data stored in the probe
- Probe specific method settings for regulatory compliance and Good Laboratory Practice (GLP)
- Security Options
- Real-time data logging via USB connection
- USB connectivity to PC/printer/USB storage device/keyboard
- Bi-directional communication with PC-based systems via a virtual serial port connection
- Sample ID and Operator ID for data traceability
- Adjustable automatic shut-off

Product components

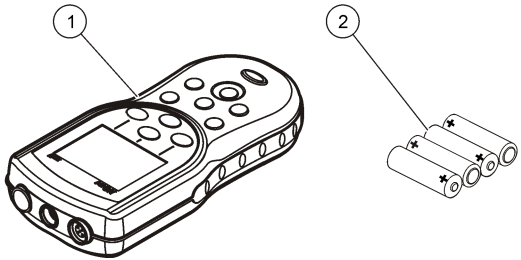
Refer to Figure 1 and Figure 2 to make sure that all components have been received. If any items are missing or damaged, contact the manufacturer or a sales representative immediately.

Figure 1 Meter components (HQ40d model)



1 Meter	**4** AC-DC power supply
2 AA batteries (pk/4)	**5** USB/DC adapter
3 AC power cord	

Figure 2 Meter components (HQ11d, HQ14d and HQ30d models)



1 Meter	**2** AA batteries (pk/4)

Installation

CAUTION

Multiple hazards. Only qualified personnel must conduct the tasks described in this section of the document.

Install the batteries

WARNING

Explosion hazard. Incorrect battery installation can cause the release of explosive gases. Be sure that the batteries are of the same approved chemical type and are inserted in the correct orientation. Do not mix new and used batteries.

NOTICE

The battery compartment is not waterproof. If the battery compartment becomes wet, remove and dry the batteries and dry the interior of the compartment. Check the battery contacts for corrosion and clean them if necessary.

NOTICE

When using nickel metal hydride (NiMH) batteries, the battery icon will not indicate a full charge after freshly charged batteries have been inserted (NiMH batteries are 1.2 V versus 1.5 V for alkaline batteries). Even though the icon does not indicate complete charge, 2300 mAH NiMH batteries will achieve 90% of instrument operation lifetime (before recharge) versus new alkaline batteries.

NOTICE

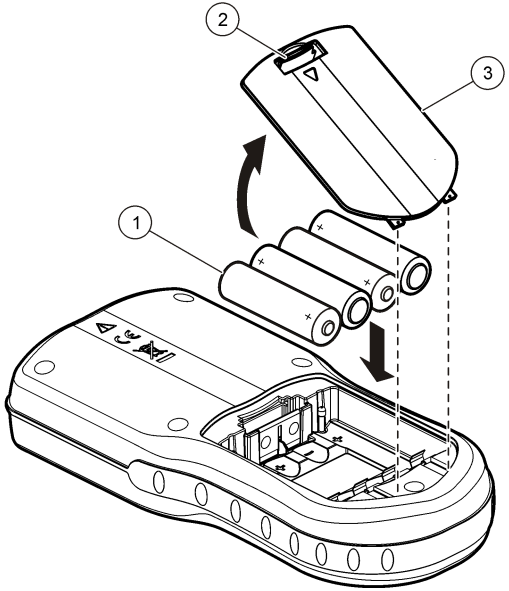
To avoid potential damage to the meter from battery leakage, remove the meter batteries prior to extended periods of non-use.

The meter can be powered with AA alkaline or rechargeable NiMH batteries. To conserve battery life, the meter will power off after 5 minutes of inactivity. This time can be changed in the Display Options menu.

For battery installation refer to Figure 3.

1. Pull the release tab on the battery cover and the remove the cover.
2. Install 4 AA alkaline or 4 AA nickel metal hydride (NiMH) batteries. Make sure that the batteries are installed in the correct polarity.
3. Replace the battery cover.

Figure 3 Battery installation



1 Batteries	**2** Release tab	**3** Battery cover

Connect to AC power

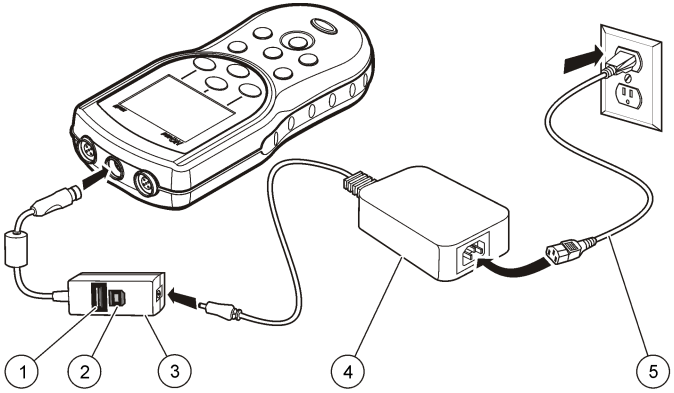
⚠ DANGER

Electrocution Hazard. AC power outlets in wet or potentially wet locations MUST ALWAYS be provided with a Ground Fault Circuit Interrupting (GFCI/GFI) circuit breaker. The AC-DC power adapter for this product is not sealed and must not be used on wet benches or in wet locations without GFCI protection.

The meter can be powered by AC power with an AC power adapter kit. The kit includes an AC-DC power supply, USB/DC adapter and AC power cord.

1. Turn the meter off.
2. Plug the AC power cord into the AC-DC power supply (Figure 4).
3. Connect the AC-DC power supply to the USB/DC adapter.
4. Connect the USB/DC adapter to the meter.
5. Plug the AC power cord into an AC receptacle.
6. Turn the meter on.

Figure 4 AC power connection

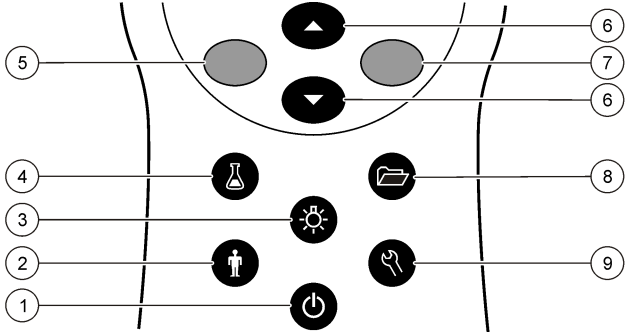


1 USB storage device/printer/Qwerty keyboard connection (USB peripheral)	**4** AC-DC power supply
2 Personal computer connection (USB host)	**5** AC power cord
3 USB/DC adapter	

User interface and navigation

User interface

Figure 5 Keypad description



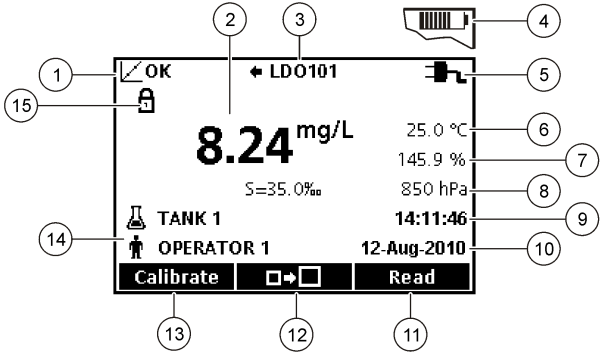
1 ON/OFF: turn on or turn off the meter	**6** UP and DOWN key: scroll through menus, enter numbers and letters or change the reading screen view
2 OPERATOR ID: associate data with an individual	**7** GREEN/RIGHT key: reads, selects, confirms or stores data
3 BACKLIGHT: illuminate the display screen	**8** DATA LOG: recall or transfer stored data
4 SAMPLE ID: associate data with a sample location	**9** METER OPTIONS: change settings, run check standards, view meter information
5 BLUE/LEFT key: calibrates, cancels or exits the current menu	

Display description

Measurement screen

The meter display shows the concentration, units, temperature, calibration status, operator ID, sample ID, date and time (Figure 6).

Figure 6 Single screen display



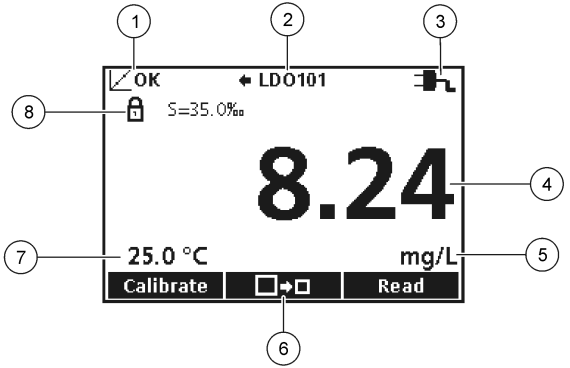
1	Calibration status indicator	**9**	Time
2	Main measurement value and unit	**10**	Date
3	IntelliCAL probe type and port indicator	**11**	Read (OK, Select)
4	Battery status	**12**	Display size icon
5	Power source	**13**	Calibrate (Cancel, Exit)
6	Sample temperature (ºC or ºF)	**14**	Sample and operator identification
7	Secondary measurement unit	**15**	Stability or display lock indicator
8	Tertiary units (for some probes)		

Big-screen mode

The font size of the sample reading can be increased or decreased with the △ key (Figure 7).

Note: *When two probes are connected, push and hold the △ key to select the big-screen mode. The big-screen mode can also be selected in the Display Options menu (Refer to* Set the display options *on page 20).*

Figure 7 Single-screen display—big-screen mode



1	Calibration status indicator	**5**	Main measurement unit
2	IntelliCAL probe type and port indicator	**6**	Display size icon
3	Power source or battery status	**7**	Sample temperature (ºC or ºF)
4	Main measurement value	**8**	Stability or display lock indicator

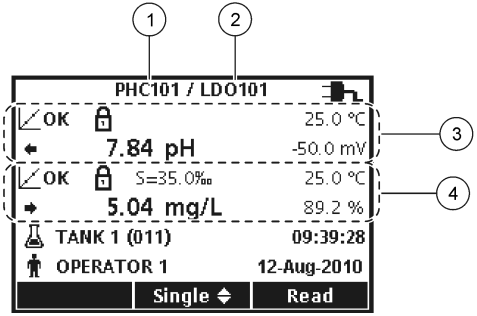
Dual-screen mode (HQ40d model only)

When two probes are connected to the HQ40d meter, the display can show the reading from both probes simultaneously or show just one probe (Figure 8).

Note: *For probe calibration, change the screen mode to the single screen mode.*

To change the screen mode to single or dual screen, use the △ and ▽ keys. In dual screen mode, the △ key will select the probe on the left and the ▽ key will select the probe on the right.

Figure 8 Dual-screen display



1	Probe that is connected to port on left	**3**	Measurement information for probe on left
2	Probe that is connected to port on right	**4**	Measurement information for probe on right

Navigation

The meter contains menus to change various options. Use the △ and ▽ keys to highlight different options. Push the GREEN/RIGHT key to select an option. There are two ways to change options:

1. Select an option from a list: Use the △ and ▽ keys to select an option. If check boxes are shown, more than one option can be selected. Push the BLUE/LEFT key under Select.

   Note: *To deselect check boxes, push the BLUE/LEFT key under Deselect.*
2. Enter an option value using the arrow keys:
   Push the △ and ▽ keys to enter or change a value.
3. Push the GREEN/RIGHT key to advance to the next space.
4. Push the GREEN/RIGHT key under OK to accept the value.

Startup

Turn the meter on and off

Push the ⏻ key to turn on or turn off the meter. If the meter does not turn on, make sure that the batteries are properly installed or that the AC power supply is properly connected to an electrical outlet.

Change the language

The display language is selected when the meter is powered on for the first time. The language can also be changed from the Meter Options menu.

Access to the language menu can be restricted with the Security Options. Refer to Security options on page 18.

1. Push the key and select Language.
2. Select a language from the list.

   Note: *While turning the meter on, the language can also be changed when the power key is pushed and held.*

Change the date and time

The date and time can be changed from the Date & Time menu.

1. Push the key and select Date & Time.
2. Update the time and date information:

Option	Description
Format	Select one of the formats below for the date and time. Use the △ and ▽ keys to select from the format options. dd-mm-yyyy 24h dd-mm-yyyy 12h mm/dd/yyyy 24h mm/dd/yyyy 12h dd-mmm-yyyy 24h dd-mmm-yyyy 12h yyyy-mm-dd 24h yyyy-mm-dd 12h
Date	Use the △ and ▽ keys to enter the current date.
Time	Use the △ and ▽ keys to enter the current time.

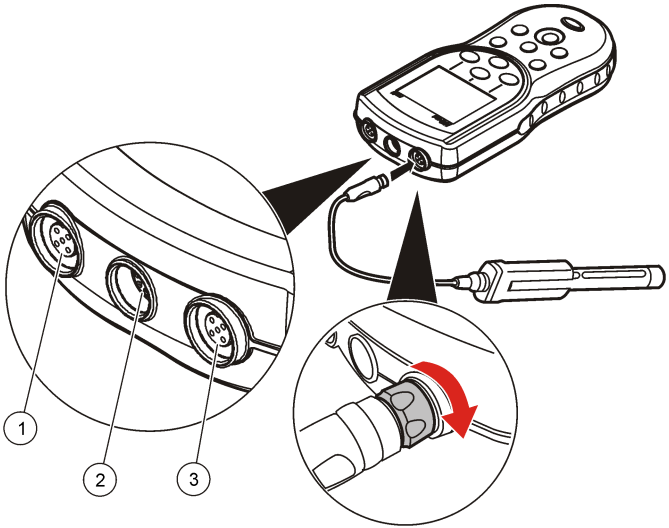
The current date and time will be shown on the display.

Connect a probe after the date and time setup, so that the meter is ready to take a measurement.

Connect a probe

1. Make sure that the display shows the current time and date.
   Note: *The time stamp for a probe is set when the probe is first connected to the meter. This time stamp makes it possible to record the probe history and record the time when measurements are made.*
2. Plug the probe into the meter (Figure 9).
3. Push and turn the locking nut to tighten.

Figure 9 Probe connection



1 Probe connection port (HQ40d only)	**2** USB/DC adapter port	**3** Probe connection port

Standard operation

About calibration

Each probe uses a different type of calibration solution. Make sure to calibrate the probes frequently to maintain the highest level of accuracy.

Note: *For step-by-step instructions, refer to the documents that are included with each probe.*

The calibration icon ? can indicate that:

- the calibration timer has expired

- the LDO sensor cap should be replaced
- the calibration is out of range
- the calibration results are outside acceptance criteria settings

About sample measurements

Each probe has specific preparation steps and procedures for taking sample measurements. For step-by-step instructions, refer to the documents that are included with the probe.

About check standards

Run Check Standards verifies equipment accuracy by measuring a solution of a known value. The meter will indicate if the Check Standard passed or failed. If the Check Standard fails, the calibration icon ? is shown until the probe is calibrated.

The meter can be set to automatically show a reminder for check standard measurement at a specified interval with a specified acceptance criteria. The reminder, value of the check standard, and acceptance criteria can be changed. For step-by-step instructions, refer to the documents that are included with the probe.

Use a sample ID

The sample ID tag is used to associate measurements with a particular sample location. If assigned, stored data will include the sample ID.

1. Push the key.
2. Select, create or delete a sample ID:

Option	Description
Current ID	Select an ID from a list. The current ID will be associated with sample data until a different ID is selected.
Create a New Sample ID	Enter a name for a new sample ID.
Delete Sample ID	Delete an existing sample ID.

Use an operator ID

The operator ID tag associates measurements with an individual operator. All stored data will include the operator ID.

1. Push the key.
2. Select, create or delete an operator ID:

Option	Description
Current ID	Select an ID from a list. The current ID will be associated with sample data until a different ID is selected.
Create a New Operator ID	Enter a name for a new operator ID (maximum 10 names can be entered).
Delete Operator ID	Delete an existing operator ID.

Data management

About stored data

The following types of data are stored in the data log:

- Sample measurements: stored automatically each time a sample is measured in the Press to Read or Interval Mode. When the continuous measurement mode is used, data is stored only when Store is selected.
- Calibrations: stored only when Store is selected at the end of a calibration. Calibration data is also stored in the IntelliCAL (R) probe.
- Check standard measurements: stored automatically each time a check standard is measured (in the Press to Read or Interval Mode).

When the data log becomes full (500 data points), the oldest data point is deleted when a new data point is added. The entire data log can be deleted to remove data that has already been sent to a printer or PC (key > Delete Data Log). To prevent deletion of the data log by a user, use the Security Options menu.

View stored data

The data log contains sample, calibration and check standard data. The most recent data point in the data log is tagged as Data Point 001.

1. Push the key.
2. Select View Data Log to view the stored data. The most recent data point is shown. The top of the screen shows whether the data is from a sample reading, a calibration or a check standard. Push the key to view the next most recent data point.

Option	Description
Reading Log	Reading Log—shows sample measurements including the time, date, operator and sample ID. Select Details to view the associated calibration data.
Calibration Log	Calibration Log—shows calibration data. Select Details to view additional information about the calibration.
Check Standard Log	Check Standard Log—shows check standard measurements. Select Details to view the calibration data that was associated with the measurement.

View stored probe data

Make sure that a probe is connected to the meter. If two probes are connected, select the appropriate probe when prompted.

1. To view the calibration data that is stored in a probe, push the key and select View Probe Data. The current calibration and calibration history for the probe can be viewed.

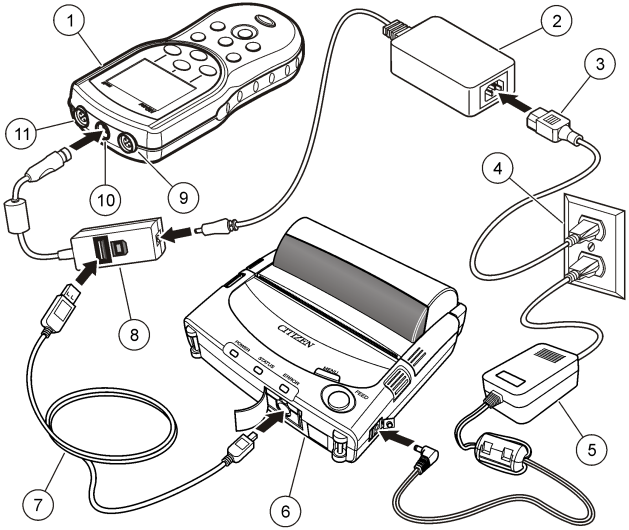
Option	Description
View Current Calibration	The current calibration information shows the calibration details for the most recent calibration. If the probe has not been calibrated by the user, the factory calibration data is shown.
View Calibration History	The calibration history shows a list of the times when the probe was calibrated. Select a date and time to view a summary of the calibration data.

Print stored data

The meter must connect to AC power to start the USB connection. Make sure that the connection to AC power is made before the meter is powered on.
All data can be sent to a printer. The PD-24 Citizen Printer is compatible with the HQd meters and is FCC Part 15B, Class B compliant with the HQ meters. Other printers may not be compatible. Compatible printers should support a minimum of 72 columns of data, be capable of printing up to 500 continuous data-stream events in 1, 2 and 3 lines of text and fully support code page 437 and code page 850.

1. Turn off the meter. Make sure that the meter is connected to AC power. Refer to Connect to AC power on page 8.
2. Connect the printer to the meter with a USB cable type A. Refer to Figure 10.
3. Turn on the meter.
4. Push the key.
5. Select Send Data Log. Wait for the display to show “Transfer Complete” and wait for the printer to stop printing. Disconnect the printer.

Figure 10 Connection to the printer



1 Meter	**7** USB cable
2 AC-DC power supply	**8** USB/DC adapter
3 AC power cord	**9** Port for probe connection
4 AC power outlet	**10** Port for USB/DC adapter
5 Power supply for printer (optional)	**11** Port for probe connection
6 Citizen Printer, FCC Part 15B, Class B compliant	

Change the report options

Printed reports for sample data can contain 1, 2 or 3 lines of information. Refer to Examples of printed reports on page 28 for further information.

1. Push the 🗁 key. Select Report Options.
2. Select Report Type and select one of the options.

Option	Description
Basic report	One line of data.
Advanced report	Two lines of data. The first line contains the same information as in the basic report.
Total report	Three lines of data. The first two lines contain the same information as in the advanced report.

Send data to a USB storage device

NOTICE

The transfer of a large number of data points will take some time. DO NOT disconnect the USB storage device until the transfer is complete.

Data can be transferred to a USB storage device for storage or transfer to a computer.

1. Turn off the meter. Make sure that the meter is connected to AC power.
2. Plug the USB storage device into the meter before the meter is powered on.
3. Turn on the meter.
4. Push the 🗁 key.
5. Select Send Data Log. Wait for the display to show “Transfer Complete” and for any lights on the USB storage device to stop flashing. Then remove the USB device.

   Note: *If the data transfer is slow, reformat the USB storage device to use the file allocation table (FAT) format for the next use.*

Open data files on a PC

Data that has been downloaded to a USB storage device can be transferred to a computer. The data is sent in a text (.txt) file format.

1. Plug the USB storage device into the computer.
2. Find the data file. The file will have the following format: “Meter Serial Number-Data File Type-Date Time”. Example: 9999NN000000-SENDDATA-0603131624.TXT
3. Save the data file to a location on the computer.
4. Open a spreadsheet program such as Microsoft® Excel® spreadsheet software.
5. Open the data file from the spreadsheet program. Select the delimited option with comma as the delimiter.
   The data will be shown in the spreadsheet program.
   Note: *If an application is used that is not compatible with column headings, the headings can be omitted. Refer to* Remove column headers *on page 18.*

Data file description

Data that is saved to a USB storage device and then opened in a spreadsheet application will have multiple columns of data. A description for each of the columns is shown in Table 1.

Table 1 Spreadsheet column descriptions

Column header name	Data description and example values
Type	Type of data: RD = Reading; CL = Calibration; CK = Check Standard; CH = Calibration History; IC = Current Calibration
Parameter	Type Parameter: LDO, pH, CD (conductivity), ORP, ISE
Date	Date of reading: stored in user-defined date format
Time	Time of reading: stored in user-defined format
Operator ID	Operator ID that was used when the data was recorded. Shows “- - -” if no operator ID is used.

Table 1 Spreadsheet column descriptions (continued)

Column header name	Data description and example values
Probe Model	Model number of probe, for example pHC101, CDC401, LDO101
Probe SN	Probe serial number If two probes are connected to the HQ40d meter, the serial number shows “<“ or “>” to identify the port (left or right) the probe was connected to during the reading.
Method name	User-defined name of the probe settings that were used for the reading.
Sample ID	Sample ID that was used when the data was recorded. Shows "Sample ID" if the default sample ID is used.
Primary Reading Value	Measured value. Shows “—" if the value was out of range.
Primary Reading Units	Measurement units, for example pH or µS/cm
Supp Reading 1	First supplemental reading (example: temperature), if applicable
Supp Units 1	Units for first supplemental reading, if applicable.
Supp Reading 2	Second supplemental reading (example: “mV” for pH), if applicable
Supp Units 2	Units for second supplemental reading, if applicable
Supp Reading 3	Third supplemental reading, if applicable
Supp Units 3	Units for third supplemental reading, if applicable.
Reading Setting 1–4	Any settings that affect the reading, for example “NaCl/Non-Linear”
Any settings that affect the reading, for example “NaCl/Non-Linear”	Reading Message 1–4 Any message that was shown during the measurement, for example “Out of limits”.

Table 1 Spreadsheet column descriptions (continued)

Column header name	Data description and example values
Check Std Value	Value of the check standard that was used to verify accuracy, for example: 7.00 pH–25 ºC (pH, temp-compensated); 7.01 pH (pH, custom)
Check Std Units	Check standard units, for example µS/cm. ***Note:*** *pH is not displayed here as it is included in the previous column.*
Check Std Graph	Bar-graph showing the measurement in relation to the acceptance limits. Example: “6.901 <—|—> 7.101”.
Check Std Status	Status of the check standard reading. Example: “Reading within limits”, “Reading outside limits”
Calibration Status	Status of the calibration that is in use. OK = current calibration is valid; ? = calibration has expired.
Cal Date	Date of calibration reading: stored in user-defined date format
Cal Time	Time of calibration reading: stored in user-defined time format
Cal Operator ID	The operator ID specified when the probe was calibrated. Shows “- - -” if undefined.
Cal Slope Name	Slope (pH or LDO) or cell constant (conductivity)
Cal Slope	The slope value for the calibration
Cal Slope Aux	Used by pH to give the percent of nominal slope
Cal Slope Units	Units of the calibration slope. Example: “mV/pH” for pH
Cal Offset	Calibration offset value
Cal Offset Units	Calibration offset units. Example: “mV” for pH.
Cal r^2	Calibration correlation coefficient without a unit (may be blank)

Table 1 Spreadsheet column descriptions (continued)

Column header name	Data description and example values
Cal Number of Std’s	Number of standards used during calibration, for example 5. May be blank depending on record type, parameter type, and method settings.
Cal Std 1	Known value of the first calibration standard
Cal Std 1 Units	Units of the first calibration standard
Cal Std 1 Primary Value	Measured value of the first calibration standard
Cal Std 1 Primary Units	Associated units for the calibration measurement
Cal Std 1 Supp Value	Value of supplemental measurement, for example temperature
Cal Std 2–7	Known value of additional calibration standards, if used
Cal Std 2–7 Units	Units of additional calibration standards, if used
Cal Std 2–7 Primary Value	Measured values of additional calibration standards, if used
Cal Std 2–7 Primary Units	Associated units for additional calibration measurements, if used
Cal Std 2–7 Supp Value	Value of supplemental measurement, for example temperature
Cal Std Supp Units	Units applicable to all secondary calibration readings. Example: “ºC” or “ºF” for temperature
Cal Message 1–4	Any messages about the calibration
Date/Time POSIX	Date and time of reading stored in POSIX format (number of seconds from January 1, 1970) Example: 1149234913
Cal Date/Time POSIX	Date and time of calibration stored in POSIX format (number of seconds from January 1, 1970). Example: 1111320348
Meter SN	Meter serial number used to take the measurement

Remove column headers

When transferred data is viewed in a spreadsheet program, the first row of data contains headings to identify the type of data in each column. If an application or post-processing method is used that is incompatible with the headers, the column headers can be omitted.

1. Push the key.
2. Select Column Headers.
3. Set the column headers to off.

Send data directly to a computer

Data can be transferred from any HQd series meter directly to a computer when the HQ40d PC Application is installed. The data can be sent in real time during data collection, or the entire data log can be transferred.

To download the most current version of the software, refer to the applicable product page on the manufacturer's website.

1. Install the HQ40d PC Application on the computer.
2. Turn off the meter. Make sure that the meter is connected to AC power.
3. Connect the PC to the meter with a USB type B cable.
4. Turn on the meter.
5. Open the HQ40d PC Application on the computer. Click on the green triangle in the menu bar to start a connection.
6. Collect the data in real time or transfer the data from the data log:
   - Real time—when a data point is stored in the meter, the result is sent simultaneously to the PC Application (refer to Set the measurement mode on page 21).
   - Data log—push the key and select Send Data Log. Wait for the display to show “Transfer Complete.” The data is sent as a comma separated values (.csv) file.

   The data is shown in the HQ40d PC Application window.

Advanced operation

Security options

The Security Options menu is used to protect the meter setup and method settings from unwanted changes. This menu is available in the Full Access Options menu.

The Setup Measurement Mode, Date and Time, Temperature Units, Language, Probe settings, Delete data log and Security Options screens are disabled in the Operator Access Options menu. All menu options are enabled in the Full Access Options menu.

Note: *The Full Access Options menu is shown when the key is pushed when Security Options is OFF, whether or not a password has been set.*

When the meter is powered on for the first time and Security Options is selected, the display prompts the user to set a password. Until the meter is shut off, pushing the key will still display the Full Access Options menu, even after Security Options is turned on and a password has been set. After the meter is shut off and powered on again with Security Options on, the Operator Access Options menu is displayed until a valid password is entered.

Store the password in a safe and accessible place. If the specified password is forgotten and Security Options is turned on, the operator is locked out of the restricted menus. Contact technical support if the password is lost.

Turn Security Options on

The Security Options and the Set Password options are used together to prevent access to restricted menus.

1. Push the key and select Security Options.
2. Change the settings as needed to allow or prevent menu access.

Option	Description
Security Options	When Security Options is on, and a password has been specified, the password is required to enable the Full Access Options menu. If the meter is turned off while Security Options is on, the password is required to enable the Full Access Options menu again when the meter is turned on.
Set Password	Set a password that must be entered to enable the Full Access Options menu. The requirement for password entry is controlled by setting Security Options on or off.

Full access options menu

The Full Access Options menu is displayed when Security Options is OFF or when Security Options is ON and a valid password is entered (Table 2). These options do not need to be changed if the factory default settings are used.

Table 2 Full Access Options

Option	Description
(Probe model) settings	Settings such as measurement options, calibration options, check standard options, units and resolution. Refer to the probe documentation for more information. ***Note:*** *A probe must be connected to the meter.*
Run check standard	Measure standard solution (available for pH, conductivity, ORP and ISE probes)
Measurement mode	Press to Read
	Interval: Duration and Interval
	Continuous
Instrument information	Probe information
	Meter information

Table 2 Full Access Options (continued)

Option	Description
Security options	ON or OFF
	Set password
Display options	Contrast
	Auto shutoff
	Backlight
	Mode
Sounds	Key press
	Stability alert
	Calibration reminder
Date and time	Format
	Date
	Time
Temperature units	Set temperature units
Language	Select language

Restricted operator access options menu

The Operator Access Options menu is shown at meter startup when Security Options is ON (Table 3). When a valid password is entered, the menu changes to Full Access Options.

Table 3 Operator access options

Option	Description
(Probe model) settings	Only methods (if methods exist) can be selected. Refer to the probe documentation. ***Note:*** *A probe must be connected to the meter.*
Run check standard	Measure standard solution (available for pH, conductivity, ORP and ISE probes) ***Note:*** *A probe must be connected to use this option.*
Instrument information	Probe information
	Meter information
Access password	Enter password
Display options	Contrast
	Auto shutoff
	Backlight
	Mode
Sounds	Key press
	Stability alert
	Calibration reminder

Set the display options

Use Display Options to change the display contrast, battery saving auto-shutoff options, the backlight option or the detailed or big reading screen mode.

1. Push the key and select Display Options.
2. Select which display option to change.

Option	Description
Contrast	Adjust the contrast of the display. The lightest setting is 0 and the darkest setting is 9.
Auto-shutoff	To maximize battery life, set a time period after which the meter will automatically power off if no key is pushed (1, 2, 5, 10, 30 min, 1 h, 2 h or never). Auto-shutoff is not active when the meter is connected to AC power or in the Interval Reading Mode.
Backlight	The display backlight is turned off when the key is pushed. Is it possible to set a time period after which the backlight will automatically power off if no key is pushed.
Mode	Select Detailed or Big screen size. Detailed will show more information with smaller numbers and text. Big will show less information with larger numbers and text. ***Note:*** *The screen size can also be selected from the measure mode (refer to* Display description *on page 9).*

Set the sound options

The meter can make an audible sound when a key is pushed, when stability is reached or when the calibration reminder is due. The meter also makes an audible sound when it begins transferring data to a USB storage device and again when the data transfer is complete.

1. Push the key and select Sound.
2. Choose which events will produce an audible sound. Multiple items can be selected.

Option	Description
Key Press	The meter will make an audible sound whenever a key is pushed.
Stability Alert	The meter will make an audible sound whenever measurement stability is reached.
Cal reminder	The meter will make an audible sound when calibration is due. ***Note:*** *Refer to* Set the probe calibration reminder *to set the calibration reminder to on or off.*

Set the probe calibration reminder

Make sure that a probe is connected to the meter.

1. Push the key and select the probe settings.
2. Select Modify Current Settings.
3. Select Calibration Options.
4. Select Calibration Reminder.

Option	Description
Calibration reminder	Reminder repeat: Off, 2 h, 4 h, 8 h, 2 d, 5 d, 7d Expires: Immediately, Reminder + 30 min, Reminder + 1 hr, Reminder + 2 hr, Continue Reading The meter can be set to make an audible sound when calibration is due. Calibration expires after a specified time set by the user. ***Note:*** *The meter cannot be used to read samples after calibration has expired unless Continue Reading is selected.*

Change the temperature units

To select degrees Celsius or Fahrenheit:

1. Push the key and select Temperature Units.
2. Select the Celsius or Fahrenheit option.

Set the measurement mode

One of three modes can be used to specify when measurements are taken and how the data is stored. When a data point is stored, the result is sent simultaneously to any device (PC/printer/ USB storage device) that is connected to the meter.

1. Push the key and select Measurement Mode.
2. Select Mode.
3. Select one of the measurement modes.

Option	Description
Press to Read	The sample is measured only when the GREEN/RIGHT key under Read is pushed. Data is stored in the data log automatically when the stability criteria are met.
Interval	The sample is measured at regular intervals for a specified duration (refer to Set auto measurement intervals on page 21). Data is stored in the data log automatically.
Continuous	The sample is measured continuously. Data is stored in the data log only when the GREEN/RIGHT key under Store is pushed.

Set auto measurement intervals

When the measurement mode is set to Interval, the time intervals and duration must be specified. Measurements are stored at the user-defined intervals whether or not stability criteria are met.

Note: *Use of an external USB storage device or direct printer connection while in Interval Measurement mode prevents data from being over-written in the data log. Data points are over-written on a First In/First Out basis. Refer to* Prevent data log overflow in interval mode *on page 22.*

1. Push the key and select Measurement Mode.
2. Select Mode.
3. Select Interval as the Measurement Mode.
4. Select Duration and select the total time that measurements will be taken for (15 min, 30 min, 1 h, 4 h, 8 h, 24 h, 48 h or no limit).
5. Select Interval and select how often measurements will be taken (every 10 s, 30 s, 1 min, 5 min, 15 min or 30 min).

Start interval measurements

During interval measurements, the meter goes into a standby state between readings to conserve power. The auto-shutoff option is disabled. Measurements stop when the selected interval duration has passed. The auto-shutoff option then becomes active.

Interval measurements are suspended for calibrations, check standard measurements or when the key is pushed. Interval measurements resume when returning to the measurement screen.

1. From the Main Measurement screen, select Start to begin interval measurements. The screen will show “Recording” and the remaining time of the duration. The sample number automatically advances when each reading is taken.
2. To stop interval measurements, select Stop.
3. To repeat the interval measurement after it has been stopped or completed, select Start.

Prevent data log overflow in interval mode

When measurements are taken at specified intervals (Table 4), each result is automatically stored. The meter can store up to 500 data records. When 500 records have been stored, data is replaced on a first-in, first-out basis. To prevent loss of data, connect the meter to a PC/printer/USB storage device.
Note: *Stop interval measurements before changes are made to a method or to meter settings.*

Table 4 Recommended interval/duration pairs

Interval	Duration
10 seconds	1 hour
30 seconds	4 hours
1 minute	8 hours
5 minutes	24 hours

Note: *When 2 probes are connected to the meter, use the next lowest recommended duration time. For example, for a 30-second interval, set the duration to 1 hour to prevent data log overload with 2 probes.*

View instrument information

The instrument information menu shows specific information such as the serial number for the meter or IntelliCAL (R) probe(s).

1. Push the key and select Instrument Information.
2. Select (Probe model) Information or Meter Information.

Option	Description
Probe information	The Probe Information screen shows the probe model number, serial number, software version and date of first use. For LDO and LBOD probes, the lot code for the sensor cap and the remaining time before sensor cap replacement is shown. ***Note:*** *A probe must be connected to the meter.*
Meter information	The Meter Information screen shows the meter model number, serial number, software version and memory information. The amount of memory used and the number of available user method settings, operator IDs and sample IDs is shown.

Update the meter software

A USB storage device that contains software update files is used to update the meter software.
Note: *The meter must be turned off and then on again before the software update will begin. The software update initiates upon meter startup after the USB device is correctly inserted.*

NOTICE

Do not remove the USB device until the “Update complete” message is shown. The meter can become damaged if the USB device is removed before the update process is complete.

1. Save stored data from the data log to a USB storage device or to a PC. Refer to Send data to a USB storage device on page 15 and Send data directly to a computer on page 18.
2. Turn off the meter.
3. Connect the USB/DC adapter, AC-DC power supply and cord (Figure 4 on page 9).

4. Insert the USB storage device that contains the software update files into the USB/DC adapter.
5. Turn on the meter.
   The update process starts. The display will show “Updating meter to <firmware version>”. After an interval, the display changes to “Updating files, please wait...” In addition, the display will show a rotating flask and emit a periodic audio signal during the update process.
   Note: *A large capacity USB storage device increases the time required for completion of the update process, even if most of the device memory is empty.*
6. Wait for the meter to finish the software update. When the update process is complete, the message “Update complete. Remove USB device” is shown. The meter will turn off after the USB device has been removed.
7. Repeat steps 1 through 6 to update the software in other HQd meters as necessary.

Download software updates

To download the most current version of the software, refer to the applicable product page on the manufacturer's website.

1. Transfer the update files to a USB storage device.
2. Follow the instructions in Update the meter software on page 22 to update the software in the meter.

Transfer method settings

Probe settings that have been changed by the user for measurements, calibrations or check standards (Meter Options > (Probe Model) Settings > Modify Current Settings) can be copied to a USB storage device. The USB device can then be used to transfer the method settings to other HQd meters that accept the same probes.

NOTICE

Make sure the USB storage device does not contain HQd meter software update files to prevent unintentional updates.

1. Turn off the meter.
2. Connect the meter to AC power (Figure 4 on page 9).
3. Plug the USB storage device into the USB/DC adapter before the meter is powered on.
4. Turn on the meter.
5. Push the key and select Transfer Methods. If the USB device already contains a method settings file, an option to export or import methods is shown. Select Export Methods.
6. In the Select Methods to Export screen, select one or more methods to copy to the USB device. A check mark is shown next to each selected method.
7. Select OK. The settings are copied to the USB storage device. When complete, the Transfer Summary screen is shown.
8. Connect the AC power and USB device to a meter that will receive the method settings. Turn the meter on.
9. Push the key and select Transfer Methods. If the USB device already contains a method settings file, an option to export or import methods is shown. Select Import Methods.
10. In the Select Methods to Import screen, select one or more methods to transfer to the meter. A check mark is shown next to each selected method.
11. Select OK. The user method settings are transferred from the USB storage device to the meter. When complete, the Transfer Summary screen is shown. Select details to view additional information about the transfer.
12. Disconnect the USB storage device from the meter.

Bi-directional Communication between the meter and a PC

For measurement automation the meter can be used to implement a command set for meter remote control or automated data transfer. The command set can be used to perform minimal configuration and to control the meter. To set up the meter for communication and control, refer to About meter configuration on page 24. For additional information and the command set contact Technical Support.

About meter control

The virtual serial connection can be used to control meter functions from a PC. For example, the functions include starting a measurement cycle,

turning off the meter and sending the entire measurement (including calibrations) to the PC or other information management system.

About meter configuration

To use the meter communication and control from the PC, an INF file must be installed.

1. The meter software must be version 2.0.0.710 or higher.
   To download the most current version of the software, refer to the applicable product page on the manufacturer's website.
2. Open the Zip file.
3. Copy the INF file from the software upgrade package to a convenient location on the PC.

   Note: *The INF file must be installed to use the meter manual control from a PC.*
4. Turn on the meter.
5. Push the key and select Instrument Information.
6. Select USB Device Type and then select Virtual Serial to use the virtual serial port on the meter.
7. Push OK. The meter will automatically restart to complete the setting change.
8. Connect the meter with the USB cable to the PC and turn on the meter.
   Windows XP starts the "Found New Hardware Wizard".
9. Select "No, not at this time" to the query "Can Windows connect to Windows Update to search for software?"
10. Click Next. The next wizard screen will prompt.
11. Select "Install from a list or specific location (Advanced)" to the query "What do you want the wizard to do?"
12. Click Next. The next wizard screen will prompt.
13. Select the option "Search for the best driver in these locations."
14. Uncheck the "Search removable media (floppy, CD-ROM)" option and select the "Include this location in the search:" and click the "Browse" button.
15. Select the INF folder or location and click OK.
16. Click Next. The new software will be installed.
17. Click Finish to complete the Found New Hardware Wizard for: HQd Meter - Virtual Serial Port.
18. To make sure that the installation succeeded, go to Computer Management>Device Manager>Ports. The new installed port is listed as HQd Meter - Virtual Serial Port (COM#).
19. The meter is now ready for communication with PC-based systems using the Virtual Serial port. A program interface must be developed by the user for the command set used to control the meter functions from the PC. Contact Technical Support for more information and command set documentation.

Maintenance

⚠ CAUTION

Multiple hazards. Only qualified personnel must conduct the tasks described in this section of the document.

Clean the meter

The meter is designed to be maintenance-free and does not require regular cleaning for normal operation. Exterior surfaces of the meter may be cleaned as necessary.

1. Wipe the surface of the meter with a damp cloth.
2. Use a cotton-tipped applicator to clean or dry the connectors.

Replace the batteries

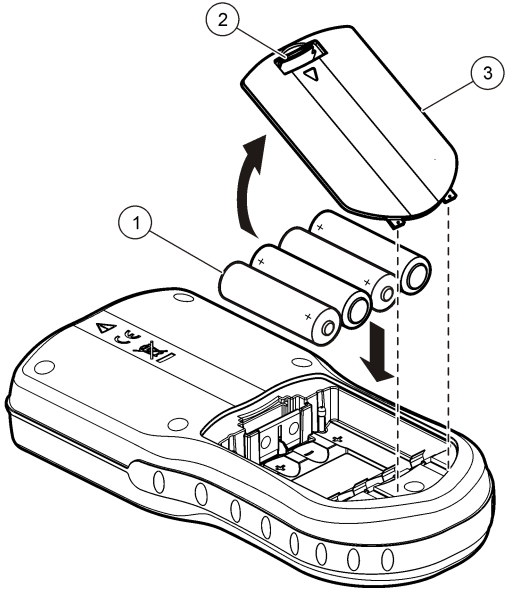
⚠ WARNING

Explosion hazard. Incorrect battery installation can cause the release of explosive gases. Be sure that the batteries are of the same approved chemical type and are inserted in the correct orientation. Do not mix new and used batteries.

For battery replacement, refer to Figure 11. Make sure that the cover is tightly closed to maintain the IP67 enclosure rating.

1. Pull the release tab on the battery cover and the remove the cover.
2. Remove the batteries.
3. Install 4 AA alkaline or 4 AA nickel metal hydride (NiMH) batteries. Make sure that the batteries are installed in the correct polarity.
4. Replace the battery cover.

Figure 11 Battery replacement



1 Batteries	**2** Release tab	**3** Battery cover

Troubleshooting

Refer to the following table for common problem messages or symptoms, possible causes and corrective actions.

Error/Warning	Description	Solution
Connect a Probe	Probe disconnected or connected improperly	Tighten the locking nut on the probe connector.
		Disconnect the probe and then connect the probe again
	Software not updated to most current version	To download the most current version of the software, refer to the applicable product page on the manufacturer's website.
	Problem with probe	Connect a different IntelliCAL probe to verify if problem is with probe or meter
Probe Not Supported	Probe disconnected or connected improperly	Tighten the locking nut on the probe connector.
		Disconnect the probe and then connect the probe again.
	Software not updated to most current version	To download the most current version of the software, refer to the applicable product page on the manufacturer's website.
	Problem with probe	Connect a different IntelliCAL probe to the meter to verify if problem is with the meter or the probe.
	HQd meter does not support IntelliCAL probe	Contact Technical Support.
Bootloader X.X.XX.XX error	Software not updated to most current version.	To download the most current version of the software, refer to the applicable product page on the manufacturer's website.

Error/Warning	Description	Solution
0 days remaining message (For LDO and LBOD only)	LDO or LBOD sensor cap used for 365 days	Replace the LDO or LBOD sensor cap and iButton®.
	There are 0 days remaining in the life of the LDO sensor cap.	Replace the LDO sensor cap. Calibration will be allowed. However, the calibration icon and question mark will appear on the measurement screen even if the calibration has passed.
	Meter set to incorrect date and time	**1.** Disconnect the probe from the meter. **2.** Remove the meter batteries. **3.** Install the meter batteries properly. Follow the polarity makings. **4.** Set correct date and time in the meter. **5.** Connect the probe and verify that message has been removed.
	Software not updated to most current version	To download the most current version of the software, refer to the applicable product page on the manufacturer's website.
Meter not configured	Software error(s)	If the meter starts up correctly, back up the Data Log and Method files. To download the most current version of the software, refer to the applicable product page on the manufacturer's website.

Error/Warning	Description	Solution
Meter will not power on or powers on intermittently	Batteries are not installed correctly	Examine battery orientation to make sure the batteries follow the polarity markings. Test again.
		Clean the battery terminals, then install new batteries.
		Connect AC power adapter and test again.
	Software not updated to most current version	To download the most current version of the software, refer to the applicable product page on the manufacturer's website.
	Damaged meter	Contact Technical Support.
Unable to access Full Access Options screen	Correct password has not been entered	Contact Technical Support.
Unable to access Full or Operator Access Options screen	Software not updated to most current version	To download the most current version of the software, refer to the applicable product page on the manufacturer's website.

Replacement parts and accessories

Note: *Product and Article numbers may vary for some selling regions. Contact the appropriate distributor or refer to the company website for contact information.*

Replacement parts

Description	Item no.
AC Power/USB Adapter Kit, 115 VAC	5826300
AC Power/USB Adapter Kit, 230 VAC	5834100
Batteries, Alkaline AA	1938004
Battery cover	9245500
Battery Contact, dual fixed	5188400

Replacement parts (continued)

Description	Item no.
Battery Contact, dual spring	5188800
Cable, USB 6 ft (1.8 m), Type A male, Type B male	5924000
Field Kit (includes Protective Glove Kit for meter and five 120-mL sample cups)	5825800
Field Case for 2 probes with up to 5 m cables (10 m total). Includes empty case, insert for meter and probe storage, 4 containers for sample collection.	8505500
Field Case for 3 probes with up to 5 m cables (15 m total). Includes empty case, insert for meter and probe storage, 4 containers for sample collection.	8505501
Field Case for 2 probes with greater than 5 m cables (30 m total). Includes empty case, insert for meter with protective glove.	8505600
Keyboard (QWERTY), USB type	LZV582
Printer, Citizen PD-24 USB printer, 120–220 VAC	**US:** 2960100 **EU:** 5835900
Printer Paper for Citizen PD-24, thermal, 5/pk	5836000
Probe Clips, color coded (5 colors, 2 clips of each color), 10/pk	5818400
Probe Depth Marker (rugged cables)	5828610
Probe Holder, standard (fits on protective glove)	5829400
Protective Glove Kit for meter	5828700
Universal Probe Stand for standard IntelliCAL Probes	8508850
Meter Stand for Portable HQd meters	4754900

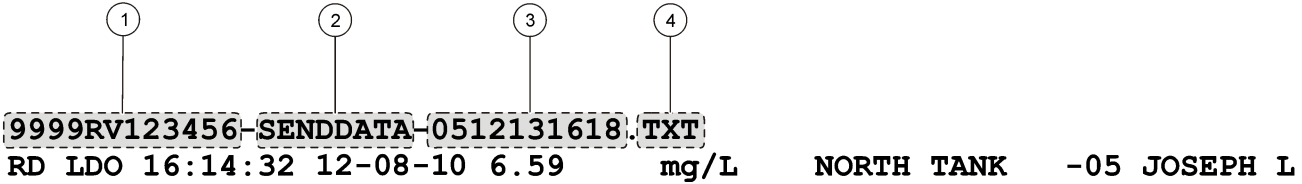
Examples of printed reports

Printed reports contain a report header and all stored data for samples, check standards and calibrations.

Report header

The first line of a report shows the report header (Figure 12).

Figure 12 Report header



1 Meter serial number[1]	**3** Date and time, 24 h (YYMMDDhhmm)
2 Report label	**4** File type extension

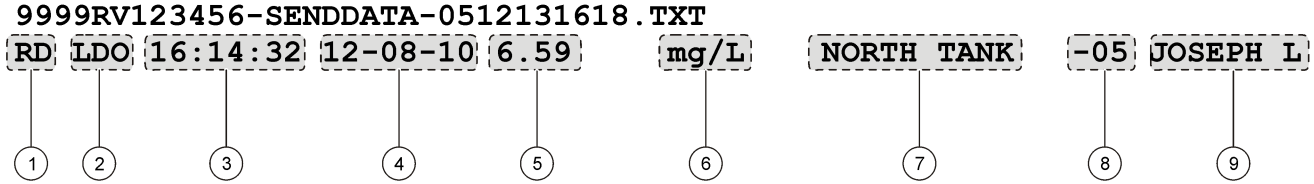
[1] The probe serial number is shown on calibration history and current calibration reports.

Data reports

Sample data can be printed in a basic, advanced or total report format.

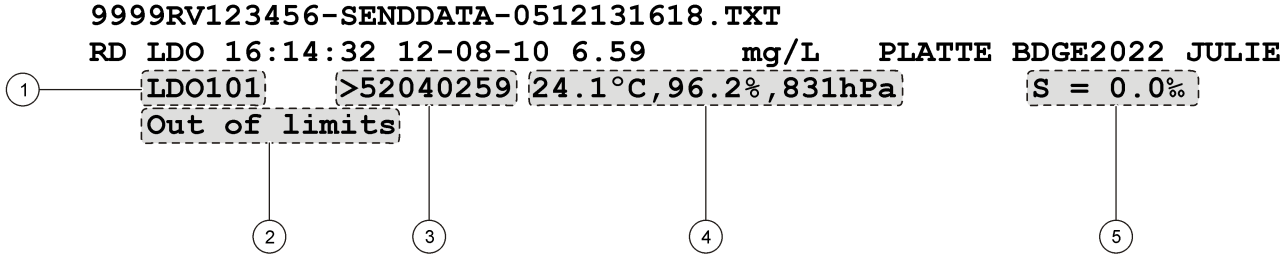
- Total report—refer to Figure 13.
- Advanced report—refer to Figure 14.
- Basic report—refer to Figure 15.

Figure 13 Basic report for sample data—1 line



1 Data type (RD=reading)	**6** Units
2 Parameter (pH, LDO, etc.)	**7** Sample ID: user-defined; shows “SAMPLE ID” if undefined
3 Time (hh:mm:ss in 24 h or user-defined format)	**8** Sample ID counter
4 Date (DD-MM-YY or user-defined format)	**9** Operator ID: user-defined; shows “- - -” if undefined
5 Measured value	

Figure 14 Advanced report for sample data—2 lines



1 Probe model	**4** Additional units: shows all additional units associated with the reading.
2 Error message (if applicable)	**5** Probe settings: shows the highest-priority setting associated with the reading
3 Probe serial number (a “<“ or “>” on the HQ40d meter indicates the probe position)	

Figure 15 Total report for sample data—3 lines

```
9999RV123456-SENDDATA-0512131618.TXT
RD pH   07:52:47 12-08-10 3.95     pH      PLATTE BDGE2046 JULIE
   pHC301    <06047527 21.8°C,167.0mV
   Default      CAL12:52 12-08-10 58.36mV/pH   -9.3mV   MICHAEL
```

1	Method name for probe settings	**4**	Calibration slope/ratio/constant
2	Time of calibration, prefaced by “CAL” and displayed as hh:mm in 24 h (or user-defined) format	**5**	Offset—contents vary depending on type of parameter and user settings. May be blank.
3	Date of calibration (DD-MM-YY or user-defined format)	**6**	Operator ID: user-defined; shows “- - -” if undefined

Check standard reports

Check standard data is printed with 1 line of information (Figure 16)

Figure 16 Check standard report

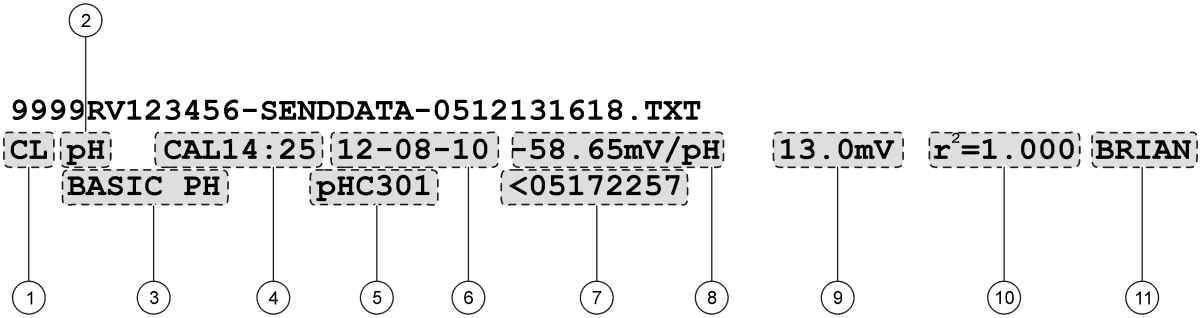
```
9999RV123456-SENDDATA-0512131618.TXT
ST pH   15:24:07 12-08-10 5.71     pH      Fail                GEORGE
```

1	Report type (ST = check standard)	**5**	Measured value
2	Report type (ST = check standard)	**6**	Units
3	Time (hh:mm:ss in 24 h or user-defined format)	**7**	Check standard status: Pass/Fail based on the acceptance criteria
4	Date (DD-MM-YY or user-defined format)	**8**	Operator ID: user-defined; shows “- - -” if undefined

Calibration reports

Calibration data is printed when the data log is sent to the printer or when probe data is sent to the printer. Calibration data is printed with 2 lines of information (Figure 17).

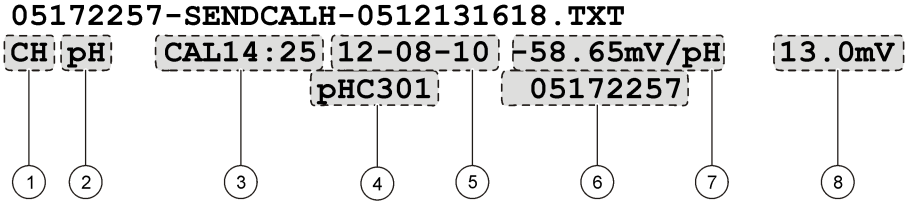
Figure 17 Calibration report



1 Report type (CL = calibration, IC = current calibration)	**7** Probe serial number (a “<“ or “>” on the HQ440d meter indicates the probe position)
2 Parameter (pH, LDO, etc.)	**8** Calibration slope/ratio/constant
3 Method name for probe settings	**9** Offset—contents vary depending on type of parameter and user settings. May be blank.
4 Time of calibration, prefaced by “CAL” and displayed as hh:mm in 24 h (or user-defined) format	**10** r^2: contents vary depending on type of parameter being read, configuration of specific method and number of calibration standards used. May be blank.
5 Probe model	**11** Operator ID: user-defined; shows “- - -” if undefined
6 Date of calibration (DD-MM-YY or user-defined format)	

The calibration history can be printed from the probe data menu. Refer to Figure 18.

Figure 18 Calibration history report



1	Report type (CH=calibration history)	**5**	Date of calibration (DD-MM-YY or user-defined format)
2	Parameter (pH, LDO, etc.)	**6**	Probe serial number (a “<“ or “>” on the HQ40d meter indicates the probe position).
3	Time of calibration, prefaced by “CAL” and displayed as hh:mm in 24 h (or user-defined) format	**7**	Calibration slope/ratio/constant
4	Probe model	**8**	Offset—contents vary depending on type of parameter and user settings. May be blank.

A

AC power connection 8
auto-shutoff 20

B

backlight 20
Bi-directional Communication 23
big screen mode 10, 20

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CAT. NO. 46500-88

PORTABLE TURBIDIMETER

Model 2100P

Instrument and Procedure Manual

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CERTIFICATION

Hach Company certifies this instrument was tested thoroughly, inspected and found to meet its published specifications when it was shipped from the factory.

The Model 2100P Portable Turbidimeter has been tested and is certified as indicated to the following instrumentation standards:

Product Safety

Battery/Eliminator Power Supply Only:
120 Vac, 60 Hz, UL Listed & CSA Certified, Class 2
230 Vac, 50 Hz, VDE Approved, GS & CE marked

Immunity

2100P Turbidimeter Tested with external Battery/Eliminator Power Supply:
EN 50082-1 (European Generic Immunity Standard) **per 89/336/EEC EMC:** Supporting test records with Dash Straus and Goodhue, Inc. (now Intertek Testing Services), certified compliance by Hach Company.

Standards include:
IEC 801-2 Electro-Static Discharge
IEC 801-3 Radiated RF Electro-Magnetic Fields
IEC 801-4 Electrical Fast Transients/Burst

Emissions

2100P Turbidimeter Tested with external Battery/Eliminator Power Supply:
EN 50081-1 (Emissions) **per 89/336/EEC EMC:** Supporting test records by Amador Corp. (now TUV Product Services), certified compliance by Hach Company

Standards include:
EN 55022 (CISPR 22) Emissions, Class B Limits

Canadian Radio Interference-Causing Regulation, Chapter 1374, Class A: Supporting test records by Amador Corp. (now TUV Product Services), certified compliance by Hach Company

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

FCC Part 15, Class "A" Limits: Supporting test records by Amador Corp. (now TUV Product Services), certified compliance by Hach Company.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. this device may not cause harmful interference, and
2. this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

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

The following techniques of reducing interference problems are applied easily:

1. Disconnect the battery eliminator from it's power source and from the 2100P Portable Turbidimeter to verify if it is the source of the interference
2. If the battery eliminator for the 2100P Portable Turbidimeter is plugged into the same outlet as the device with which it is interfering, try another outlet.
3. Move the 2100P Portable Turbidimeter away from the device receiving the interference.
4. Reposition the receiving antenna for the device receiving the interference.
5. Try combinations of the above.

SAFETY PRECAUTIONS

Please read this entire manual before unpacking, setting up, or operating this instrument. Pay particular attention to all danger and caution statements. Failure to do so could result in serious injury to the operator or damage to the equipment.

To ensure the protection provided by this equipment is not impaired, do not use or install this equipment in any manner other than that which is specified in this manual.

Use of Hazard Information

If multiple hazards exist, this manual will use the signal word (Danger, Caution, Note) corresponding to the greatest hazard.

DANGER
Indicates a potentially or imminently hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION
Indicates a potentially hazardous situation that may result in minor or moderate injury.

NOTE
Information that requires special emphasis.

Precautionary Labels

Read all labels and tags attached to the instrument. Personal injury or damage to the instrument could occur if not observed.

⚠ This symbol, if noted on the instrument, references the instruction manual for operational and/or safety information.

SPECIFICATIONS

Specifications subject to change without notice.
Operating specifications applicable at 25 °C unless noted.
Program software copyrighted by Hach Company, 1991.

Measurement Method: Ratio Nephelometric signal (90°) scatter light ratio to transmitted light

Range: 0-1000 NTU with automatic decimal point placement or manual range selection of 0-9.99, 0-99.9 and 0-1000 NTU

Accuracy: ± 2% of reading plus stray light from 0-1000 NTU

Resolution: 0.01 NTU on lowest range

Repeatability: ±1% of reading or 0.01 NTU, whichever is greater (with Gelex standards)

Response Time: 6 seconds for full step change without signal averaging in constant reading mode

Stray Light: <0.02 NTU

Standardization: StablCal® Stabilized Formazin primary standards or Formazin primary standards

Secondary Standards: Gelex® Secondary Standards

Display: Four-digit liquid crystal; 10.16 mm (0.4 in) high digits with custom icons

Light Source: Tungsten filament lamp; lamp life typically greater than 100,000 readings

Detectors: Silicon photovoltaic

Signal Averaging: Operator selectable on or off

Sample Cells: (Height X width) 60.0 X 25 mm (2.36 X 1 in) Borosilicate glass with screw caps, marking band and fill line

Sample Required: 15 mL (0.5 oz.)

Storage Temperature: -40 to 60 °C (-40 to 140 °F) (instrument only)

Operating Temperature: 0 to 50 °C (32 to 122 °F) (instrument only)

Operating Humidity Range: 0 to 90% RH noncondensing at 30 °C;
0 to 80% RH noncondensing at 40 °C;
0 to 70% RH noncondensing at 50 °C

Power Requirements: Four AA Alkaline cells or optional battery eliminator

Battery Life: Typically 300 tests with signal average mode off; 180 tests with signal average mode on

Battery Eliminator (optional):

For 120 V eliminator: CSA and UL approved for 120 VAC ±10%, 60 Hz, 6 V at 800 mA DC output

For 230 V eliminator: CE (VDE) approval pending for 230 VAC ±10%, 50 Hz, 6 V at 900 mA DC output

Enclosure: High impact ABS plastic

Dimensions: 22.2 X 9.5 X 7.9 cm (8.75 X 3.75 X 3.12 in)

Instrument Weight: 520 kg (1 lb 2.5 oz)

Shipping Weight: 3.1 kg (6 lbs 8.5 oz)

OPERATION

DANGER

Handling chemical samples, standards, and reagents can be dangerous. Review the necessary Material Safety Data Sheets and become familiar with all safety procedures before handling any chemicals.

DANGER

La manipulation des échantillons chimiques, étalons et réactifs peut être dangereuse. Lire les Fiches de Données de Sécurité des Produits (FDSP) et se familiariser avec toutes les procédures de sécurité avant de manipuler tous les produits chimiques.

PELIGRO

La manipulación de muestras químicas, estándares y reactivos puede ser peligrosa. Revise las fichas de seguridad de materiales y familiarícese con los procedimientos de seguridad antes de manipular productos químicos.

GEFAHR

Das Arbeiten mit chemischen Proben, Standards und Reagenzien ist mit Gefahren verbunden. Es wird dem Benutzer dieser Produkte empfohlen, sich vor der Arbeit mit sicheren Verfahrensweisen und dem richtigen Gebrauch der Chemikalien vertraut zu machen und alle entsprechenden Materialsicherheitsdatenblätter aufmerksam zu lesen.

PERIGO

A manipulação de amostras, padrões e reagentes químicos pode ser perigosa. Reveja a folha dos dados de segurança do material e familiarize-se com todos os procedimentos de segurança antes de manipular quaisquer produtos químicos.

PERICOLO

La manipolazione di campioni, standard e reattivi chimici può essere pericolosa. La preghiamo di prendere conoscenza delle Schede Techniche necessarie legate alla Sicurezza dei Materiali e di abituarsi con tutte le procedure di sicurezza prima di manipolare ogni prodotto chimico.

SECTION 1 DESCRIPTION

1.1 General Description

The Hach Model 2100P Portable Turbidimeter (*Figure 1*) measures turbidity from 0.01 to 1000 NTU in automatic range mode with automatic decimal point placement. The manual range mode measures turbidity in three ranges: 0.01 to 9.99, 10 to 99.9 and 100 to 1000 NTU. Designed primarily for field use, the microprocessor-based Model 2100P has the range, accuracy, and resolution of many laboratory instruments. The instrument operates on four AA batteries or with an optional battery eliminator. Rechargeable nickel-cadmium cells may be used, but cannot be recharged in the instrument. The instrument automatically shuts off after 5.5 minutes if no keystrokes occur (does not influence operation). If this occurs, simply turn the instrument on – the 2100P will resume operation as if the power had not been interrupted. The instrument, all standard accessories, and the optional battery eliminator may be conveniently stored in the carrying case.

Figure 1 2100P Turbidimeter and Accessories

Note: *Avoid prolonged exposure to ultraviolet light and sunlight.*

Note: *Do not hold the instrument during measurements; place the instrument on a flat, steady surface.*

1.2 Accessories

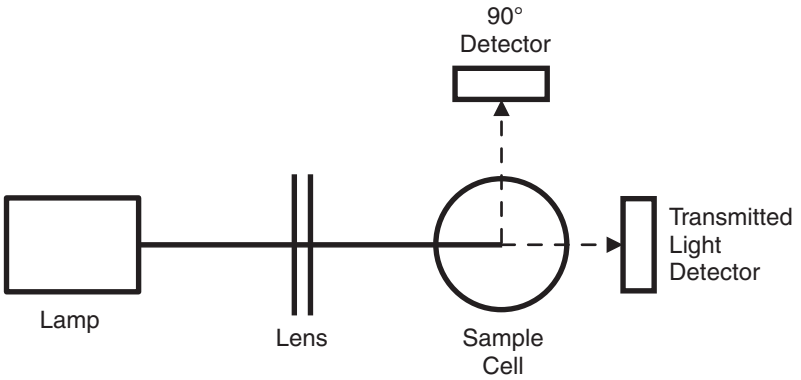
Accessories supplied with the turbidimeter include nine sample cells; three Gelex® Secondary Standards (included with 4650000 only); one sealed vial each of:
<0.1-NTU, 20-NTU, 100-NTU, and 800-NTU StablCal® Stabilized Formazin Standards; 4 AA alkaline batteries; 15 mL of silicone oil; oiling cloth; carrying case; instrument manual; and quick reference card.

1.3 Principle of Operation

The Model 2100P Portable Turbidimeter operates on the nephelometric principle of turbidity measurement. This instrument meets the design criteria specified by the United States Environmental Protection Agency, Method 180.1.

The optical system* (*Figure 2*) includes a tungsten-filament lamp, a 90° detector to monitor scattered light and a transmitted light detector. The instrument's microprocessor calculates the ratio of the signals from the 90° and transmitted light detectors. This ratio technique corrects for interferences from color and/or light absorbing materials (such as activated carbon) and compensates for fluctuations in lamp intensity, providing long-term calibration stability. The optical design also minimizes stray light, increasing measurement accuracy.

Figure 2 Ratio Optical System



* Patent number 4,198,161; other patents pending.

1.4 Preparation for Use

1.4.1 Unpacking

Remove the instrument and accessories from the shipping box and inspect them for damage that may have occurred due to rough handling or extreme weather conditions. Verify the following are present:

- Model 2100P Portable Turbidimeter
- Instrument Manual (with quick reference card)
- Set of StablCal Primary Standards in sealed vials, one each of:
  <0.1 NTU*
  20 NTU
  100 NTU
  800 NTU
- Standardization Kit containing Gelex Secondary Standards (0-10, 0-100 and 0-1000 ranges) (included with 4650000 only) plus nine sample cells with caps.
- Silicone Oil, 15-mL (0.5 oz) dropping bottle
- Oiling Cloth
- Carrying Case
- Four AA alkaline batteries

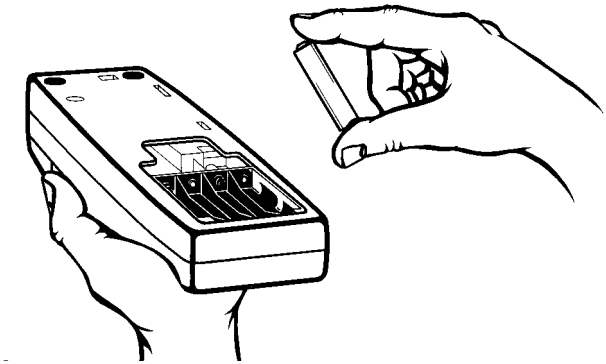
If any of the items are missing or damaged, please contact the Customer Service Department, Hach Company, Loveland, Colorado. The toll-free number in the United States is 800-227-4224. International customers should contact the Hach office or authorized distributor serving your area. Refer to *REPAIR SERVICE* on page *77*. **Please do not return the instrument without prior authorization from Hach.**

* Used in place of the dilution water standard when performing a calibration.

1.4.2 Battery Installation

The instrument is shipped completely assembled without the batteries installed. Before use, install the four AA alkaline batteries or connect the battery eliminator (*Figure 3*). For battery operation, remove the battery compartment cover on the instrument bottom and install the batteries. Correct battery polarity is shown on the battery holder. The instrument will not function if the batteries are not installed correctly. Reinstall the battery compartment cover.

Figure 3 Battery Installation



1.4.3 Using the Battery Eliminator and Rechargeable Batteries

For operation with the optional battery eliminator, plug the eliminator jack into the connector on the turbidimeter side. The battery eliminator may be used with or without the batteries installed. **The eliminator will not charge batteries.** Rechargeable batteries may be used in the instrument, but must be removed for recharging. See *HOW TO ORDER* on page *76* for ordering information. To prolong battery life, the instrument lamp turns on temporarily when the **READ** key is depressed. Batteries are not necessary for battery eliminator operation.

1.4.4 Calibration

The 2100P Portable Turbidimeter is calibrated with Formazin Primary Standard at the factory**.** However, the instrument should be calibrated upon receipt for best results. Hach recommends recalibration with

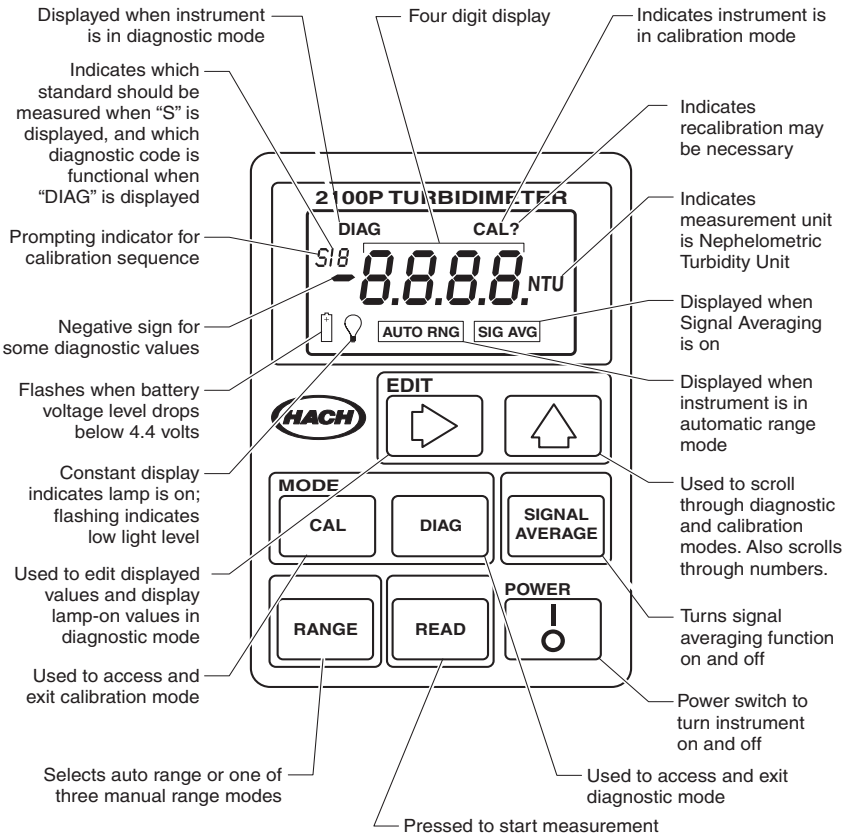
formazin once every three months, or more often as experience dictates. The Gelex Secondary Standards supplied with the instrument (included with 4650000 only) are labelled with general ranges for application, but must be assigned values before use from formazin calibration. See *Section 3.6* on page *37* for calibration instructions.

SECTION 2 TURBIDITY MEASUREMENT

2.1 Operating Controls and Indicators

Figure 4 shows the 2100P controls and indicators. Refer to *SECTION 3* for a detailed description of each control and indicator.

Figure 4 Keyboard and Display with Descriptions



2.2 Turbidity Measurement

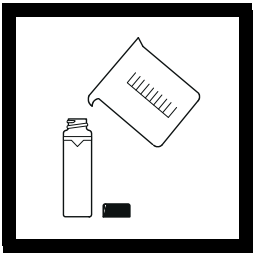
Measurements may be made with the signal average mode on or off and in manual or automatic range selection mode. Using automatic range selection is recommended. Signal averaging uses more power and should be used only when the sample causes an unstable reading. Signal averaging measures and averages ten measurements while displaying

intermediate results. The initial value is displayed after about 11 seconds and the display is updated every 1.2 seconds until all ten measurements are taken (about 20 seconds). After this, the lamp turns off, but the final measured turbidity value continues to be displayed until another key is pressed.

When not in signal average mode, the final value is displayed after about 13 seconds.

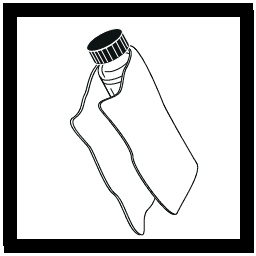
Accurate turbidity measurement depends on good measurement technique by the analyst, such as using clean sample cells in good condition and removing air bubbles (degassing). Refer to *Section 2.3* on page *22* for a detailed discussion of measurement techniques.

2.2.1 Turbidity Measurement Procedure

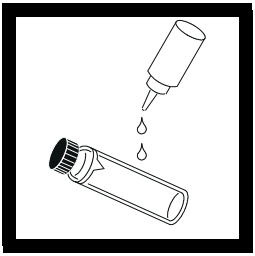


1. Collect a representative sample in a clean container. Fill a sample cell to the line (about 15 mL), taking care to handle the sample cell by the top. Cap the cell. (See *Section 2.3* on page *22* for more information about collecting a representative sample).

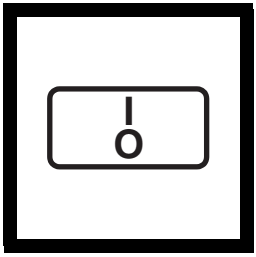
Note: *The instrument automatically shuts off after 5.5 minutes if no keystrokes occur. To resume operation, press* **I/O**.



2. Wipe the cell with a soft, lint-free cloth to remove water spots and fingerprints.

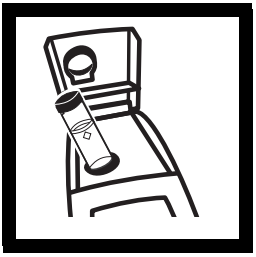


3. Apply a thin film of silicone oil. Wipe with a soft cloth to obtain an even film over the entire surface.



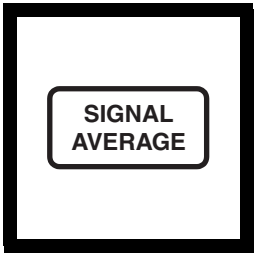
4. Press: **I/O**.

The instrument will turn on. Place the instrument on a flat, sturdy surface. Do not hold the instrument while making measurements.

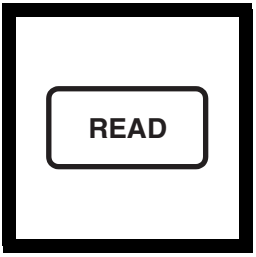


5. Insert the sample cell in the instrument cell compartment so the diamond or orientation mark aligns with the raised orientation mark in front of the cell compartment.
Close the lid.

6. Select manual or automatic range selection by pressing the **RANGE** key. The display will show **AUTO RNG** when the instrument is in automatic range selection.



7. Select signal averaging mode by pressing the **SIGNAL AVERAGE** key. The display will show **SIG AVG** when the instrument is using signal averaging. Use signal average mode if the sample causes a noisy signal (display changes constantly).



8. Press: **READ**

The display will show **- - - - NTU**, then the turbidity in NTU. Record the turbidity after the lamp symbol turns off.

Note: *The instrument defaults to the last operating mode selected. If automatic range mode and signal averaging were used on the previous measurements, these options will automatically be selected for subsequent samples.*

2.2.2 Measurement Notes

- Always cap the sample cell to prevent spillage of sample into the instrument.
- When taking a reading, place the instrument on a level, stationary surface. It should not be held in the hand during measurement.
- Always close the sample compartment lid during measurement and storage.
- Always use clean sample cells in good condition. Dirty, scratched, or damaged cells can cause inaccurate readings.
- Do not leave a sample cell in the cell compartment for extended periods of time. This may compress the spring in the cell holder.
- Remove sample cell and batteries from instrument if the instrument is stored for extended time period (more than a month).
- Avoid operating in direct sunlight.
- Make certain cold samples do not “fog” the sample cell.
- Avoid settling of sample prior to measurement.
- Keep sample compartment lid closed to prevent dust and dirt from entering.

2.3 Measurement Techniques

Proper measurement techniques are important in minimizing the effects of instrument variation, stray light and air bubbles. Regardless of the instrument used, measurements are more accurate, precise and repeatable if the analyst pays close attention to proper measurement techniques.

Measure samples immediately to prevent temperature changes and settling. Avoid sample dilution when possible. Particles suspended in the original sample may dissolve or otherwise change characteristics when the sample temperature changes or when the sample is diluted, resulting in a non-representative sample measurement.

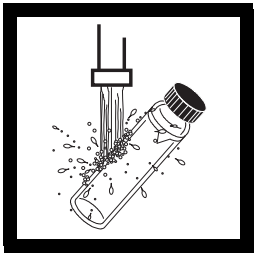
2.3.1 Cleaning Sample Cells

Cells must be extremely clean and free from significant scratches. The glass used to make cells is easily scratched – manufacturing cells free of minor scratches and other imperfections is difficult. However, minor imperfections are effectively masked by applying silicone oil as outlined in *Section 2.3.2*.

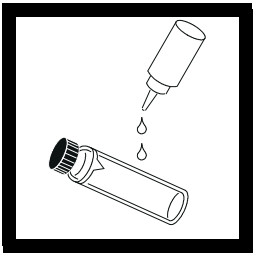
Clean the inside and outside of the cells by washing with laboratory detergent. Follow with multiple rinses of distilled or deionized water. Allow cells to air dry. Handle cells only by the top to minimize dirt, scratches and fingerprints in the light path.

2.3.2 Oiling the Sample Cell

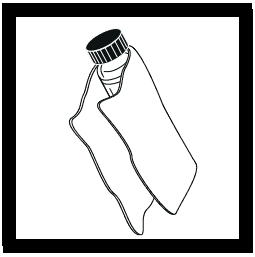
Applying a thin coat of silicone oil will mask minor imperfections and scratches which may contribute to turbidity or stray light. Use silicone oil equivalent to Hach Cat. No. 1269-36. This silicone oil has the same refractive index as glass. When applied in a thin, uniform coat, the oil fills in and masks minor scratches and other imperfections in the glass. Apply the oil uniformly by wiping with a soft, lint-free cloth.
Avoid application of excess oil. Applying excess oil may retain dirt and contaminate the instrument's cell compartment.



1. Thoroughly clean the sample cell.



2. Apply a small bead of silicone oil from the top to the bottom of the cell-- just enough to coat the cell with a thin layer of oil.



3. Using a soft, lint-free cloth, spread the oil uniformly, then wipe off the excess so that only a thin coat of oil is left. The cell should appear nearly dry with little or no visible oil.

Note: *Soft, lint-free cloth (velvet) works well for oiling. Store the oiling cloth with the sample cells and keep it free of dirt. After a few applications of oil, the cloth will contain enough residual oil that simply wiping the cell with the oiled cloth will provide a sufficient oil coat on the sample cell. Periodically, add a small amount of oil to the sample cell surface to replenish the oil in the cloth.*

Note: *Only a thin coat of oil on the sample cells is necessary.* ***Avoid using excessive amounts of oil.***

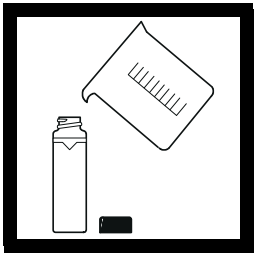
2.3.3 Orienting Sample Cells

Note: *When orienting and matching cells, it may be more efficient to use the continuous reading mode. The instrument performs continuous readings if the* **READ** *key is pressed and held. As long as the key is held, the lamp remains on and the display is updated every 1.2 seconds. The instrument cannot be used in continuous read mode if the Signal Averaging mode is on.*

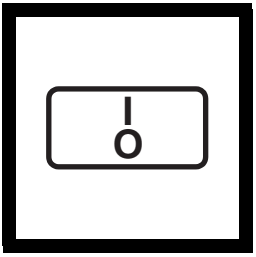
Precise measurements for very low turbidity samples require using a single cell for all measurements or optically matching the cells. Using one cell provides the best precision and repeatability. When one cell is used, an orientation mark (other than the factory-placed diamond) can be placed on the cell so it's inserted into the instrument with the same orientation each time.

2.3.3.1 Orienting a single cell

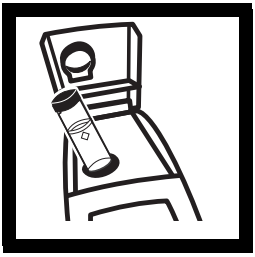
When using a single cell, make an index or orientation mark on the cell as follows:



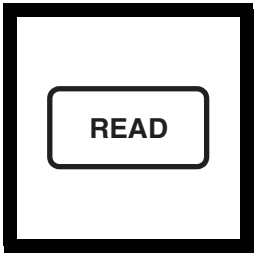
1. Fill the clean sample cell to the line with high quality water (< 0.5 NTU). Cap and wipe with lint-free cloth. Apply silicone oil. See *Section 3.6.2.2* on page *40* for more information about high quality water.



2. Press: **I/O** to turn the instrument on.



3. Insert the sample cell into the sample compartment. Close the cover.



4. Press: **READ**

Record the cell's position in the cell compartment and the displayed reading.

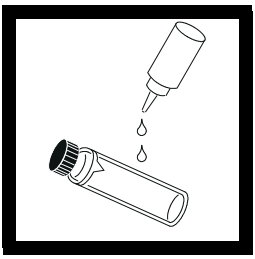
Note: *This procedure may be easier if the user holds the* **READ** *key through the whole process. This allows the lamp to remain on and make continuous readings.*

5. Remove the cell, rotate it slightly and reinsert it into the cell compartment. Close the cover, then press **READ**. Record the cell's position and the displayed reading.

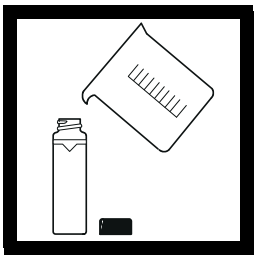
6. Repeat *step 5* until the lowest reading is displayed. Place an orientation mark on the cell's marking band near the top of the cell so the cell can be consistently inserted in the position that yields the lowest reading. When using the cell, always place it in the instrument so the orientation mark aligns with the raised mark on the instrument.

2.3.4 Matching multiple sample cells

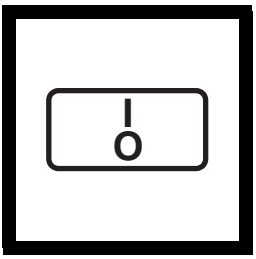
Precise measurements of very low turbidity samples require the cells be optically matched or a single cell be used for all measurements. If more than one cell is used, follow this procedure to match (index) the cells:



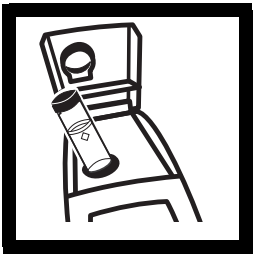
1. Clean and oil the sample cells as instructed in *Section 2.3.1* on page *23* and *Section 2.3.2* on page *23*.



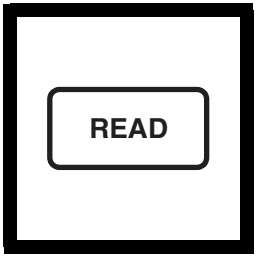
2. Fill the clean sample cells to the line with the same sample.



3. Press: **I/O** to turn the instrument on.



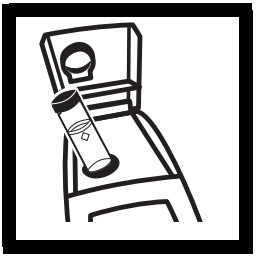
4. Insert the **first** sample cell into the sample compartment and close the cover.



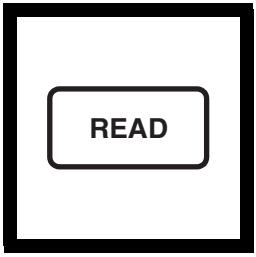
5. Press: **READ**

Record the cell's position in the cell compartment and the displayed reading. Place an orientation mark on the cell's marking band.

Note: *This procedure may be easier if the user holds the* **READ** *key through the whole process. This allows the lamp to remain on and make continuous readings.*



6. Insert the **second** sample cell into the cell compartment and close the cover.



7. Press: **READ**

Record the cell's position in the cell compartment and the displayed reading.

8. Remove the cell, rotate it slightly and reinsert into the cell compartment. Close the cover, then press **READ** again. Record the cell's position and the displayed reading.

9. Repeat *step 8* until the value displayed for the second cell is within 0.01 NTU (or 1%) of the value obtained for the first cell. Place an orientation mark on the second cell's marking band so it is consistently inserted in this position.

Note: *Due to variability in glass, it may not be possible to match all cells.*

10. Repeat *step 6* through *step 9* if matching other sample cells.

2.3.5 Removing Bubbles (Degassing)

Before measurement, removing air and other trapped gasses from the sample is strongly recommended, even if bubbles are not visible. Four degassing methods are commonly used:

1. applying a partial vacuum
2. adding a surfactant
3. using an ultrasonic bath
4. heating the sample

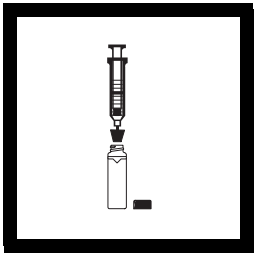
In some cases, more than one method may be necessary for effective bubble removal. For example, use of both a surfactant and ultrasonic bath may be necessary for some severe conditions. Use care with these techniques. If misused, sample turbidity can be altered.

Removing air bubbles by letting the sample stand for a period of time is not recommended. Particulates that cause turbidity may settle and the sample temperature may change. Both conditions may alter sample turbidity, resulting in measurements not representative of the original turbidity.

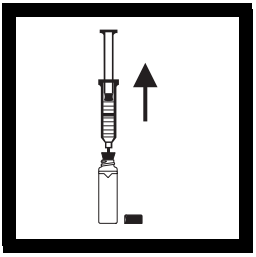
2.3.5.1 Application of vacuum

Apply a vacuum with any convenient, clean, oil-free vacuum source. The vacuum lowers the atmospheric pressure, allowing trapped bubbles to escape into the air above the sample. Vacuum works well with non-viscous samples (such as water) that don't contain volatile components. Applying vacuum to viscous, volatile-containing samples (paint resins) may cause the volatile components to come out of solution and aggravate the bubble problem.

To apply a vacuum, use a sample degassing kit equivalent to Cat No. 43975-00 (Degassing Kit) or 43975-10 (Degassing and Filtration Kit). These kits contain a syringe and rubber stopper for vacuum degassing. An electric or hand-operated pump equivalent to Cat No. 14283-00 or 14697-00, respectively, may also be used.



1. Fill a sample cell to the mark with sample. Insert a #2 single-hole rubber stopper and syringe into the cell. If using a pump, insert a piece of glass tubing into the stopper.



2. **Slowly** apply the vacuum by carefully pulling the plunger upward, then holding it. If using a hand or electric pump, connect the tubing to the vacuum pump with vacuum hose. Apply vacuum until visible gas bubbles disappear. **Slowly** release the vacuum. Remove the vacuum apparatus and cap the cell.

2.3.5.2 Adding a surfactant

Surfactants should be limited to severe problems when other degassing methods are ineffective. Surfactants change the surface tension of the water, which releases trapped gases. Hach recommends a surfactant such as Triton X-100 or the equivalent, Hach Cat No. 14096-37. Put one drop of Triton X-100 in the sample cell before adding sample.

Note: *Any turbidity contributed by surfactant addition is negligible.*

This technique is very effective when the water is super-saturated with air. However, changing the surface tension may accelerate settling of turbidity-causing particles. Mix the sample gently, but thoroughly, and analyze as soon as possible after adding the surfactant. Avoid vigorous mixing as the surfactant may foam. Rinse the sample cells thoroughly between samples to prevent surfactant accumulation.

2.3.5.3 Using an ultrasonic bath

Note: *The time necessary to expel bubbles may vary from a few seconds to a minute or more. To avoid excessive application of ultrasound, a simple procedure can be followed. First, apply ultrasound until all visible bubbles are absent. Then measure the sample turbidity. Apply ultrasound for a short time period and again measure turbidity. Continue for several repetitions, noting the treatment time and turbidity readings. If turbidity begins to increase instead of decrease, the ultrasound waves have probably started to alter the suspended particles. Note the time it takes for this to occur and record it as the maximum time limit for ultrasonic treatment.*

Ultrasonic baths effectively remove gas bubbles from most samples, especially viscous liquids. However, the ultrasonic waves which cause degassing may also alter the characteristics of the particles causing the turbidity. Turbidity depends on the size, shape, composition and refractive index of the suspended particles. Excessive ultrasound application may alter particle size and shape, thus changing sample turbidity. In some cases, ultrasound may aggravate air bubble removal by fracturing the bubbles, making degassing more difficult.

1. Fill a clean sample cell to the line with sample. Leave uncapped.

2. Immerse the cell (1/2 to 2/3 immersed) in an ultrasonic bath and allow it to stand until visible bubbles are expelled.

3. Remove the cell, cap, then thoroughly dry the cell. Apply silicone oil as directed.

2.3.5.4 Application of heat

Whenever possible, avoid using heat to degas samples because heat may change the characteristics of the suspended particles and cause volatile components to come out of solution. Gentle heating may be helpful for degassing some very viscous samples when combined with application of vacuum or ultrasound. If heat is necessary, heat the sample only until degassing occurs. The simplest technique is to prepare a warm water bath and partially immerse the filled sample cell. Use the shortest time necessary for expelling visible bubbles. Cool sample to original sample temperature before taking measurements.

2.3.6 Measuring Overrange Samples

Nephelometric turbidity measurement depends on detection of light scattered from particles suspended in the liquid. If the turbidity is very high, a significant amount of light is blocked or absorbed by the particles and only a small amount of light reaches the detector. This results in a negative interference – the measured turbidity is lower than the actual turbidity. This condition is called “going blind”. A multidetector ratioing instrument, such as the Hach 2100P Turbidimeter, minimizes this effect and extends the instrument range. Highly turbid samples may also be diluted, but this should be avoided when possible since it may alter the characteristics of the suspended particles and produce erroneous results.

Light absorbing particles such as activated carbon and highly colored samples may also cause an instrument to “go blind”. Dilution may not correct for these interferences. A ratioing instrument will correct for the presence of light absorbing particles and color.

2.3.7 Condensation (fogging)

Condensation may occur on the outside of the sample cell when measuring a cold sample in a warm, humid environment. Condensation interferes with turbidity measurement, so all moisture must be thoroughly wiped off the sample cell before measurement. If fogging recurs, let the sample warm slightly by standing at room temperature or immersing it in a warm bath for a short period. After warming, mix the sample thoroughly before measurement. Allowing samples to warm can alter sample turbidity, so it is best to avoid warming samples before measurement when possible.

2.3.8 Calibration

Turbidimeters must be properly calibrated with a primary standard. Hach recommends formazin or StablCal Stabilized Formazin for calibration. For U.S. Environmental Protection Agency (USEPA) reporting, calibrate at least as often as required by the appropriate regulatory agencies. The frequency of calibration depends on environmental conditions (humidity, temperature) and use. If necessary, calibrate more frequently.

Use secondary standards for periodic calibration checks. Please note that Gelex® standards must be assigned values after StablCal Stabilized Formazin calibration or formazin calibration and before use as secondary standards. Gelex standards must be recalibrated (values assigned) each time the instrument is calibrated with StablCal Stabilized Formazin or formazin. See *Section 3.6* on page *37* for detailed information on the use of StablCal Stabilized Formazin, formazin, and Gelex standards.

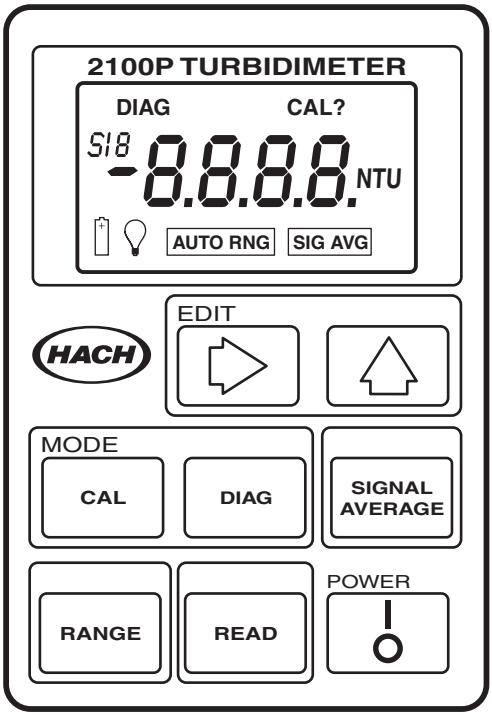
2.3.9 Representative Sampling

A representative sample accurately reflects the true condition of the water source from which the sample was taken. To ensure a representative sample, gently, but thoroughly, mix every sample before aliquots are taken. Do not allow the sample to settle.

When sampling from a tap in a distribution system or treatment plant, allow the water to run for at least five minutes before sampling. When sampling from a stream, reservoir, clarifier, or storage tank, collect at least one liter (l quart) and thoroughly mix before measurement. If the water source is not uniform, it may be necessary to sample several locations at varying depths and combine the samples into a single, well-mixed composite sample before measurement.

SECTION 3 OPERATION

3.1 Operational Controls and Indicators



Key	Description
I O	Power key to turn instrument on and off. If no keys are pressed for 5.5 minutes, the instrument turns off automatically.
READ	Depressed to perform a measurement. To conserve battery power, the lamp turns on only when **READ** is depressed. A reading is displayed about 12 seconds after the key is depressed. During the delay, a flashing **NTU** is displayed. After the reading is displayed, the lamp turns off and the reading continues to be displayed. Continuous readings may be done by holding this key if **not** in the Signal Averaging mode. After the initial delay, the reading is updated every 1.2 seconds.
CAL	Used to perform a calibration or review calibration data. Also terminates a calibration or calibration review and returns to the 2100P measurement mode.

Key	Description
△	Edits a flashing digit in the calibration mode or sequences through the calibration standards (S0,S1, S2, S3) or diagnostic menu.
▷	Used to move the editing cursor to the digits being edited in the calibration mode or initiate editing of a standard value.
SIGNAL AVERAGE	Turns the signal averaging function on or off.
DIAG	Selects the diagnostic mode.
RANGE	Selects Auto Range or Manual Range (one of three manual modes).

Display Icon	Description
DIAG	Turns on after the **DIAG** is pressed to access the diagnostic mode. A number displayed under the **DIAG** icon (1-9) indicates which diagnostic function is active. See *Section 5.1* on page *67* for more information on diagnostic codes.
CAL	Turns on after the **CAL** key is pressed to access the calibration mode and remains on during the calibration.
CAL?	Appears after calibration if a value entered during calibration is outside an acceptable range. May indicate an operator error or possible instrument malfunction. Flashing **CAL?** indicates the default calibration coefficients are being used (even after a user-calibration has been done) or that no calibration data is currently stored.
S__	Displayed during calibration. The S is followed by a number to indicate which standard value is currently being edited or displayed. Flashing number is prompting user for measurement of **S0**, **S1**, **S2** or **S3** to establish a calibration. Steady number identifies which standard's value is being displayed.
+	Flashes when the battery voltage drops to 4.4 volts as an indication to change batteries. At <4.0 volts, the instrument automatically shuts off.
	The lamp symbol is constantly on when the lamp is on and flashes after a reading if a marginal light level reaches the transmitted light detector. A flashing icon indicates the sample may be too turbid (not within measurement range) and needs dilution or the lamp needs replacing.
SIGNAL AVERAGE	Indicates the signal averaging mode is on. The icon turns off if signal averaging is not selected.

Display Icon	Description
AUTO RNG	Indicates instrument is in automatic range mode. The icon turns off when manual range mode is selected.
8888	The 4-digit display is active when the instrument is on (measurements are displayed to three digits). After the **READ** key is pressed **- - - -** is displayed during wait periods.
NTU	Identifies the measurement units- Nephelometric Turbidity Units. This icon is active during measurements and in the calibration mode.

3.2 Using the Read Key

To preserve battery power and prolong lamp life, the lamp turns on only after the **READ** key is pressed. Pressing the key turns the instrument lamp on; after about 12 seconds, the lamp turns off, but the measurement value continues to be displayed. After the first measurement, a four-second recovery time occurs before another measurement can be started. If **READ** is pressed during the recovery time, the display will begin flashing, but the lamp will not turn on until the full four seconds have passed. If no other key strokes occur within 5.5 minutes, the instrument turns off.

3.2.1 Continuous Reading

The instrument cannot be used in continuous read mode if the Signal Averaging mode is on.

The instrument will perform continuous readings if the **READ** key is pressed and held. As long as the key is held, the lamp remains on and the display is updated every 1.2 seconds.

3.3 Using the Signal Averaging Key

The signal averaging mode compensates for reading fluctuations caused by drifting of sample particles through the light path. Signal averaging is turned on or off by pressing the **SIGNAL AVERAGE** key. The **SIG AVG** icon is displayed when signal averaging is on.

Signal averaging measures and averages ten measurements while displaying intermediate results. The initial value is displayed after about 11 seconds and the display is updated every 1.2 seconds until all ten measurements are taken (about 22 seconds). After 22 seconds, the lamp

turns off, but the final measured turbidity value continues to be displayed until another key is pressed.

When signal averaging is off, the instrument takes three measurements, the microprocessor averages them, then displays the average. If the **READ** key is held during measurement, the initial value is displayed in 12 seconds and is updated every 1.2 seconds as long as the **READ** key is held.

When the instrument is turned on, the instrument defaults to the signal averaging mode which was used during the last measurement.

3.4 Using the Range Selection Key

As shipped, the instrument defaults to automatic range mode. The first time the **RANGE** key is pressed, the instrument goes into manual range mode. The second, third, and fourth key strokes put the instrument in the 0.00-9.99, 10 to 99.9 or 100-1000 NTU range, respectively. Another key stroke brings the selection back to automatic range mode. When the automatic range mode is selected, the **AUTO RNG** icon is displayed. Range selection can be done any time except when a measurement or calibration is in progress.

When the instrument is turned on, the instrument defaults to the range mode and measurement range which was used during the last measurement.

3.5 Restoring the Default Calibration

To restore and use the default calibration, turn the instrument off. Press and hold **DIAG**, then press and release **I/O**. Release **DIAG** when the software version number disappears from the display. (For models with serial number less than 920300000800, **2100** disappears). This clears any user-entered calibration from memory; the 2100P will use the default calibration for measurement. **CAL?** will appear and continue to flash until a user-entered calibration is successfully completed.

For best results, a user-entered calibration should be done every three months.

3.6 Calibration

Calibration of the 2100P Turbidimeter is based on formazin, the primary standard for turbidity. The instrument's electronic and optical design provide long-term stability and minimize the need for frequent calibration. The two-detector ratioing system compensates for most fluctuations in lamp output. **A formazin recalibration should be performed at least once every three months,** more often if experience indicates the need. When calibration is necessary, use a primary standard such as StablCal™ Stabilized Standards or formazin standards.

Hach Company only recommends the use of StablCal® Stabilized Formazin or formazin standards for the calibration of Hach turbidimeters. Hach Company cannot guarantee the performance of the turbidimeter if calibrated with co-polymer styrene divinylbenzene beads or other suspensions.

Important Note: DO NOT calibrate with Gelex® Secondary Standards. Gelex standards are designed for instrument verification, not calibration.

3.6.1 StablCal Stabilized Formazin Standards*

Most consistent results will be achieved with the use of StablCal Stabilized Formazin Standards for calibration. Refer to *Section 3.6.1.2* and *Section 3.6.1.3* for information on preparing the standards for use.

Note: *Hach StablCal Stabilized Formazin in 20-, 100-, and 800-NTU values is packaged in convenient sets for calibration of the 2100P Turbidimeter. The set may be ordered in 500-mL size bottles by specifying Cat. No. 26594-00, in 100-mL size bottles by specifying Cat. No. 26594-10 or in sealed vials by ordering Cat. No. 26594-05. (See OPTIONAL ACCESSORIES AND REAGENTS on page 74.)*

3.6.1.1 Storing and Handling StablCal Stabilized Standards

For optimum results when using StablCal Stabilized Standards, adhere to the following recommendations:

* StablCal Stabilized Formazin is cited as a primary standard in Hach Method 8195, an acceptable version of USEPA Method 180.1.

- Do not transfer the standard to another container for storage.
- Do not return standard from the sample cell back into the its original container. Standard contamination will result.
- Store standards between 0 and 25 °C.
- For long-term storage, refrigeration at 5 °c is recommended. Do not store above 25 °C.
- Allow the standard to acclimate to ambient instrument conditions before use (not to exceed 40 °C).
- Store away from direct sunlight. Store vials in their respective kit or shipping box with the cover in place.

3.6.1.2 Preparing Bulk StablCal Stabilized Standards

Bulk standards that have been sitting undisturbed for longer than a month must be shaken to break the condensed suspension into its original particle size. Start at *step 1* for these standards. If the standards are used on at least a weekly interval, start at *step 3*.

Important Note: These instructions do not apply to <0.1-NTU* StablCal Standards; <0.1NTU StablCal Standards should not be shaken or inverted.

1. Shake the standard vigorously for 2-3 minutes to resuspend any particles.
2. Allow the standard to stand undisturbed for 5 minutes.
3. Gently invert the bottle of StablCal 5 to 7 times.
4. Prepare the sample cell for measurement using traditional preparation techniques. This usually consists of oiling the sample cell (see*Section 2.3.2* on page *23*) and marking the cell to maintain the same orientation in the sample cell compartment (see *Section 2.3.3* on page *24*). This step will eliminate any optical variations in the sample cell.

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* Used in place of the dilution water standard when performing a calibration.

5. Rinse the sample cell at least one time with the standard and discard the rinse.

6. Immediately fill the sample cell with the standard. Cap the sample cell and let it stand for one minute. The standard is now ready for use in the calibration procedure, *Section 3.6.3*.

3.6.1.3 Preparing StablCal Stabilized Standards in Sealed Vials

Sealed vials that have been sitting undisturbed for longer than a month must be shaken to break the condensed suspension into its original particle size. Start at *step 1* for these standards. If the standards are used on at least a weekly interval, start at *step 3*

Important Note: These instructions do not apply to <0.1-NTU* StablCal Standards; <0.1NTU StablCal Standards should not be shaken or inverted.

1. Shake the standard vigorously for 2-3 minutes to resuspend any particles.

2. Allow the standard to stand undisturbed for 5 minutes.

3. Gently invert the vial of StablCal 5 to 7 times.

4. Prepare the vial for measurement using traditional preparation techniques. This usually consists of oiling the vial (see *Section 2.3.2* on page *23*) and marking the vial to maintain the same orientation in the sample cell compartment (see *Section 2.3.3* on page *24*). This step will eliminate any optical variations in the sample vial.

5. Let the vial stand for one minute. The standard is now ready for use in the calibration procedure, *Section 3.6.3*.

3.6.2 Formazin Primary Standards

Perform the procedure in *Section 3.6.2.1* to prepare a 4000-NTU standard. Alternately, order a 4000-NTU stock solution from Hach by specifying Cat. 2461-49. Prepare the dilutions from the 4000-NTU stock solution by following the instructions in *Section 3.6.2.4*.

3.6.2.1 Preparing Formazin Stock Solution

Dilute formazin standard solutions from a 4000 NTU stock solution equivalent to Hach Cat. No. 2461-49. The prepared stock solution is stable for up to one year when properly prepared. An alternative to purchasing the 4000 NTU stock solution is preparing a stock solution as follows:

1. Dissolve 5.000 grams of reagent grade hydrazine sulfate ($N_2H_4 \cdot H_2SO_4$) in 400 mL of distilled water.

2. Dissolve 50.000 grams of pure hexamethylenetetramine in 400 mL of distilled water.

3. Pour the two solutions into a 1000-mL volumetric flask and dilute to the mark with distilled water.

4. Let the solution stand for 48 hours at 25 °C (77 °F) to develop the 4000-NTU stock suspension. The standing temperature is critical for correct formation of formazin polymers.

5. Mix the 4000 NTU suspension for at least ten minutes before use. Then it can be diluted with distilled or demineralized water to achieve a solution of the desired NTU value.

Instead of diluting a formazin stock solution, StablCal Stabilized Formazin Standards may be used. Order the StablCal Calibration Set for the 2100P Turbidimeter, Cat.No. 26594-00 (500-mL bottles), Cat. No. 26594-10 (100 mL bottles), or Cat. No. 26594-05 (sealed vials). (See *OPTIONAL ACCESSORIES AND REAGENTS* on page *74*.)

3.6.2.2 Correcting for Turbidity of Dilution Water

The 2100P Turbidimeter automatically compensates for turbidity contributed by dilution water when calculating the true value of the lowest formazin standard. Use high quality distilled or deionized water less than 0.5 NTU. The instrument will display E 1 after calibration if

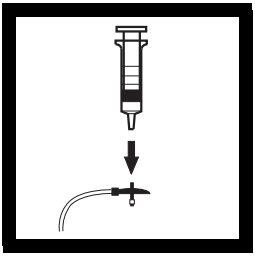
the dilution water turbidity is greater than 0.5 NTU. In this case, prepare the water as directed below.

The value of the dilution water can be arbitrarily forced to zero (see calibration procedure). This is not recommended for most applications and, if done, should be done only if the dilution water turbidity is less than 0.2 NTU.

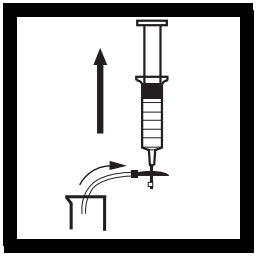
3.6.2.3 Preparing Dilution Water

Note: *Use the same dilution water for all dilutions and the sample blank.*

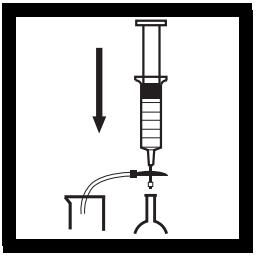
Collect at least 1000 mL of high quality dilution water (distilled or deionized water). The 2100P Turbidimeter, as received from the factory, is precalibrated and may be used to check the dilution water turbidity. If the turbidity is greater than 0.5 NTU, filter the water with the Sample Filtration and Degassing Kit (Cat. No. 43975-10) or equivalent. When measuring low range turbidity, clean all glassware with 1:1 hydrochloric acid and rinse several times with dilution water. If the glassware is not used immediately, use stoppers to prevent contamination from small particles.



1. Attach the syringe to the 3-way valve by gently twisting the square end into the syringe tip. Attach the connector, tubing and a 0.2 micron filter (clear part faces syringe) as shown. Be sure the connections are tight.



2. Fill a beaker or container with the water to be filtered. Insert the tubing into the container. Slowly draw the water into the syringe by pulling up on the syringe plunger.



3. Draw about 50 mL of sample into the syringe. Slowly push on the plunger to force the water through the filter and into a graduated cylinder or volumetric flask. Repeat Steps 2 and 3 until the desired amount of water is obtained.

Note: *As the filter clogs, it gets more difficult to push water through it. At this point, discard the filter and attach a new filter. Replacement filters are available in packages of 10 (Cat. No. 23238-10).*

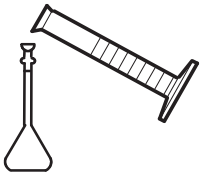
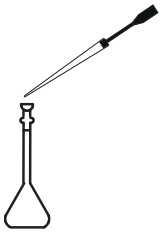
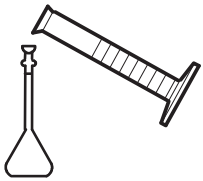
3.6.2.4 Preparing Formazin Dilutions (Factory recommended)

Hach Company recommends using 20, 100, and 800 NTU formazin standards for calibrating the 2100P Turbidimeter. Dilutions with other NTU values can be prepared and used (see *Section 3.6.3.1* on page *48*). If problems occur when using alternate solutions, use the dilutions specified here.

Prepare all formazin dilutions immediately before use and discard after calibration. The 4000 NTU solution is stable for up to a year, but dilutions deteriorate more rapidly. Use the same high quality water (turbidity <0.5 NTU) for the dilutions and the blank.

Preparing the 20, 100 and 800 NTU standards

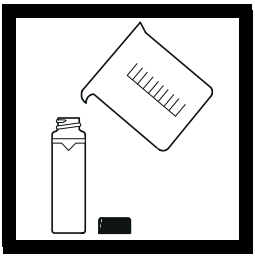
Table 1 Formazin Standard Preparation

	Step 1	Step 2	Step 3
Standards			
20 NTU	Add 100 mL of dilution water to a clean **200-mL** class A volumetric flask.	With a TenSette* pipet, add 1.00 mL of well-mixed 4000 NTU Formazin stock solution to the 200-mL flask.	Dilute to the mark with dilution water. Stopper and mix.
100 NTU	Add 100 mL of dilution water to a clean **200-mL** class A volumetric flask.	With a TenSette pipet, add 5.00 mL of well-mixed 4000 NTU Formazin stock solution to the 200-mL flask.	Dilute to the mark with dilution water. Stopper and mix.
800 NTU	Add 50 mL of dilution water to a clean **100-mL** class A volumetric flask.	With a TenSette pipet, add 20.00 mL of well-mixed 4000 NTU Formazin stock solution to the 100-mL flask.	Dilute to the mark with dilution water. Stopper and mix.

* A class A volumetric pipet may be used in place of a TenSette Pipet.

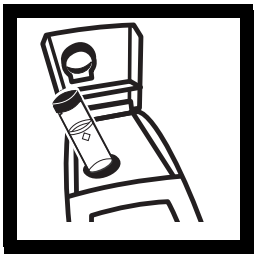
3.6.3 Calibrating the Turbidimeter

Note: *For best accuracy use the same sample cell or four matched sample cells for all measurements during calibration. Always insert the cell so the orientation mark placed on the cell during the matching procedure is correctly aligned. (See Section 2.3.4 on page 26 for matching sample cells).*



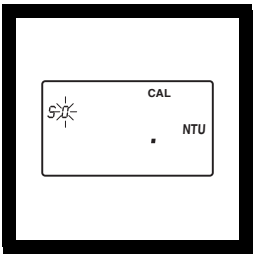
1. Rinse a clean sample cell with dilution water several times. Then fill the cell to the line (about 15 mL) with dilution water or use StablCal <0.1 NTU standard.

Note: *The same dilution water used for preparing the standards must be used in this step.*



2. Insert the sample cell in the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment. Close the lid. Press **I/O**.

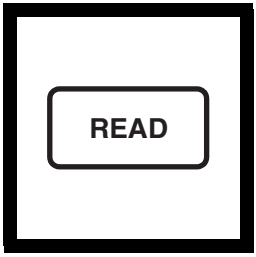
Note: *Choose signal average mode option (on or off) before pressing* **CAL** *– the* **SIGNAL AVERAGE** *key is not functional in calibration mode.*

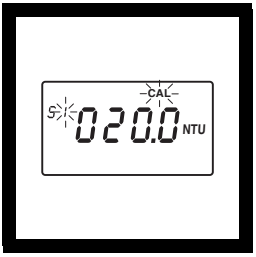


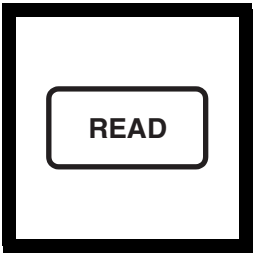
3. Press: **CAL**

The **CAL** and **S0** icons will be displayed (the **0** will flash). The 4-digit display will show the value of the S0 standard for the previous calibration. If the blank value was forced to 0.0, the display will be blank (as shown). Press → to get a numerical display.

Hach Company only recommends the use of StablCal® Stabilized Formazin or formazin standards for the calibration of Hach turbidimeters. Hach Company cannot guarantee the performance of the turbidimeter if calibrated with co-polymer styrene divinylbenzene beads or other suspensions. DO NOT calibrate with Gelex® Secondary Standards.







4. Press: **READ**

The instrument will count from 60 to 0, (67 to 0 if signal average is on), read the blank and use it to calculate a correction factor for the 20 NTU standard measurement. If the dilution water is ≥ 0.5 NTU, E 1 will appear when the calibration is calculated (See *Section 3.6.2.3* on page *41* for more dilution water information). The display will automatically increment to the next standard. Remove the sample cell from the cell compartment.

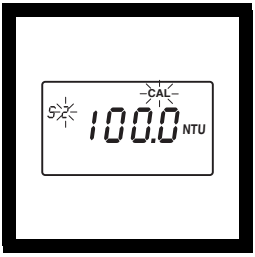
Note: *The turbidity of the dilution water can be "forced" to zero by pressing → rather than reading the dilution water. The display will show* **S0 NTU** *and the ↑ key must be pressed to continue with the next standard.*

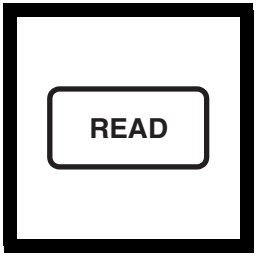
5. The display will show the **S1** (with the 1 flashing) and **20 NTU** or the value of the S1 standard for the previous calibration. If the value is incorrect, edit the value by pressing the → key until the number that needs editing flashes. Use the ↑ key to scroll to the correct number. After editing, fill a clean sample cell to the line with **well mixed** 20 NTU StablCal Standard or 20 NTU formazin standard. Insert the sample cell into the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment. Close the lid.

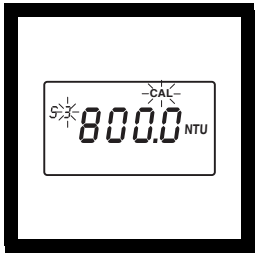
6. Press: **READ**

The instrument will count from 60 to 0 (67 to 0 if signal average is on), measure the turbidity and store the value. The display will automatically increment to the next standard. Remove the sample cell from the cell compartment.

Note: *For potable water applications with low turbidity values the instrument calibration may be stopped after the 20 NTU StablCal Standard has been read. Press* **CAL** *after reading the 20 NTU standard. The instrument calibration is now complete for the range of 0-20 NTU only. The instrument will continue to read turbidity values above 20 NTU. These values were not updated during the 0-20 NTU calibration.*





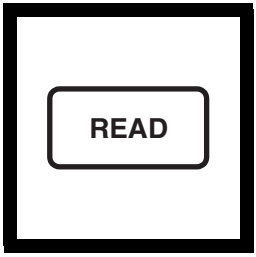


7. The display will show the **S2** (with the 2 flashing) and **100 NTU** or the value of the S2 standard for the previous calibration. If the value is incorrect, edit the value by pressing the → key until the number that needs editing flashes. Use the ↑ key to scroll to the correct number. After editing, fill a clean sample cell to the line with **well mixed** 100 NTU StablCal Standard or 100 NTU formazin standard. Insert the sample cell into the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment. Close the lid.

8. Press: **READ**

The instrument will count from 60 to 0 (67 to 0 if signal average is on), measure the turbidity and store the value. Then, the display will automatically increment to the next standard. Remove the sample cell from the cell compartment.

9. The display will show the **S3** (with the 3 flashing) and **800 NTU** or the value of the S3 standard for the previous calibration. If the value is incorrect, edit the value by pressing the → key until the number that needs editing flashes. Use the ↑ key to scroll to the correct number. After editing, fill a clean sample cell to the line with **well mixed** 800 NTU StablCal Standard or 800 NTU formazin standard. Insert the sample cell into the cell compartment by aligning the orientation mark on the cell with the mark on the front of the cell compartment. Close the lid.



10. Press: **READ**

The instrument will count from 60 to 0 (67 to 0 if signal average is on), measure the turbidity and store the value. Then the display will increment back to the S0 display. Remove the sample cell from the cell compartment.

11. Press: **CAL** to accept the calibration. The instrument will return to measurement mode automatically.

Note: *Pressing* **CAL** *completes the calculation of the calibration coefficients. If calibration errors occurred during calibration, error messages will appear after* **CAL** *is pressed. If* **E 1** *or* **E 2** *appear, check the standard preparation and review the calibration; repeat the calibration if necessary. If* **CAL?** *appears, an error may have occurred during calibration. If* **CAL?** *is flashing, the instrument is using the default calibration.*

NOTES

- If the **I/O** key is pressed during calibration, the new calibration data is lost and the old calibration will be used for measurements. Once in calibration mode, only the **READ, I/O,** ↑, and → keys function. Signal averaging and range mode must be selected before entering the calibration mode.

- If **E 1** or **E 2** are displayed, an error occurred during calibration. Check the standard preparation and review the calibration; repeat the calibration if necessary. Press **DIAG** to cancel the error message (**E 1** or **E 2**). To continue without repeating the calibration, press **I/O** twice to restore the previous calibration. If **CAL?** is displayed, an error may have occurred during calibration. The previous calibration may not be restored. Either recalibrate or use the calibration as is.

- To review a calibration, press **CAL** and then ↑ to view the calibration standard values. As long as **READ** is never pressed and **CAL** is not flashing, the calibration will not be updated. Press **CAL** again to return to the measurement mode.

3.6.3.1 Preparing User-selected Formazin Dilutions

The formazin solutions should span the entire range of the instrument. Hach recommends preparing three standards:

1. 10 to 30 NTU

2. 90 to 110 NTU

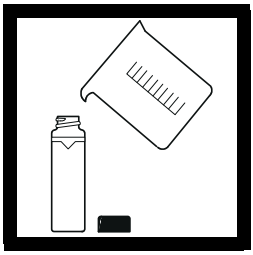
3. 700 to 900 NTU

The standards must have a difference of at least 60 NTU.
In addition, a blank made from the dilution water should be prepared.

Prepare the formazin standard solutions from the well mixed 4000 NTU stock solution as specified in *Section 3.6.2.4* on page *42* and dilution water as specified in *Section 3.6.2.2* and *Section 3.6.2.3* on page *41*. Make the standards **immediately** before use and discard them after calibration is done.

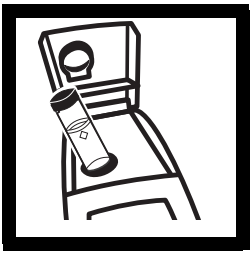
3.6.3.2 Calibrating with User-selected Standards

Note: *For best accuracy use the same sample cell or four matched sample cells for all measurements during calibration. Always insert the sample cell with the same orientation.*



1. Fill a clean sample cell to the line (about 15 mL) with dilution water.

Note: *The same dilution water used for preparing the standards must be used in this step.*

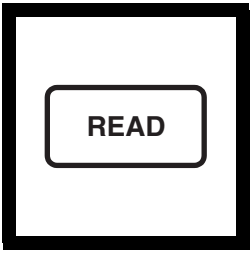


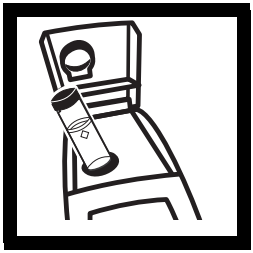
2. Insert the sample cell into the cell compartment and close the lid. Press **I/O**.

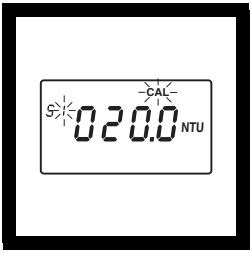
Note: *Choose signal average mode option (on or off) before pressing* **CAL** *– the* **SIGNAL AVERAGE** *key is not functional in calibration mode.*

3. Press: **CAL**.

The **CAL** and **S0** icons will appear (the **0** will flash). The 4-digit display will show the value of the S0 standard for the previous calibration.





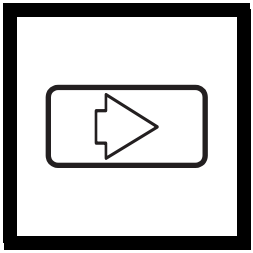


4. Press: **READ**.

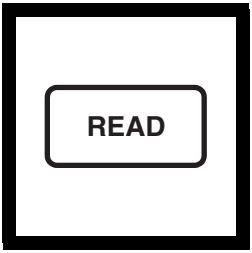
The instrument will count from 60 to 0 (67 to 0 if signal average is on), measure the blank and use it to calculate a correction factor for the lowest standard. If the dilution water is ≥0.5 NTU, **E 1** will appear (see *Section 3.6.2.3* on page *41* for more dilution water information). The display will automatically increment to the next standard. Remove the sample cell from the cell compartment.

5. Thoroughly mix the 10 to 30 NTU range standard, then fill a clean sample cell to the line with the standard. Insert the sample cell into the cell compartment

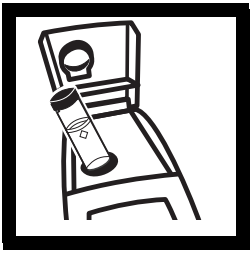
6. The display will show the **S1** icon (with the **1** flashing) and **20 NTU** or the value of the S1 standard for the previous calibration.



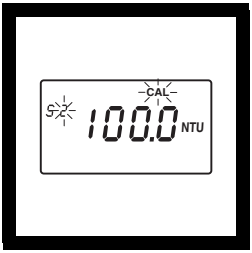
7. Edit the standard concentration by pressing →. The **1** will stop flashing and the left digit in the display will flash. Press ↑ to scroll the digit up to the appropriate number. Press → again to move the cursor to the next digit and edit it in the same manner.



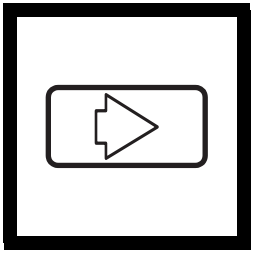
8. When all the digits show the appropriate value, press **READ**. The instrument will count from 60 to 0 (67 to 0 if signal average is on), measure the turbidity and store the value. The display will automatically increment to the next standard. Remove the sample cell from the cell compartment.



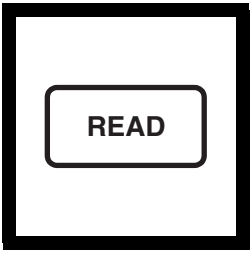
9. Thoroughly mix the 90 to 110 NTU standard, then fill a clean sample cell to the line with the standard. Insert the cell into the cell compartment.



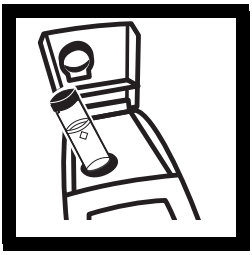
10. The display will show the **S2** icon (with the **2** flashing) and **100 NTU** or the value of the S2 standard for the previous calibration.



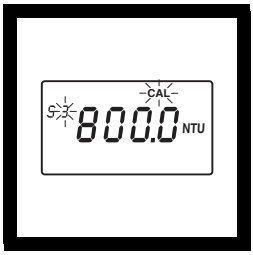
11. Edit the standard concentration by pressing →. The **2** will stop flashing and the left digit in the display will flash. Press ↑ to scroll the digit up to the appropriate number. Press → again to move the cursor to the next digit and edit it in the same manner.



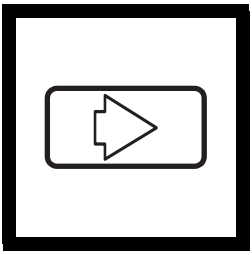
12. When all the digits show the appropriate value, press **READ**. The instrument will count from 60 to 0 (67 to 0 if signal average is on), measure the turbidity and store the value. Remove the sample cell from the cell compartment.



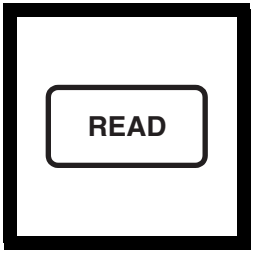
13. Thoroughly mix the 700 to 900 NTU standard, then fill a clean sample cell to the line with the standard. Insert the cell into the cell compartment.



14. The display will show the **S3** icon (with the **3** flashing) and **800 NTU** or the value of the S3 standard for the previous



15. Edit the standard concentration by pressing →. The **3** will stop flashing and the left digit in the display will flash. Press ↑ to scroll the digit up to the appropriate number. Press → again to move the cursor to the next digit and edit it in the same manner.



16. When all the digits show the appropriate value, press **READ**. The instrument will count from 60 to 0 (67 to 0 if signal average is on), measure the turbidity and store the value. The instrument will increment back to **S0**. Remove the sample cell from the cell compartment.

17. Press: **CAL**.

The instrument will store the new calibration data and return the instrument to the measurement mode. It will use the new calibration to calculate turbidity for subsequent measurements.

Note: *Pressing* **CAL** *completes the calculation of the calibration coefficients. If calibration errors occurred during calibration, error messages will appear after* **CAL** *is pressed. If* **E 1** *or* **E 2** *appear, check the standard preparation and review the calibration; repeat the calibration if necessary. If* **CAL?** *appears, an error may have occurred during calibration. If* **CAL?** *is flashing, the instrument is using the default calibration.*

NOTES

- If the **I/O** key is pressed during calibration, the new calibration data is lost and the old calibration will be used for measurements. Once in calibration mode, only the **READ, I/O,** ↑, and → keys function. Signal averaging and range mode must be selected before entering the calibration mode.

- If **E 1** or **E 2** are displayed, an error occurred during calibration. Check the standard preparation and review the calibration; repeat the calibration if necessary. If the error messages recur, calibrate using the factory specified standards, *Section 3.6.2.4* on page *42* and *Section 3.6.3* on page *44*. Press **DIAG** to cancel the error message (**E 1** or **E 2**). To continue without repeating the calibration, press **I/O** twice to restore the previous calibration. If **CAL?** is displayed, an error may have occurred during calibration. The previous calibration may not be restored. Either recalibrate or use the calibration as is.

- To review a calibration, press **CAL** and then only ↑ to view the calibration standard values. As long as **READ** is never pressed and **CAL** isn't flashing, the calibration will not be updated. Press **CAL** again to return to the measurement mode.

3.6.4 Using Gelex® Secondary Turbidity Standards

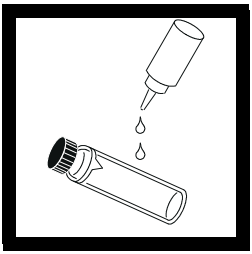
Note: *Store Gelex standards at room temperature. Do not allow to freeze or exceed 50 °C.*

Gelex Secondary Standards (included with 4650000 only) are particulate suspensions similar to formazin primary standards in light scattering characteristics. NTU values on the Gelex standards indicate the range for which they should be used. Due to minor variations in glass and individual instrument optical systems, the true value of the Gelex standards must be determined against formazin in the same instrument they will be used with for later calibration checks.

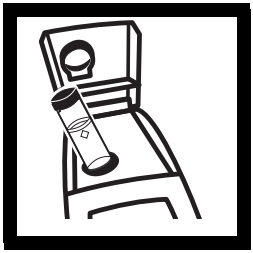
3.6.4.1 Assigning Values to Gelex Standards

1. Calibrate the instrument with formazin.

2. Select automatic range mode using the **RANGE** key.

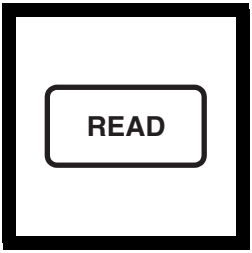


3. Thoroughly clean the outside of the Gelex vials and apply a thin coating of silicone oil.



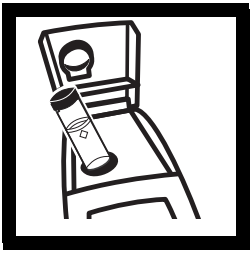
4. Place the 0-10 NTU Gelex standard in the cell compartment so the diamond on the vial aligns with the orientation mark on the instrument. Close the sample lid.

Note: *Correct cell orientation is essential to obtain accurate Gelex values. Always orient the cell so the diamond mark aligns with the orientation mark on the instrument.*



5. Press: **READ**.

Record the displayed value, remove the vial from the instrument and mark the value on the band near the top of the vial.



6. Repeat *step 3* through *step 5* for the other Gelex standards, being careful to orient the cells properly.

Re-assign with every formazin calibration

7. Re-assign values to the Gelex standards each time the instrument is calibrated with formazin.

3.6.4.2 Routine Calibration Check With Gelex Standards

The 2100P Turbidimeter does not require standardization before every measurement as some turbidimeters do. Periodically, as experience dictates, check the instrument calibration using the appropriate Gelex Secondary Standard. Be sure the Gelex standards are aligned correctly when inserting them (diamond aligns with orientation mark). If the reading is not within 5% of the previously established value, recalibrate the instrument with StablCal Stabilized Formazin Primary Standard or formazin primary standard (*Section 3.6.3* on page *44*).

Important Note: DO NOT calibrate with Gelex® Secondary Standards. Gelex standards are designed for instrument verification, not calibration.

MAINTENANCE

Some of the following manual sections contain information in the form of warnings, cautions and notes that require special attention. Read and follow these instructions carefully to avoid personal injury and damage to the instrument. Only personnel qualified to do so, should conduct the maintenance tasks described in this portion of the manual.

Certains des chapitres suivants de ce mode d'emploi contiennent des informations sous la forme d'avertissements, messages de prudence et notes qui demandent une attention particulière. Lire et suivre ces instructions attentivement pour éviter les risques de blessures des personnes et de détoriation de l'appareil. Les tâches d'entretien décrites dans cette partie du mode d'emploi doivent être seulement effectuées par le personnel qualifié pour le faire.

Algunos de los capítulos del manual que presentamos contienen muy importante información en forma de alertas, notas y precauciones a tomar. Lea y siga cuidadosamente estas instrucciones a fin de evitar accidentes personales y daños al instrumento. Las tareas de mantenimiento descritas en la presente sección deberán ser efectuadas únicamente por personas debidamente cualificadas.

Einige der folgenden Abschnitte dieses Handbuchs enthalten Informationen in Form von Warnungen, Vorsichtsmaßnahmen oder Anmerkungen, die besonders beachtet werden müssen. Lesen und befolgen Sie diese Instruktionen aufmerksam, um Verletzungen von Personen oder Schäden am Gerät zu vyyyermeiden. In diesem Abschnitt beschriebene Wartungsaufgaben dürfen nur von qualifiziertem Personal durchgeführt werden.

Algumas das seguintes secções do manual contêm informações em forma de advertências, precauções e notas que requerem especial atenção. Leia e siga atentamente as presentes instruções para evitar ferimentos pessoais e não danificar o instrumento. As tarefas de manutenção descritas nesta parte do manual só poderão ser executadas por pessoal qualificado.

SECTION 4 MAINTENANCE

4.1 Cleaning

Keep the turbidimeter and accessories as clean as possible and store the instrument in the carrying case when not in use. Avoid prolonged exposure to sunlight and ultraviolet light. Wipe spills up promptly. Wash sample cells with non-abrasive laboratory detergent, rinse with distilled or demineralized water, and air dry. Avoid scratching the cells and wipe all moisture and fingerprints off the cells before inserting them into the instrument. Failure to do so can give inaccurate readings. See *Section 2.3.1* on page *23* for more information about sample cell care.

4.2 Battery Replacement

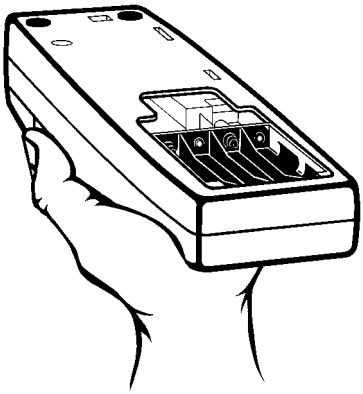
AA alkaline cells typically last for about 300 tests with the signal averaging mode off, about 180 tests if signal averaging is used. The “battery” icon flashes when battery replacement is needed. Refer to *Section 1.4.2* on page *16* for battery installation instructions. If the batteries are changed within 30 seconds, the instrument retains the latest range and signal average selections. If it takes more than 30 seconds, the instrument uses the default settings.

If, after changing batteries, the instrument will not turn off or on and the batteries are good, remove the batteries and reinstall them. If the instrument still won't function, contact Hach Service or the nearest authorized dealer.

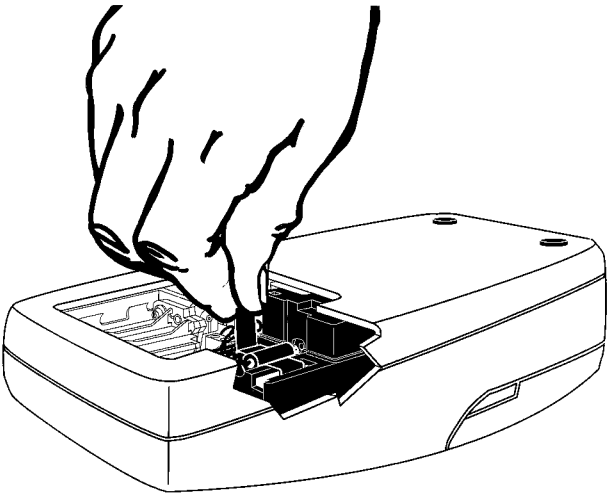
4.3 Lamp Replacement

The procedure below explains lamp installation and electrical connections. Use a small screwdriver to remove and install the lamp leads in the terminal block. The instrument requires calibration after lamp replacement.

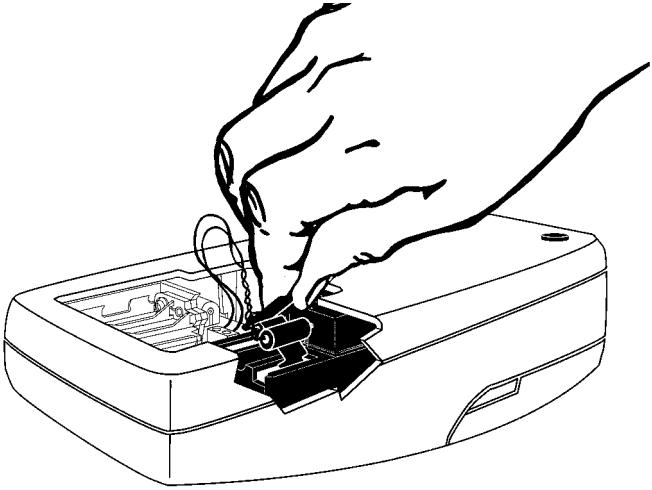
1. Orient the instrument so it is upside down and the top faces away from you. Remove the battery cover and at least one battery.



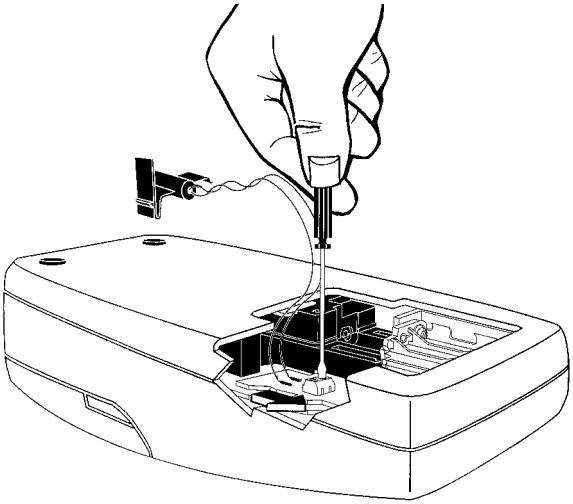
2. Remove the lamp assembly by grasping the tab on the left side of the assembly. Firmly, but gently, slide the assembly towards the rear of the instrument.



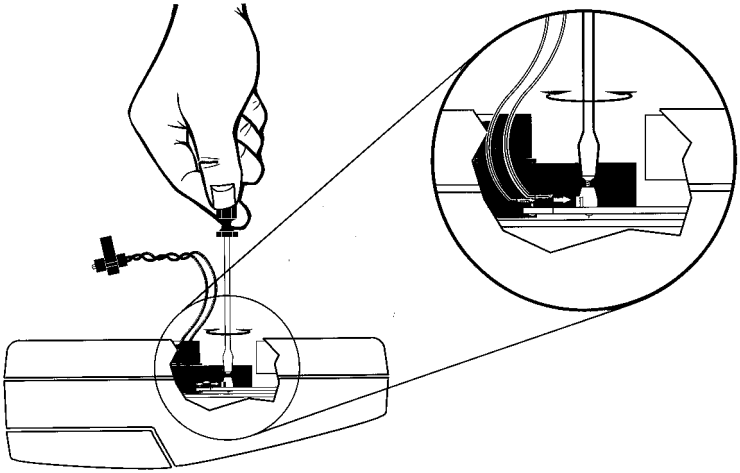
3. Rotate the tab towards the nearest outside edge. The assembly should release and slip out easily.



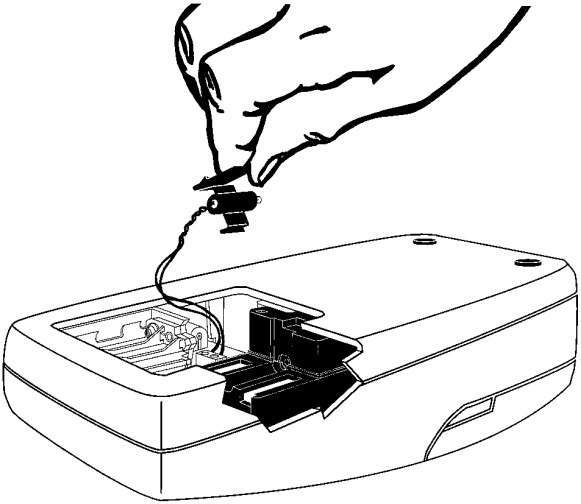
4. Back the terminal block screws **partially** out (1 to 2 turns) and remove the old lamp leads.



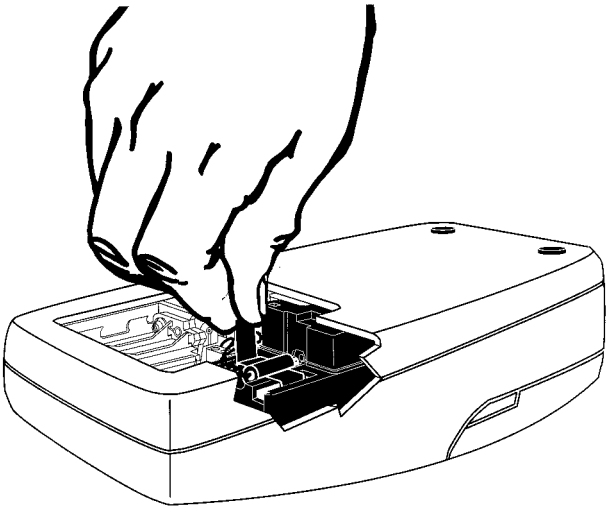
5. Gently bend the wires of the new lamp assembly into an “L” shape so they fit easily into the housing. Insert the leads into the terminal screws and tighten with clockwise turns. Gently tug on the wires to make sure they are connected to the terminal block.



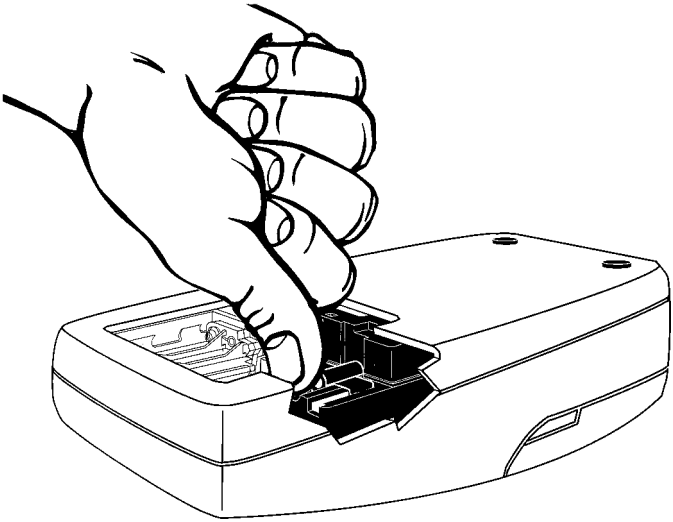
6. Hold the new lamp assembly by the tab with the lamp facing the tope (keyboard) of the instrument. Slide the small catch on the other side of the assembly into the black plastic slot (towards the nearest edge of the instrument).



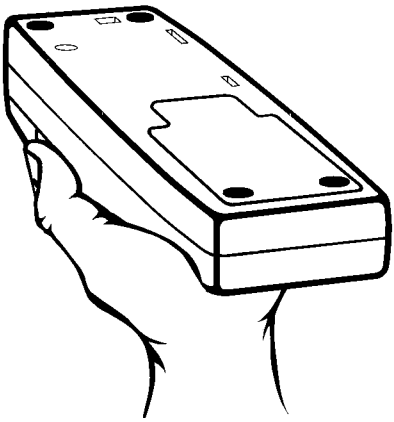
7. Snap the U-shaped bottom of the tab into the slot on the left side of the black plastic that holds the lamp assembly.



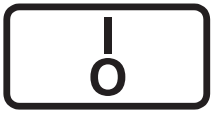
8. With your thumb, firmly slide the assembly forward until it stops. Again, push firmly against the tab to make sure the lamp is seated correctly.



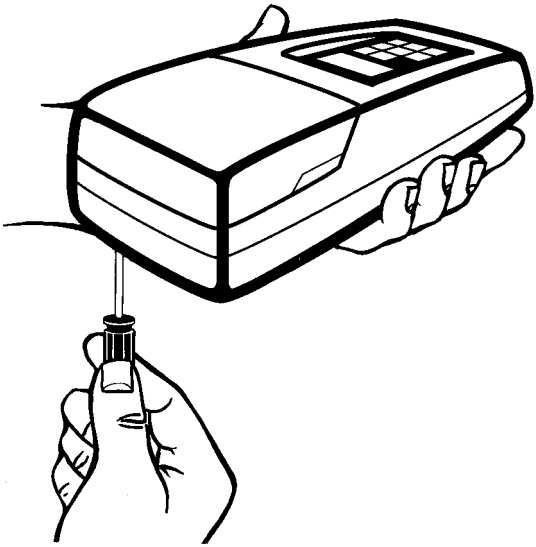
9. Replace the battery(s) and battery cover.



10. Insert the 800 NTU formazin standard into the sample cell. Press and hold **READ**. Then press **I/O**. Release the **READ** key after the software version number disappears from the display (for models with serial numbers less than 920300000800, **2100** disappears).



11. Adjust the scattered light amplifier output by inserting a small flat-bladed screwdriver into the trimpot hole (located on bottom). Adjust the display to read 2.5 ± 0.3 volts (2.0 volts for models that display **2100** when turned on).



12. Press **I/O** to exit gain adjust mode.

13. Perform a formazin calibration according to *Section 3.6.3* on page *44* or *Section 3.6.3.1* on page *48*.

SECTION 5 TROUBLESHOOTING

5.1 Using the Diagnostic Functions Key

Enter the diagnostic mode by pressing the **DIAG** key. Exit this mode at any time by pressing the key again. The diagnostic mode allows access to information about instrument function which may be useful for servicing and troubleshooting.

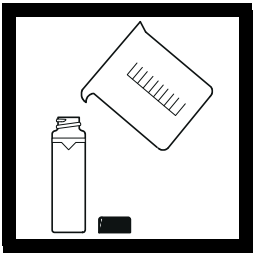
5.1.1 Basic Diagnostic Codes

The diagnostic codes are:

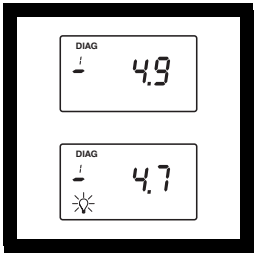
Code	Description
1	Checks the battery voltage with the lamp on, then with the lamp off. This is a dual diagnostic code.
2	Displays calibration coefficient a_o
3	Displays calibration coefficient a_1
4	Displays calibration coefficient b_o
5	Displays calibration coefficient b_1
6	Displays the lamp voltage (about 3 volts)
7	Displays the dark voltage of the transmitted light detector amplifier with the lamp off and the detector amplifier voltage with the lamp on.
8	Displays the high gain dark voltage of the 90° detector amplifier with the lamp off and the detector amplifier voltage with the lamp on.*
9	Displays the low gain dark voltage of the 90° detector amplifier with the lamp off and the detector amplifier voltage with the lamp on.

* Samples with turbidity >10 NTU may display **- - -** for the lamp-on amplifier voltage.

5.2 The Diagnostic Procedure

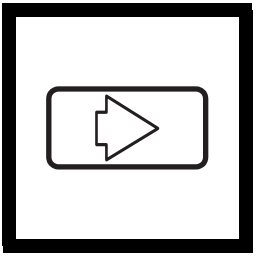


1. Fill a clean sample cell to the line with clear water, cap the cell and place it in the cell compartment. Press the **READ** key and wait until the reading is finished.

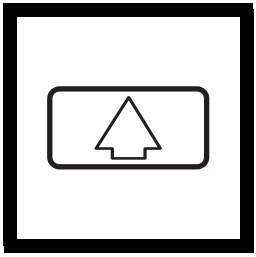


2. Press: **DIAG**

The **DIAG** icon will turn on and **1** will be displayed below the icon. The instrument will measure the battery voltage with the lamp off and display the result in volts (V). Then the lamp icon will turn on and the instrument will measure the voltage with the lamp on. The value is briefly displayed before defaulting to the lamp-off reading. To repeat the measurement, press **READ**.



3. To continuously display the lamp-on voltage, press →. The lamp icon will flash. Press → to turn the lamp icon off (the lamp is not on during this display).



4. Press the ↑ key to scroll through the other diagnostics. Each press of the key increments the digit in the small numerical display below the **DIAG** icon and the result of the diagnostic measurement is then displayed. Each press of the **READ** key updates the value. For measurements made with the lamp off and again with the lamp on, the measurement with the lamp off is displayed when the diagnostic is entered. To see the second measurement with the lamp on, press the → key (only works with diagnostic codes 1, 7, 8, & 9). The lamp icon will flash and the lamp-on measurement will be displayed in volts. Press → to turn the lamp icon off.

Note: *DIAG 8 will display* ***----*** *for the lamp-on voltage if a of >10 NTU is placed in the cell compartment.*

5.3 Other Instrument Diagnostics

5.3.1 Display Test

Pressing and holding the **I/O** key turns on all the display icons and elements so you can determine if all the elements and icons are functioning. The display test sequence will cycle as long as the key is held down.

5.4 Error Messages

Error messages indicate sample interferences and/or instrument malfunction.

5.4.1 Flashing Numeric Display

If the highest value in the range selected is flashing in the display, the sample is too turbid (or overrange) for the selected range. In automatic or manual range, **1000** flashes if the sample is over the instrument's range. In manual range mode, select the next higher range mode if **9.99** or **99.9** flashes. See *Section 2.3.6* on page *31* for measuring overrange samples. The display will stop flashing if a sample within range is inserted and read.

5.4.2 E Messages

An error message indicates either an instrument failure or an operation cannot be performed. **An error message can be cleared by pressing DIAG** (display will return to previous measurement or calibration value). The meter continues to operate as best it can. If the message occurs during a calibration, calibration can continue. If the error message occurs when a calibration is being calculated, the instrument will discard the new calibration and retain the old calibration. Error messages and corrective actions are listed below.

5.4.3 CAL?

A flashing **CAL?** appears when the instrument is using the default calibration programmed at the factory. It will appear if the analyst has erased the user-entered calibration using the procedure to restore the default calibration or after and E 4 error is cleared by pressing DIAG. Recalibrate as soon as possible when **CAL?** appears. **CAL?** (not flashing) appears when a calibration has questionable validity.

Message*	Probable Cause	Corrective Action
E1	Dilution water is ≥ 0.5 NTU.	Start calibration over with better quality dilution water or use a membrane filter to filter the water before use.
E2	Two standards have the same value or their difference is less than 60 NTU. Not all standards were read during the calibration. Standard 1 is too low (<10 NTU).	Recheck preparation of standards and repeat calibration.
E3	Low light error.	Re-read measurement. Check lamp** Check for obstructed light path. Dilution may be necessary.
E4	EEPROM malfunction.	Check sum failed. Press **I/O**. If E 4 reappears, call Hach service. If **CAL?** appears, recalibrate.
E5	A/D overrange.	Check for obstructed light path. Call Hach Service.
E6	A/D underrange.	Check for open lid during reading and re-read. Check for obstructed light path. If persists, call Hach Service.
E7	Light Leak.	Close lid before pressing **READ** key.
E8	Bad lamp circuit.	Reinsert lamp leads at terminal block-make sure the lead ends are not touching each other.If this fails, call Hach Service.

* Error messages 4, 5, and 6 may indicate a failure in the internal electronics.
** Check lamp by inserting a pencil or piece of paper into the cell compartment and pressing READ. Light should be visible on the inserted object.

GENERAL INFORMATION

At Hach Company, customer service is an important part of every product we make.

With that in mind, we have compiled the following information for your convenience.

Replacement Parts & Accessories

REPLACEMENT PARTS

Description	Cat. No.
StablCal Calibration Set for 2100P, Sealed Vials: <0.1 NTU, 20 NTU, 100 NTU, and 800 NTU	26594-05
AA Batteries, 4/pkg	19380-04
Battery Door	46005-00
Carrying Case	46506-00
Gelex® Standards, set (includes standards and 3 sample cells)	24641-05
Instrument Manual	46500-88
Lamp Assembly, with leads	46539-00
Oiling Cloth	47076-00
Sample Cells, 1 inch, with cap, 6/pkg	24347-06
Silicone Oil, 15 mL	1269-36

OPTIONAL ACCESSORIES AND REAGENTS

Deionized Water, 3.78 L	272-17
Bath, Ultrasonic, 2.8 L (0.75-gal), w/heater	24895-00
Battery Eliminator, 120 V	46079-00
Battery Eliminator, 230 V	46080-00
Filter, 0.2 micron, 10/pkg	23238-10
Formazin, 4000 NTU, 500 mL	2461-49
Formazin, 4000 NTU,100 mL	2461-42
Hexamethylenetetramine, 500 g	1878-34
Hydrazine Sulfate, 100 g	742-26
NiCad Rechargeable Battery (4 required)	16077-00

OPTIONAL ACCESSORIES AND REAGENTS, continued

Description	Cat. No.
Pipet, TenSette®*, 1-10 mL	19700-10
Pipet Tips, for 1-10 mL TenSette Pipet, 50/pkg	21997-96
Pipet Tips, for 1-10 mL TenSette Pipet, 1000/pkg	21997-28
Pipet, Volumetric, Class A, 1.00 mL	14515-35
Pipet, Volumetric, Class A, 5.00 mL	14515-37
Pump, Vacuum, Hand-Operated	14283-00
Sample Degassing Kit	43975-00
Sample Filtration and Degassing Kit	43975-10
StablCal® Calibration Set for 2100P Turbidimeter	
<0.1, 20, 100, 800 NTU, 500 mL each	26594-00
<0.1, 20, 100, 800 NTU, 100 mL each	26594-10
<0.1 NTU** StablCal®*** Stabilized Formazin Standard,100 mL	26597-42
20 NTU StablCal® Stabilized Formazin Standard, 100 mL	26601-42
100 NTU StablCal® Stabilized Formazin Standard, 100 mL	26602-42
800 NTU StablCal® Stabilized Formazin Standard, 100 mL	26605-42
Triton-X Solution, 118 mL (4 oz)	14096-32
Volumetric Flask, 100 mL	14574-42
Volumetric Flask, 200 mL	14574-45

* TenSette™ is a Hach Company trademark.

** <0.1 NTU StablCal® Standard is used in place of dilution water standard when performing a calibration.

*** StablCal® is a registered trademark of Hach Company.

HOW TO ORDER

By Telephone:

6:30 a.m. to 5:00 p.m. MST
Monday through Friday
(800) 227-HACH
(800-227-4224)
By FAX: (970) 669-2932

By Mail:

Hach Company
P.O. Box 389
Loveland, CO 80539-0389
U.S.A.

Ordering information by E-mail: orders@hach.com

Information Required

- Hach account number (if available)
- Your name and phone number
- Purchase order number
- Brief description or model number
- Billing address
- Shipping address
- Catalog number
- Quantity

Technical and Customer Service (U.S.A. only)

Hach Technical and Customer Service Department personnel are eager to answer questions about our products and their use. Specialists in analytical methods, they are happy to put their talents to work for you. Call **1-800-227-4224** or E-mail **techhelp@hach.com**.

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Telephone: (970) 669-3050; FAX: (970) 669-2932

In Europe, the Middle East, or Mediterranean Africa:
HACH Company, c/o
Dr. Bruno Lange GmbH
Willstätterstr. 11
D-40549 Düsseldorf
Germany
Telephone: +49/[0]211.52.88.0
Fax: +49/[0]211.52.88.231

REPAIR SERVICE

Authorization must be obtained from Hach Company before sending any items for repair. Please contact the HACH Service Center serving your location.

In the United States:
Hach Company
100 Dayton Avenue
Ames, Iowa 50010
(800) 227-4224 (U.S.A. only)
Telephone: (515) 232-2533
FAX: (515) 232-1276

In Canada:
Hach Sales & Service Canada Ltd.
1313 Border Street, Unit 34
Winnipeg, Manitoba
R3H 0X4
(800) 665-7635 (Canada only)
Telephone: (204) 632-5598
FAX: (204) 694-5134
E-mail: canada@hach.com

In Latin America, the Caribbean, the Far East, the Indian Subcontinent, Africa, Europe, or the Middle East:
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Loveland, Colorado, 80539-0389
U.S.A.
Telephone: (970) 669-3050
FAX: (970) 669-2932
E-mail: intl@hach.com

WARRANTY

Hach warrants most products against defective materials or workmanship for at least one year from the date of shipment; longer warranties may apply to some items.

HACH WARRANTS TO THE ORIGINAL BUYER THAT HACH PRODUCTS WILL CONFORM TO ANY EXPRESS WRITTEN WARRANTY GIVEN BY HACH TO THE BUYER. EXCEPT AS EXPRESSLY SET FORTH IN THE PRECEDING SENTENCE, HACH MAKES NO WARRANTY OF ANY KIND WHATSOEVER WITH RESPECT TO ANY PRODUCTS. HACH EXPRESSLY DISCLAIMS ANY WARRANTIES IMPLIED BY LAW, INCLUDING BUT NOT BINDING TO ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

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This warranty applies only to Hach products purchased and delivered in the United States.

Catalog descriptions, pictures and specification, although accurate to the best of our knowledge, are not a guarantee or warranty.

For a complete description of Hach Company's warranty policy, request a copy of our Terms and Conditions of Sale for U.S. Sales from our Customer Service Department.