Water Quality Monitoring and Management Plan for the Wallowa Falls Hydroelectric Project

(FERC No. P-308)

Grande Ronde River Basin

Wallowa County, Oregon

March 16, 2017

Prepared by:
PacifiCorp
825 NE Multnomah Street
Portland, OR 97232

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1.0 Introduction

Upon Federal Energy Regulatory Commission (FERC) issuance of a license for the Wallowa Falls Hydroelectric Project (Project), PacifiCorp must comply with all requirements under the associated Project Clean Water Act § 401 Certification Conditions document. This document is considered the Water Quality Monitoring and Management Plan (WQMMP) for the Wallowa Falls Hydroelectric Project that addresses requirements under Sections 3(a), 3(b), 3(c) within the § 401 Certification Conditions which states:

> ***Section 3(a):*** *Within ninety (90) days of issuance of the FERC license, PacifiCorp, in consultation with the Oregon Department of Environmental Quality (DEQ), must, as necessary to ensure consistency with these § 401 Certification Conditions, develop a Project Water Quality Monitoring and Management Plan (WQMMP). Upon approval, the WQMMP becomes part of these § 401 Certification Conditions for the Project for the purposes of any federal license or permit.*
>
> *The WQMMP must include: applicable dissolved oxygen (DO) and total dissolved gas (TDG) criteria; monitoring methodology; reporting schedule; and procedures for suspending operation during DO or TDG violations. PacifiCorp must measure DO at the outlet of the new Project tailrace continuously during Project operations for a one-time period of 90 days starting August 1st of the first year of operation of the realigned tailrace. PacifiCorp must download and evaluate DO data on a weekly basis. During Project operation, PacifiCorp must also measure TDG in the Project Tailrace outlet for a minimum of seventy-two (72) hours under lower flow conditions in August-September and higher flow conditions in June-July. Concurrent with DO and TDG measurements, PacifiCorp must also record flow and water temperature at the Project Tailrace outlet immediately upstream of the velocity barrier, as well as record power generation from the Project. PacifiCorp must report all DO, TDG, flow, water temperature and power generation data to DEQ within 90 days of the conclusion of the monitoring period.*
>
> ***Section 3(b):*** *If it is determined based on monitoring results, that Project operations are contributing to downstream violations of the applicable DO standard, TDG standard or the Antidegradation standard, PacifiCorp must follow the procedures in the WQMMP, including project shutdown, as necessary. If taking the actions described in the WQMMP do not correct the problem and allow water quality standards to be achieved, PacifiCorp must consult with DEQ to evaluate whether any modifications to the Project or Project operations can mitigate the impacts to water quality. If DEQ determines that such modifications can reverse such impacts, PacifiCorp must propose the modifications to DEQ, and following DEQ's approval, PacifiCorp must implement the approved modifications. PacifiCorp may operate the Project during the development and implementation of modifications if conditions allow water quality standards to be met. If it can be demonstrated that the DO and TDG criteria are being met, PacifiCorp can request approval to terminate monitoring of these parameters.*

Section 3 (c):

i. *Procedures and measures that will be implemented to prevent monitoring equipment malfunctions;*
ii. *Procedures for identifying the occurrence and nature of any monitoring equipment malfunctions that may occur;*
iii. *Plan, schedule, and corrective measures that will be implemented to address monitoring equipment malfunctions;*
iv. *Procedures for notifying DEQ of the occurrence and nature of monitoring equipment malfunctions, corrective measures implemented, and recommencement of monitoring equipment operation.*
v. *Procedures and timelines for Project shutdown as may be necessitated by monitoring equipment malfunctions;*
vi. *Plan and schedule for maintenance and calibration of field test equipment.*

2.0 Study Area

The Wallowa Falls Hydroelectric Project is located on the East Fork Wallowa River approximately 11 miles outside of the City of Joseph in Northeastern Oregon. The Project (Figure 1) reservoir/forebay lies over 1,600 meters (m) above mean sea level (msl) and is approximately 0.2 surface acres (0.08 ha) in size and averages 5 feet (1.5 m) in depth. Because the Project operates as run of river, there is no measurable storage. Though no measurable storage is present in the forebay, habitat in this area is lacustrine, and given the shallow water depth no thermal stratification is present. Substrate in the forebay consists of deposited silt, sand, and other glacial fines.

Water diverted at the forebay travels through the flow line and penstock to the generating turbine in the Project powerhouse. Water exits the turbine and is discharged into an approximately 985-foot (300 m) long tailrace discharge channel that empties into the West Fork Wallowa River. This channel has an average wetted-width of 10 feet (3.1 m) and an average depth of one foot (0.3 m). The habitat type within the tailrace channel is dominated by high gradient riffle with very few pools.

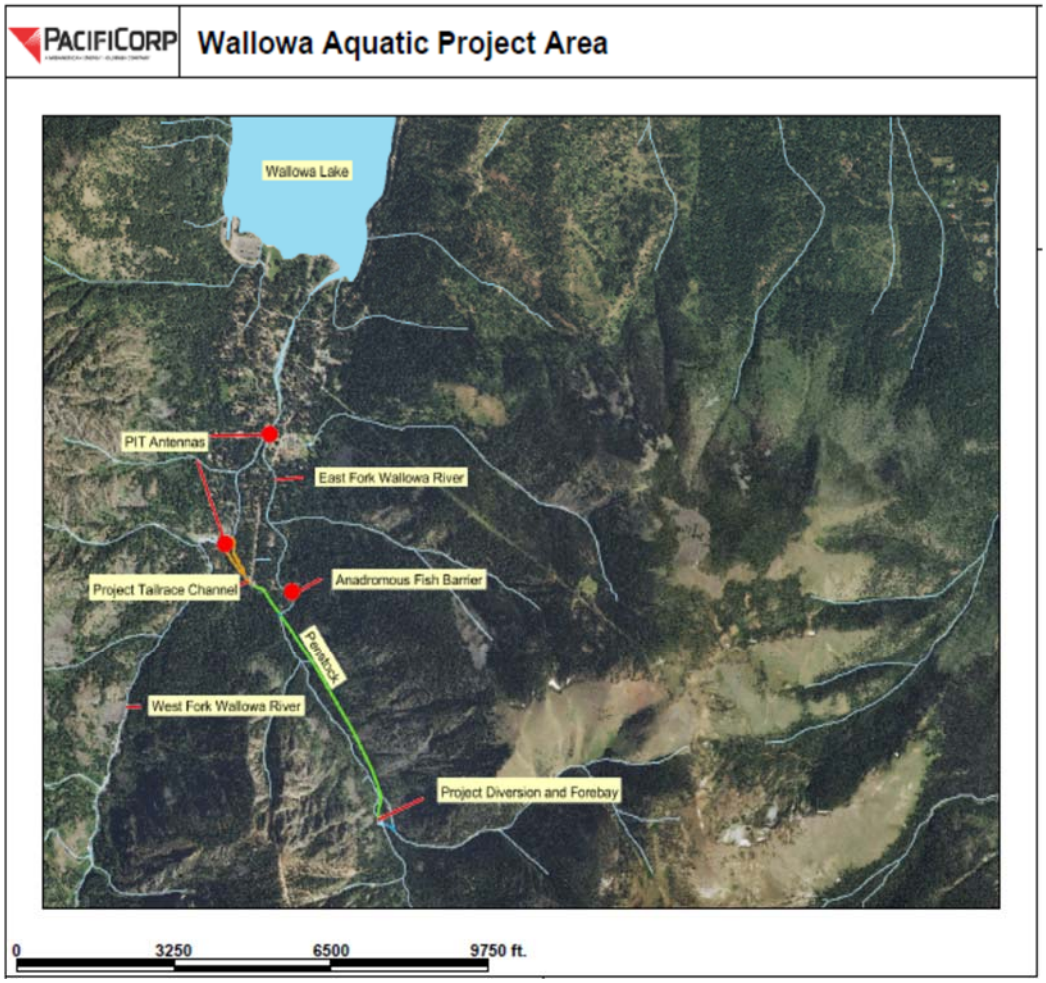


Figure 1. Wallowa Falls Hydroelectric Project.

3.0 Methods

3.1 Addressing requirements under §401 Certification Conditions Section 3(a):

Section 3(a) in the § 401 Certification Conditions contains various requirements for the criteria, monitoring methodology, and reporting schedule for the water quality parameters to be monitored (e.g. Temperature, Flow, Generation, Dissolved Oxygen, and Total Dissolved Gas) as well as procedures for suspending operations during dissolved oxygen (DO) or total dissolved gas (TDG) criteria violations.

The Project specific criteria for water quality standards of potential concern that are included in this WQMMP are shown in **Table 1**.

Table 1. Project temperature, DO, and TDG water quality criteria.

	August 15 through May 15	May 16 through August 14	Rule
Use	Bull trout/Kokanee spawning through fry emergence	Cold Water Aquatic Life	OAR 340-041-016 and Figure 151A
Temperature	12˚C/53.6˚F	12˚C/53.6˚F	OAR 340-041-0028
Dissolved Oxygen	a) Not less than 11.0 mg/L. If IGDO ≥ 8.0 mg/L the DO spawning criterion is 9.0 mg/L; b) where pressure, altitude or temperature preclude attainment of the 11.0 or 9.0 mg/L criteria, DO saturation must be at least 95 percent; c) Spatial median IGDO must be at least 8.0 mg/L.	Criterion is 8.0 mg/L. Where precluded by pressure, altitude or temperature, DO saturation must be at least 90 percent. At DEQ discretion, DO must not fall below 8.0 mg/L as a 30-day mean, 6.5 mg/L as a 7-day mean, and 6.0 mg/L as an absolute minimum.	OAR 340-041-0016
Total Dissolved Gas	Except when stream flow exceeds the ten-year, seven-day average flood, the concentration of TDG relative to atmospheric pressure at the point of sample collection may not exceed 110 percent saturation.	Except when stream flow exceeds the ten-year, seven-day average flood, the concentration of TDG relative to atmospheric pressure at the point of sample collection may not exceed 110 percent saturation.	OAR 340-041-0031

The DEQ Evaluation and Findings Report (dated 3/31/2016) of the §401 Water Quality Certification for the Project describes several water quality standards of potential concern that, upon DEQ findings, DEQ is 'reasonably assured' that Project operations will comply with the respective water quality standard; these water quality standards that are subsequently not included in this WQMMP are shown in **Table 2**.

Table 2: Water quality standards of concern that upon investigation DEQ is reasonably assured will not be violated from Project operations.

Criterion	Rule	DEQ Findings Reference
Biocriteria	OAR 340-041-0011	Section 6.36 of the Evaluation and Findings Report
Discoloration, oily sheen, oily coating	OAR 340-041-0007(13)	Section 6.4.6 of the Evaluation and Findings Report.
Antidegradation	OAR 340-041-0004	Section 6.5.5 of the Evaluation and Findings Report.
Temperature	OAR 340-041-028	Section 6.6.4 of the Evaluation and Findings Report. To be included in WQMMP only to support dissolved oxygen monitoring.

Monitoring activities will occur during two separate monitoring periods, a high-flow monitoring period and a low-flow monitoring period, that will commence immediately after commissioning of the realigned tailrace. The high-flow monitoring period entails 72 hours of TDG monitoring during tailrace barrier initial high-flow operation in June-July. The low-flow monitoring period entails another 72 hour period of TDG monitoring during tailrace barrier initial low-flow operation in August-September and DO monitoring for 90 days starting August 1.

Temperature:

For redundancy, two (2) HOBO® Water Temp Pro v2 temperature data loggers will be placed in the water column in the Project tailrace at a location within 25 feet of the discharge to the West Fork Wallowa River. Temperature monitoring activities will coincide with all TDG and DO monitoring events. The temperature data loggers will be set to continuously record data in one-hour intervals.

Hourly temperature data will be converted to and reported as seven day averages of maximum daily temperatures. Temperature data will be included in the high-flow and low-flow monitoring reports.

Flow:

For redundancy, two (2) HOBO ® U20L-01 water depth loggers will be used to establish a temporary flow measurement gage in the tailrace immediately above the barrier. The depth loggers will be placed on the upstream side of the fish barrier and will be vertically fixed. The vertical distance between the logger and the crest of the barrier will be measured and subtracted out of the depth data. This will allow PacifiCorp to gather data representing the depth of flow over the barrier. The depth of flow over the barrier will then be used in a standardized weir-flow equation with the assigned discharge coefficient of the barrier to compute flow. Flow monitoring activities will coincide with all TDG and DO monitoring events. The water depth data loggers will be set to continuously record data in fifteen-minute intervals.

Flow data will be included in the high-flow and low-flow monitoring reports.

Generation:

Plant generation is remotely controlled, monitored and recorded using a SAP software "Pi" module. Continuous real-time monitoring of generation via Pi is conducted at the Hydro Control Center located in Ariel, Washington. Generation data will be reported for all TDG and DO monitoring events at the same interval times as flow.

Generation data will be included in the high-flow and low-flow monitoring reports.

Dissolved Oxygen:

For redundancy and comparison purposes, two Hach® Hydrolab® DS5 Multiprobe water quality meters will be used for measuring DO levels in the Project tailrace. The DO monitoring event will begin on the next ensuing August 1st following operational commencement of the realigned tailrace. Hourly DO measurements will be taken within the water column at the outlet of the new Project for a one-time 90 day

(low-flow monitoring) period. DO data will be downloaded and evaluated on a weekly basis for the entire monitoring period. The DS5 Multiprobe is capable of collecting water temperatures in addition to DO levels and will be programmed to do so during the monitoring period. Barometric pressure data will also be recorded on the same time interval and period as DO measurements in close vicinity to the DO meter. Barometric pressure will be measured using a Hach® Hydrolab® MS5 Multiprobe. These barometric pressure and water temperature data will be used to compute DO saturation levels in case altitude, temperature, or pressure preclude attainment of the concentration-based (e.g. mg/L) DO criteria.

DO data will be reported to DEQ within 90 days of the conclusion of the low-flow monitoring period. These data will be reported in hourly measurements in both tabular and graphical format. All flow, water temperature, and power generation data for the low-flow monitoring period will also be submitted.

Total Dissolved Gas:

For redundancy and comparison purposes, two Hach® Hydrolab® DS5 Multiprobe water quality meters will be used for measuring TDG levels in the Project tailrace. Hourly TDG measurements will be recorded in the Project tailrace at a location within 25 feet of the discharge to the West Fork Wallowa River. Barometric pressure data will be recorded using a Hach® Hydrolab® MS5 Multiprobe on the same time interval and period that TDG measurements are taken and within close vicinity to the TDG meter. TDG saturation levels will then be computed as the ratio of aqueous TDG pressure to barometric pressure. There will be two (2) separate monitoring periods for a given year; one monitoring period during June-July under higher flow conditions and another monitoring period during August-September under lower flow conditions. Both monitoring periods will record hourly TDG levels in the Project Tailrace outlet continuously until, at a minimum, each monitoring periods data-makeup contains seventy-two (72) hours of TDG data that occurred during Project generating conditions. Monitoring will begin during the first June-July and August-September time frames following operational commencement of the realigned tailrace.

TDG data will be reported to DEQ within 90 days of the conclusion the high-flow and low-flow monitoring periods. These data will be reported in hourly measurements in both tabular and graphical format. All flow, water temperature, and power generation data collected during TDG monitoring events will be included in the low-flow and high-flow monitoring period reports.

3.2 Addressing requirements under §401 Certification Conditions Section 3(b):

Within section 3(b) of the §401 Certification Conditions is the requirement for the WQMMP to contain procedures to correct the problem if monitoring results determine that Project operations are contributing to downstream violations of the applicable DO, TDG, or Antidegradation standards.

An additional monitoring period for identified parameters will be triggered if the above initial monitoring results find the Project may be contributing to violations of applicable State water quality standards. If the additional monitoring period results conclude that the Project is contributing to violations of applicable State water quality standards, consultation will ensue with the DEQ to discuss potential corrective action including possible modifications to Project structures or Project operations. Shut down of the Project due

to violations of the applicable DO or TDG standards is not recommended as it would result in an increase in flow (i.e. ramping) in the East Fork bypassed reach. Ramping in the East Fork bypassed reach during the bull trout spawning period would result in a violation of § 401 Certification Condition 1(c).

3.3 Addressing requirements under §401 Certification Conditions Section 3(c):

Within section 3(c) of the §401 Certification Conditions are a list of procedures that must be included in this WQMMP that address water quality monitoring equipment malfunctions. The required procedures are provided by monitoring parameter below. Item *v.* under Section 3(c) of the Certification Conditions document suggests developing '*Procedures and timelines for Project shutdown as may be necessitated by monitoring equipment malfunctions'*. PacifiCorp does not propose to execute Project shutdown due solely to monitoring equipment malfunctions.

Temperature:

Before the deployment for each monitoring event, the HOBO® data loggers will be checked for battery life and assessed for correct temperature readings. To calibrate, the loggers will be set to record temperature measurements on 30 second intervals and will be immersed in an ice bath for 15 minutes. During the 15 minute immersion PacifiCorp staff will take temperature measurements of the ice bath on one (1) minute intervals with a handheld National Institute of Standards and Technology (NIST) temperature probe. At the end of the 15 minute trial the data loggers will be downloaded, the data graphed and made sure the recordings converge to +/- 0.5° Celsius the data recorded by the handheld NIST temperature probe. Any data logger found to not meet this criterion will be taken out of service and replaced.

Upon any site visit to the project area by a qualified employee, the temperature data loggers will be downloaded, checked for battery life, and evaluated for proper function. Additional temperature loggers will be stored on site in the storage building in the case of equipment malfunction. Two (2) data loggers will be deployed in the tailrace during the monitoring periods in the case of equipment malfunction. In the event of equipment malfunction, DEQ will be notified of the date, duration and nature of the equipment malfunction and the corrective action taken.

Flow:

Prior to deployment both HOBO® depth loggers will be checked for battery life and assessed for correct depth readings. To calibrate, the loggers will be set to record depth measurements on 30 second intervals and will be placed at the bottom of a cooler filled with water. The cooler plug will then be slightly opened and the cooler will be allowed to slowly drain. PacifiCorp staff will measure the depth of the water with a ruler every 30 seconds until the cooler is fully drained. Pressure readings will then be downloaded, converted to water depth, and compared to the hand-measured depths. Any data logger found to not match the hand-measured data will be taken out of service and replaced.

Upon any site visit to the project area by a qualified employee, the water depth data loggers will be downloaded, checked for battery life, and evaluated for proper function. Two (2) data loggers will be deployed in the tailrace during the monitoring periods in the case of equipment malfunction. In the event

of equipment malfunction, DEQ will be notified of the date, duration and nature of the equipment malfunction and the corrective action taken.

Generation:

Plant generation is remotely controlled, monitored and recorded using a SAP software Pi module. Real-time monitoring of generation via Pi is conducted at the Hydro Control Center located in Ariel, Washington. Generation records for any time period can be retrieved from the SAP database. If communication to the plant is lost for any period of time, the generator automatically holds the last generation set-point indicated in Pi before communication was lost. A review of the tailrace flow data during the period communication is lost will be conducted to confirm generation did not fluctuate during the period when generation data was not recorded.

Dissolved Oxygen:

Prior to deployment, the DS5 DO meter will be cleaned, given new batteries, and calibrated. Calibration will be done by following the Hydrolab® instruction sheet for the Hach LDO™ Sensor (Cat. No. 00745589). Steps 1-8 under Method 1 of the instruction sheet will be followed for calibrating the DO meter. The Hydrolab® instruction sheet for the Hach LDO™ Sensor is provided in **Appendix A**.

During the DO monitoring event the meter will be downloaded weekly, installed with new batteries, and checked for proper function. During the download staff will view real time readings from the DO meter in the Project tailrace and simultaneously verify the readings with a handheld OxyGuard® Handy Polaris DO meter. In the event of equipment malfunction, DEQ will be notified of the date, duration and nature of the equipment malfunction and the corrective action taken.

Total Dissolved Gas:

Before deployment the MS5 TDG meter will be cleaned, installed with a new TDG membrane, given new batteries, and calibrated. A Hach Surveyor® 4a will be used to gather real time barometric pressure readings. The TDG meter will be connected to a PC and controlled through the Hyrdas 3 LT program/interface. With the TDG meter in air and reading the same ambient conditions as the Surveyor®, barometric pressure readings from the Surveyor® will be entered into Hyrdas 3 LT as the calibration standard and the TDG meter will be calibrated.

PacifiCorp staff will be onsite during the entirety of both seventy-two (72) hour TDG monitoring events. The TDG meter will be set to record measurements on the top of each hour, in this way (at the bottom of a given hour) PacifiCorp staff can momentarily connect a PC to the TDG meter during monitoring and check for proper function. In the event of equipment malfunction, DEQ will be notified of the date, duration and nature of the equipment malfunction and the corrective action taken.

4.0 Reporting

Within 90 days of completion of the high-flow and low-flow monitoring periods, a Water Quality Monitoring Report detailing all raw data collected and associated analysis of said parameters as well as water temperature, tailrace flow, and Project generation will be submitted to DEQ and the Federal Energy Regulatory Commission for review and comment.

5.0 Record of Consultation with ODEQ

A draft of the WQMMP was sent to the Oregon DEQ for review and comment on February 17, 2017. Comments on the draft WQMMP were received from DEQ on March 13, 2017. PacifiCorp revised the draft document to incorporate DEQ comments. A matrix summarizing the comments and PacifiCorp's response is provided below.

Agency	Comment	PacifiCorp Response
ODEQ	Page 7, paragraph 1 top of page. Please specify flow monitoring periods include 72 hours of TDG monitoring.	Incorporated into document.
ODEQ	Page 7, paragraph 2 on Temperature Monitoring. "Not necessary to convert to avg daily max. better to report as raw data as that is what is needed to calculate DO saturation."	Oregon State OAR temperature water quality standards are set as 7 day averages of daily maximum water temperature (7dadMAX). In order to assess compliance to set water quality standards, all captured temperature data will be converted to 7dadMAX and reported in this format. All raw hourly data will be utilized to calculate DO saturation.
ODEQ	Page 8, paragraph 6. "This suggestion is acceptable to DEQ. I did not envision a shutdown of the project due to the results of the first round of monitoring. If no violations are detected in the first round of monitoring described in the cert. conditions PacifiCorp can request to terminate monitoring."	Comment noted
ODEQ	Page 9, paragraph 5 on Flow Monitoring. "What is the level of accuracy expected, 0.1 foot?"	Expected level of accuracy per the manufacturer is below: Typical error: ±0.05% FS, 0.5 cm (0.015 ft) water Maximum error: ±0.1% FS, 1.0 cm (0.03 ft) water

6.0 References

ODEQ. (2016). *Evaluation and Findings Report: 401 Water Quality Certification Wallowa Falls Hydroelectric Project.* Pendleton, OR. March 2016.

ODEQ. (2016). *Clean Water Act, § 401 Certification Conditions for the Wallowa Falls Hydroelectric Project, (FERC No. P-308) Grande Ronde River Basin, Wallowa County, Oregon.* Bend, OR. March 2016.

APPENDIX A

Instruction Sheet

Hach LDO™ Sensor

Safety Precautions

Please read this entire instruction sheet before operating this sensor. 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 sensor.

Do not use or install this sensor in any manner other than that which is specified in this instruction sheet.

Use of Hazard Information

If multiple hazards exist, this instruction sheet 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 or instrument damage.

Important Note: *Information that requires special emphasis.*

Note: *Information that supplements points in the main text.*

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 sheet for operational and/or safety information.

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.*

Introduction

The luminescent dissolved oxygen (Hach LDO, Figure 1) sensor is an in-situ optical probe that determines the dissolved oxygen concentration in a given water sample. The sensor cap is coated with a luminescent material. Blue light from a LED is transmitted to the sensor surface. The blue light excites the luminescent material. As the luminescent material relaxes it emits red light. The time from when the blue light was sent and the red light is emitted is measured. The more oxygen that is present, the shorter the time it takes for the red light to be emitted. This time is measured and correlated to the oxygen concentration. Between the flashes of blue light a red LED is flashed on the sensor and used as an internal reference to help validate each measurement. The sonde can display the oxygen either as a concentration from 0–20 mg/L or as a percent saturation with either air saturated water or water-saturated air serving as the 100% reference point.

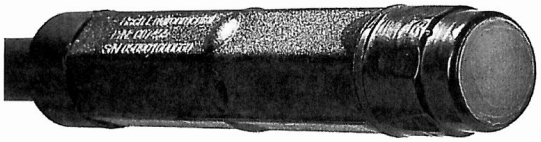


Figure 1 Hach LDO Sensor

Maintenance

Important Note: *Do not use organic solvent solutions such as acetone or methanol with the Hach LDO sensor. These solvents will damage the plastic sensor cap.*

The Hach LDO sensor is not affected by fouling or other debris, unless the growth is an organism that locally consumes or produces oxygen, such as barnacles, or algae growing on the sensor cap. Nevertheless, the manufacturer recommends periodic maintenance to remove contaminants such as oil, biological growth, dirt, etc. Sensor maintenance should be conducted after every deployment cycle.

1. Flush the entire instrument with clean, fresh water. Use soapy water and a soft brush to clean the outside surfaces of the instrument.

2. Soak the entire instrument in fresh water for at least 30 minutes.

3. Visually inspect the sensor cap. Use optical tissue or a cotton swab with soapy water to clean the sensor cap. Rinse with fresh water.

It is not advised to remove the sensor cap unless the cap is being replaced. If the cap is sealed properly using the top O-ring seal, no water should be present between the sensor cap and the clear plastic window at the top of the probe. If water is present between the sensor cap and the clear plastic window at the top of the probe, remove the cap and thoroughly dry the inside of the cap and the clear plastic window. The cap may require replacement.

Installing the Sensor Cap

1. Place the cap seal (item 1, Figure 2) and the O-ring (item 2, Figure 2) on the probe.

2. Screw on the sensor cap (Figure 2) so that the o-ring seal is compressed. Do not over-tighten the sensor cap.

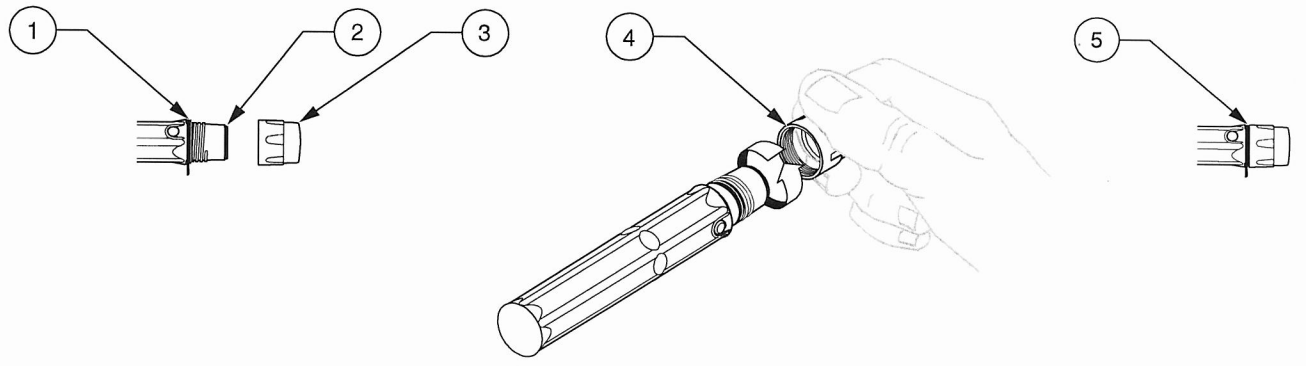


Figure 2 Installing the Sensor Cap

1	Cap Seal; Place the narrow shoulder towards probe tip.	**3**	Sensor cap	**5**	Narrow shoulder is inside the cap.
2	O-ring in place on probe tip	**4**	Screw sensor cap onto probe tip.		

Hach LDO Sensor Calibration

Dissolved oxygen concentration is associated with either a concentration in mg/L or a percent saturation, relative to 100% water saturated air or air saturated water.

There are three standard methods for calibrating the Hach LDO sensor. Each method requires a single point calibration for measurement of concentration in mg/L. In order to calibrate the sensor for percent saturation reading, the local barometric pressure must be determined independently by the user and input into the software during calibration.

In order to retain calibration accuracy between multiple deployments, store with sensor fully immersed in water at all times or at a minimum stored in a sealed container with water saturated air such as a sealed storage cup. Make sure the storage cap has at least 10cc of water and is sealed to prevent evaporation. It is important that the end of the sensor cap and the sonde temperature sensor are at the same temperature during calibration. When calibrating in water saturated air, the temperature sensor should be in air. When calibrating in air saturated water or water with a known oxygen concentration, the temperature sensor should be immersed in water.

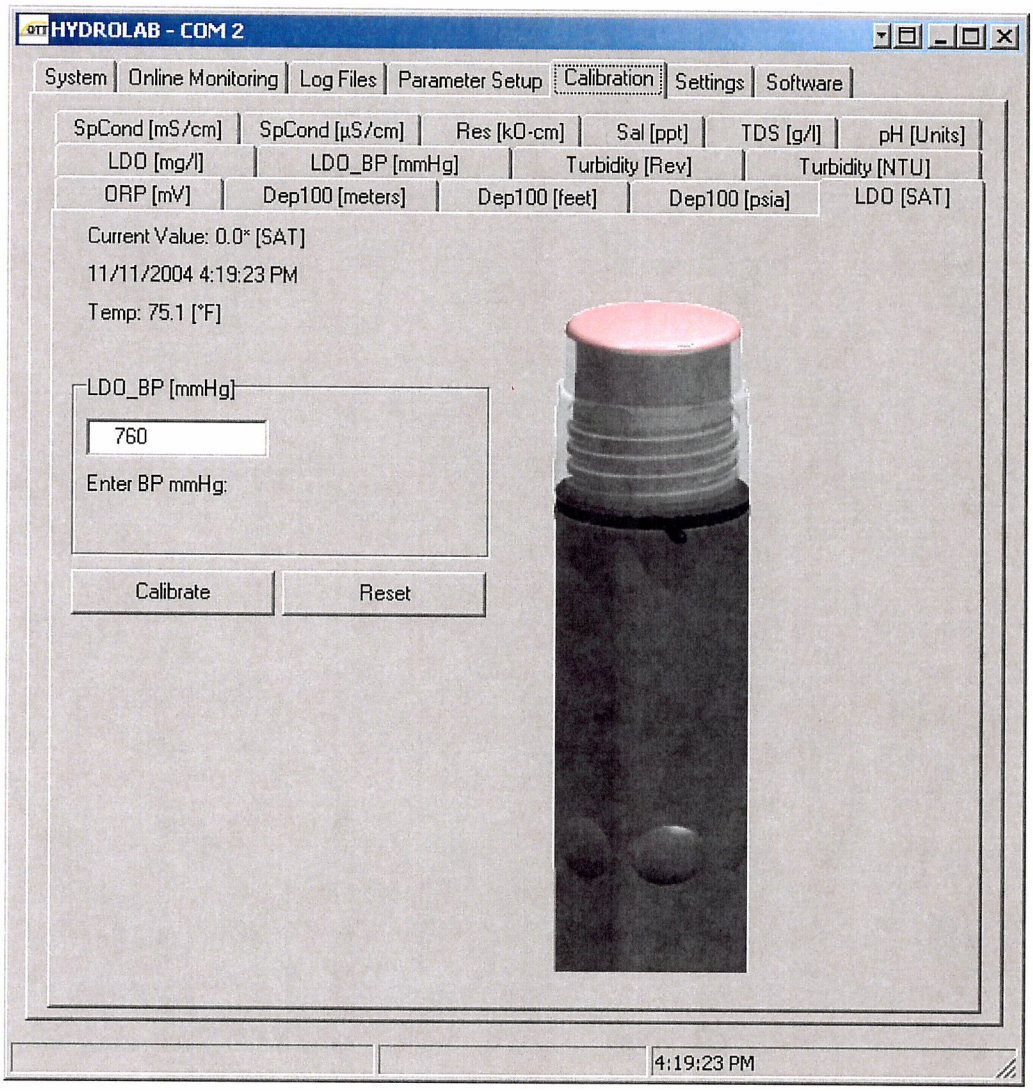
Method 1
Use this method when air saturated water is applied to the sensor.

1. Connect the sensor to a PC.

2. Start Hydras 3 LT. Wait for Hydras 3 LT to establish communications with the sensor. Click the **OPERATE SONDE** button.

3. Click the **Calibration** tab and select the **LDO [SAT]** tab.

Note: *It is important to maintain temperature stability during calibration. Care should be taken to keep the sonde out of direct sunlight or away from any other energy/heat source which will cause the temperature in the calibration cup to change during calibration. A reflective sun-shield is recommended if no natural shade is available. If the temperature in the calibration cup changes more than 0.5 °C during the calibration, it is recommended to recalibrate the sensor.*



4. Calibrate the sensor using temperature-stabilized air-saturated water. In a laboratory environment this is typically done by allowing water to equilibrate at least 12 hours after being run from a faucet or decanted from an opened water bottle. The water is air-saturated in a temperature-stabilized container using an air stone injecting air into the well-mixed water bath. Continuous use of compressed air can lead to super-saturation of oxygen in the water bath. To minimize this effect, it is recommended to turn off the air purge prior to final calibration.

5. A recommended method for producing air-saturated water in the field and using it to calibrate the sensor is as follows:

   a. Take a 1 liter bottle and fill 50% with water. Another possibility is a 4 liter (1 gallon) bottle with 500cc of water. Use water that has been at equilibrium with atmospheric pressure for at least 12 hours, i.e. unseal/open any bottled water or draw water from a tap well in advance of calibration.

   b. Make sure the water in the bottle is close to temperature equilibrium with the calibration environment.

c. Seal the bottle and shake it very vigorously for 40 seconds.

d. With the sonde positioned with sensors facing upright, pour the water into the calibration cup, fully submersing the Hach LDO sensor cap and the temperature sensor (Figure 3). Make sure the water comes close to the top of the calibration cup. Place the calibration cup cap upside down (concave upward) on top of the calibration cup to cover the calibration cup. This stops the exchange of air and allows the local environment to equilibrate. Do not tightly seal or otherwise raise the barometric pressure in the calibration cup. Make sure that the calibration cup is not in direct sunlight or in the presence of a heat or light source that could change the temperature in the calibration cup. If needed, protect the calibration cup with a reflective shield.

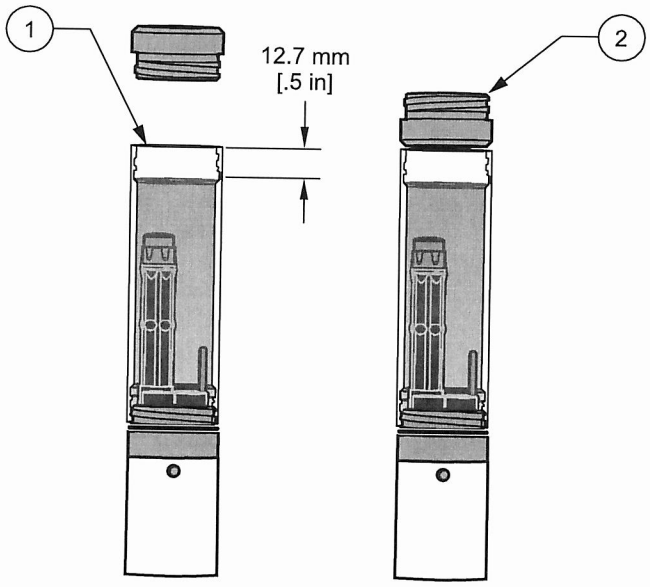


Figure 3 Method 1 Calibration

1	Calibration cup filled with temperature-stabilized air-saturated water	**2**	Proper coverage using inverted cap

6. Determine the barometric pressure for entry as the calibration standard. The barometric pressure needs to be in mmHg. 1mmHg = 0.00133322 bar = 133.322 pascal = 0.019336778 pounds/square inch [absolute].

Local Barometric Pressure, BP, in mmHG can be estimated using:

$BP' = 780 - 2.5(A_{ft}/100)$ or $BP' = 780 - 2.5(A_m/30.5)$
where:
BP' = Barometric pressure at altitude
BP=Barometric pressure at sea level
A_{ft} = Altitude in feet
A_m = ALtitude in meters

If using the local weather bureau BP, remember these numbers are corrected to sea level. To calculate the uncorrected atmospheric pressure BP', use the following equations:

$BP' = BP - 2.5(A_{ft}/100)$ or $BP' = BP - 2.5(A_m/30.5)$
where:
BP' = Barometric pressure at altitude

BP=Barometric pressure at sea level
A_{ft} = Altitude in feet
A_m = ALtitude in meters

Local barometric pressure in mbar (*BPmbar*) can be converted to local barometric pressure in mmMG (*BPmmHG*) using:

$$BPmmHG = 0.75 \times BPmbar$$

7. In either laboratory or field-prepared air-saturated-water, wait 3-5 minutes to assure that the luminescent dissolved oxygen sensor material has reached the same temperature as the water bath. Enter the barometric pressure in the field provided.

8. Click **CALIBRATE**. A "Calibrate Successful!" screen will be displayed.

Method 2
Use this method when water saturated air is applied to the sensor.

1. Connect the sensor to a PC.

2. Start Hydras 3 LT. Wait for Hydras 3 LT to establish communications with the sensor. Click the **OPERATE SONDE** button.

3. Click the **Calibration** tab and select the **LDO [SAT]** tab.

4. Place the calibration cup with one end sealed so that the calibration cup opening is facing upwards. The sonde will be inserted downwards into this cup (item 1, Figure 4).

5. Fill the calibration cup with approximately ½ inches of deionized water or tap water (specific conductance less than 0.5 mS/cm) (item 2, Figure 4). Water will not touch the top of the sensor cap.

6. Carefully remove any water droplets from the sensor cap and temperature probe with the corner of a tissue or clean cotton cloth. It is important that no evaporative cooling take place either on the sensor cap or the temperature probe during calibration.

Note: *It is important to maintain temperature stability during calibration. Care should be taken to keep the sonde out of direct sunlight or away from any other energy/heat source which will cause the temperature in the calibration cup to change during calibration. A reflective sun-shield is recommended if no natural shade is available. If the temperature in the calibration cup changes more than 0.5 °C during the calibration, it is recommended to recalibrate the sensor.*

7. Gently set the sonde with sensors down into the calibration cup blocking any air exchange with the outside environment. Do not screw the calibration cup fully onto the sonde body as the compression of the o-ring will increase the pressure inside the calibration cup to above the barometric pressure and give a false 100% saturated reading. The goal is to block air exchange between the sealed calibration cup and the outside (items 3 and 4, Figure 4).

8. Allow the dissolved oxygen and temperature readings to stabilize. As the temperature sensor has a smaller thermal mass than the luminescent dissolved oxygen sensor, it is best to allow the entire unit to stabilize for an additional 3–5 minutes after the temperature sensor stabilizes. At this point,