UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Klamath River Renewal Corporation	**Project Nos. 14803-001;**
PacifiCorp	**2082-063**

AMENDED APPLICATION FOR SURRENDER OF LICENSE FOR MAJOR PROJECT AND REMOVAL OF PROJECT WORKS

EXHIBIT O
Water Quality Monitoring and Management Plan

KLAMATH RIVER RENEWAL CORPORATION

Lower Klamath Project
FERC Project No. 14803

Water Quality Monitoring and Management Plan

Klamath River Renewal Corporation
2001 Addison Street, Suite 317
Berkeley, CA 94704

February 2021

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1.0 Introduction

The Lower Klamath Project (Project) (FERC No. 14803) consists of four hydroelectric developments on the Klamath River: J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate (Figure 1-1). Specifically, the reach between J.C. Boyle dam and Iron Gate dam is known as the Hydroelectric Reach. In September of 2016, the Renewal Corporation filed an *Application for Surrender of License for Major Project and Removal of Project Works,* FERC Project Nos. 2082-063 & 14803-001 (License Surrender). The Renewal Corporation filed the License Surrender application as the dam removal entity for the purpose of implementing the Klamath River Hydroelectric Settlement (KHSA). In November of 2020, the Renewal Corporation filed its Definite Decommissioning Plan (DDP) as Exhibits A-1 and A-2 to its amended License Surrender application. The DDP is the Renewal Corporation's comprehensive plan to physically remove the Lower Klamath Project and achieve a free-flowing condition and volitional fish passage, site remediation and restoration, and avoidance of adverse downstream impacts (Proposed Action). The Limits of Work is a geographic area that encompasses dam removal related activities in the Proposed Action and may or may not expand beyond the FERC boundary associated with the Lower Klamath Project.

The Proposed Action includes the deconstruction of the J.C. Boyle Dam and Powerhouse (Figure 1-2), Copco No. 1 Dam and Powerhouse (Figure 1-3), Copco No. 2 Dam and Powerhouse (Figure 1-4), and Iron Gate Dam and Powerhouse (Figure 1-5), as well as associated features. Associated features vary by development, but generally include powerhouse intake structures, embankments, and sidewalls, penstocks and supports, decks, piers, gatehouses, fish ladders and holding facilities, pipes and pipe cradles, spillway gates and structures, diversion control structures, aprons, sills, tailrace channels, footbridges, powerhouse equipment, distribution lines, transmission lines, switchyards, original cofferdam, portions of the Iron Gate Fish Hatchery, residential facilities, and warehouses. Facility removal will be completed within an approximately 20-month period.

This Water Quality Monitoring and Management Plan identifies measures that the Renewal Corporation will implement to assess potential water quality impacts relating to implementation of the Proposed Action from the site of J.C. Boyle Dam to the Pacific Ocean. The Renewal Corporation has prepared 16 Management Plans for FERC's review and approval as conditions of a license surrender order. These Management Plans were developed in consultation with federal, state and county governments and tribes.

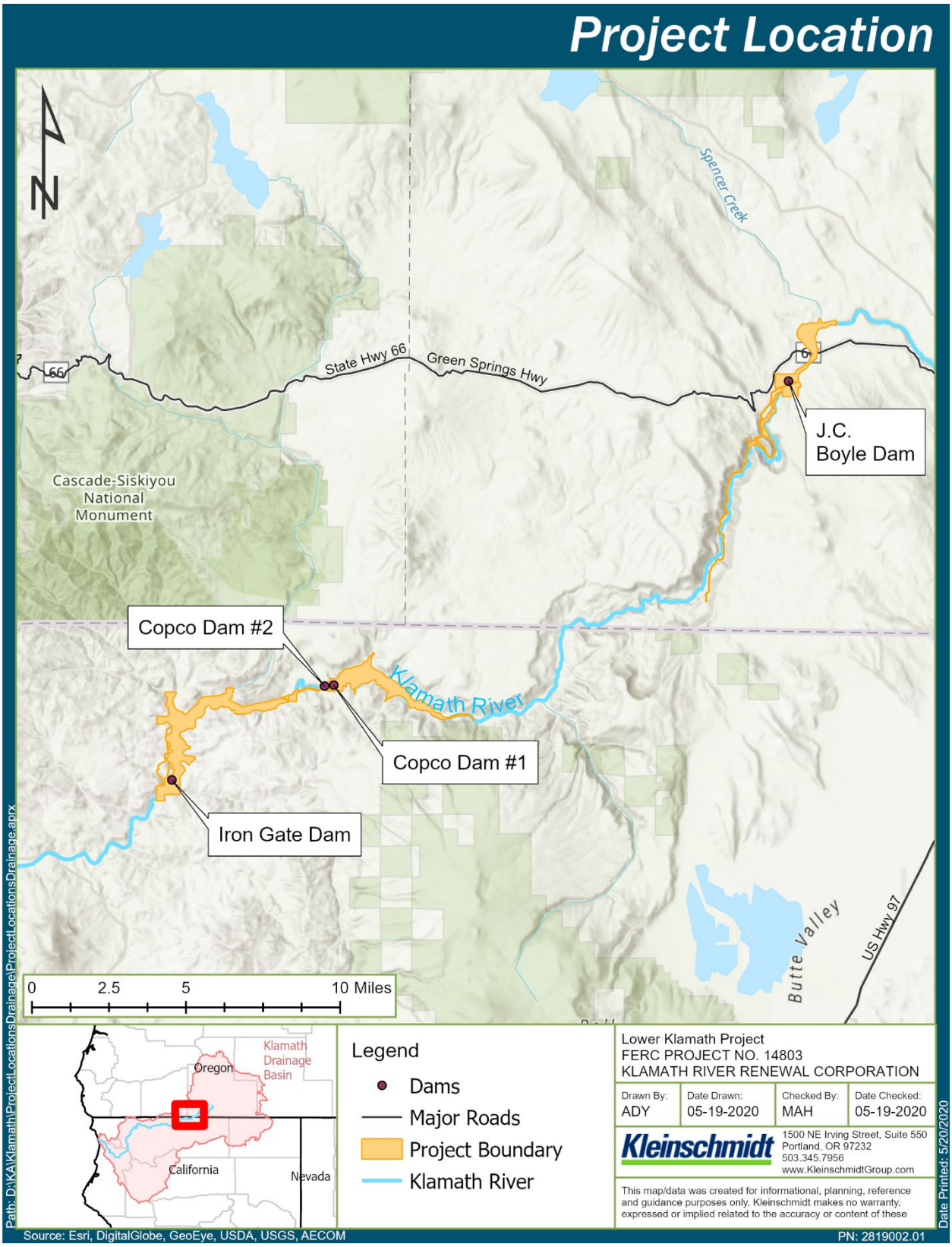

Figure 1-1. Lower Klamath Project Location

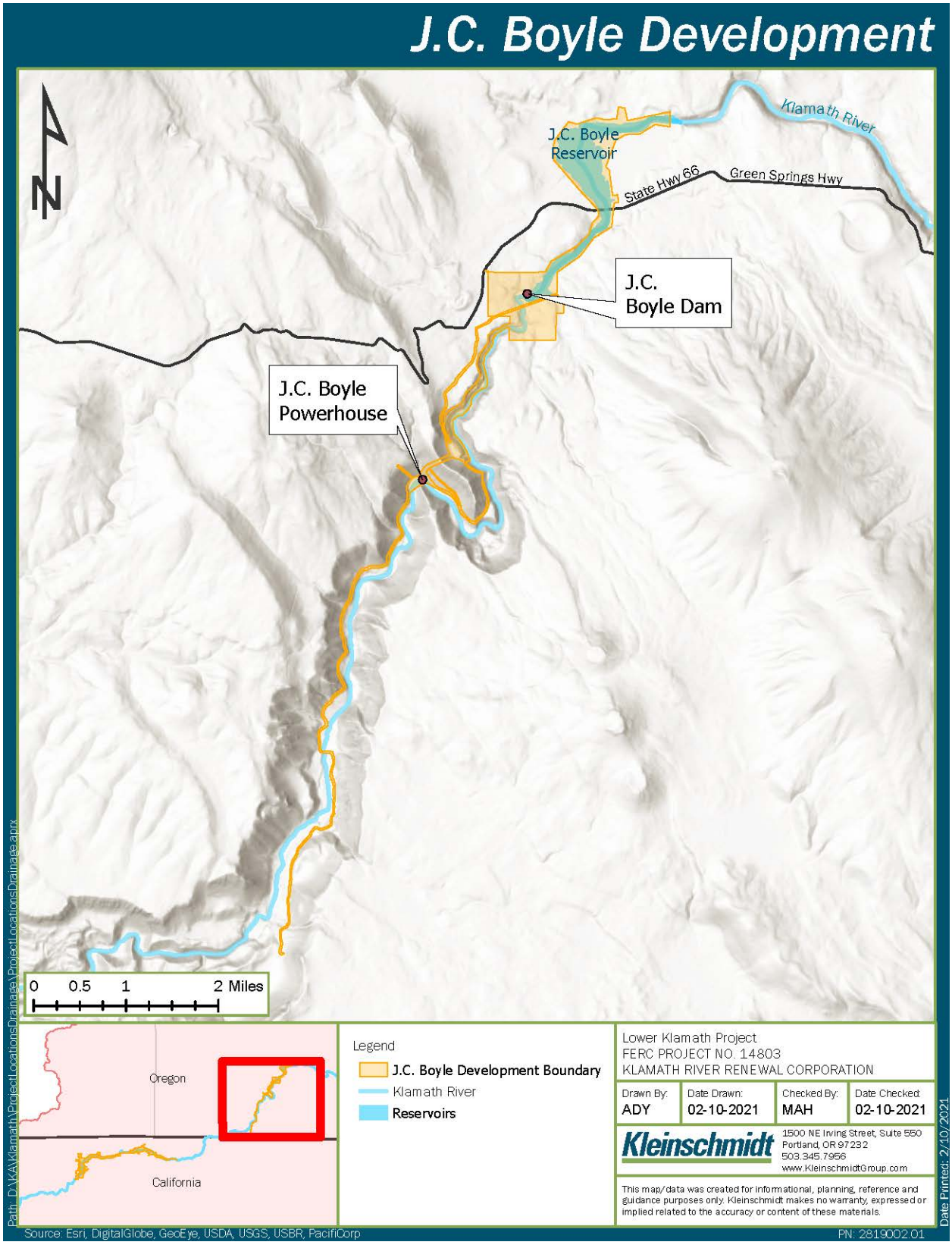

Figure 1-2. J.C. Boyle Development Facility Details

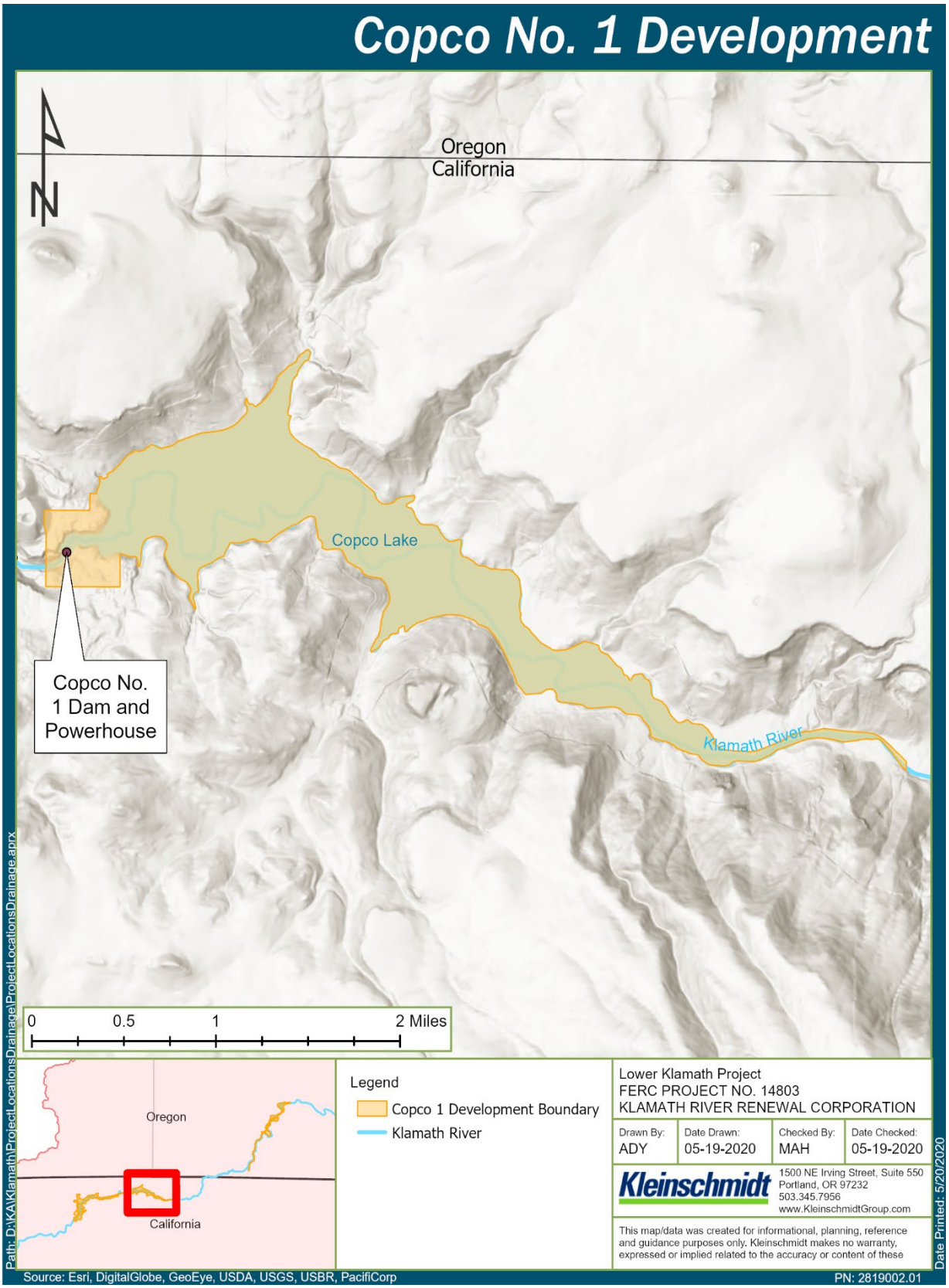

Figure 1-3. Copco No.1 Development Facility Details

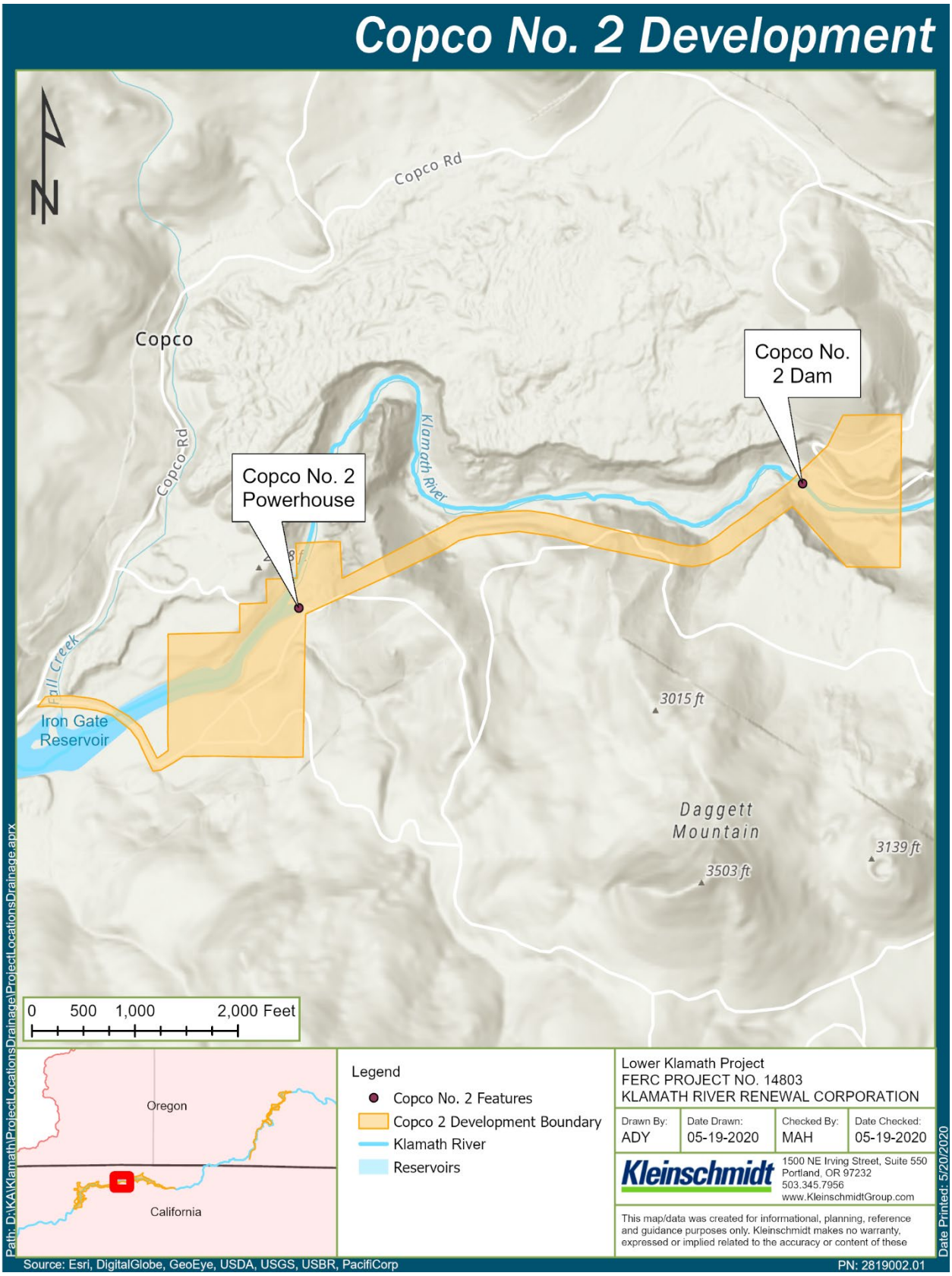

Figure 1-4. Copco No.2 Development Facility Details

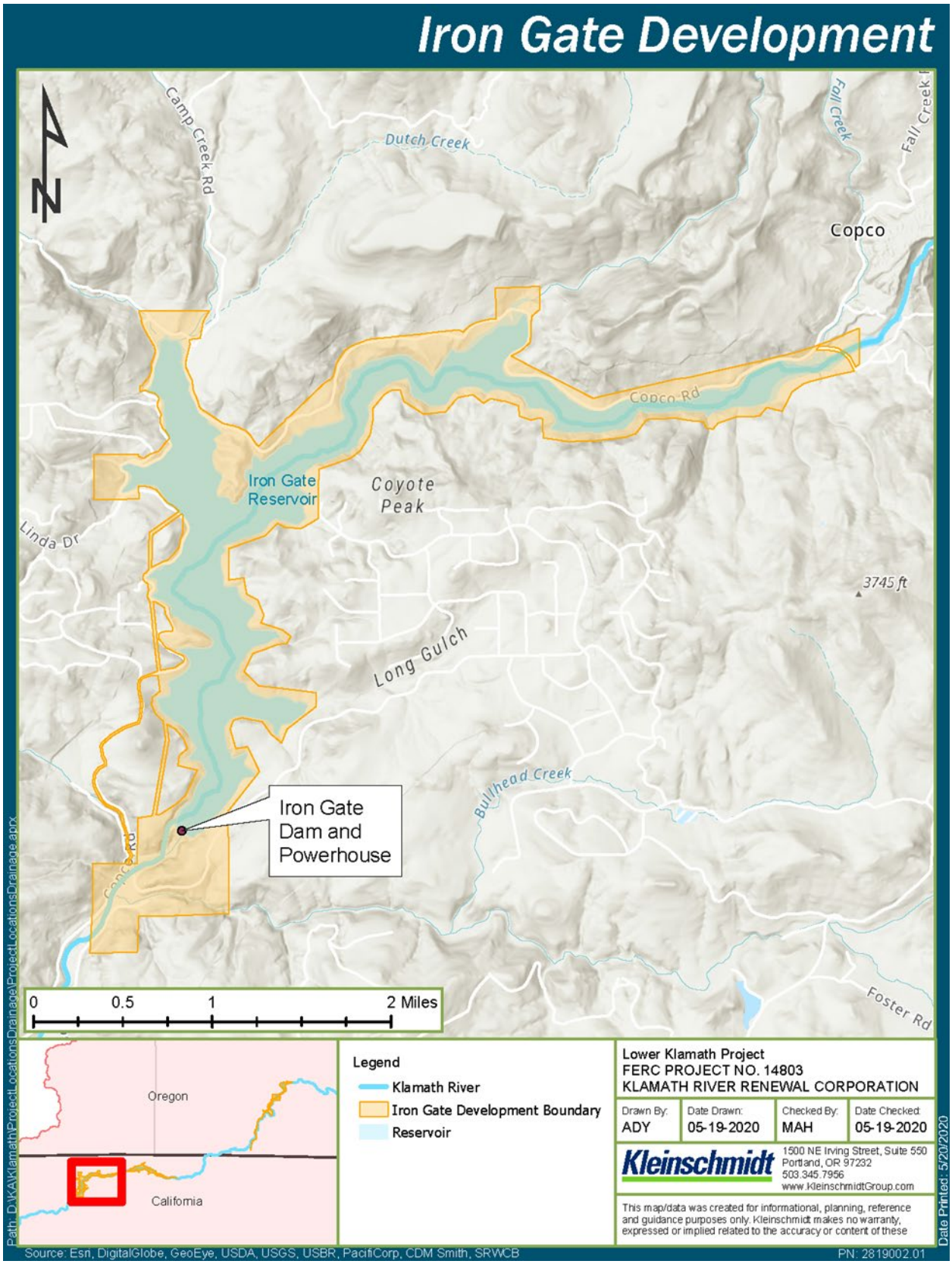

Figure 1-5. Iron Gate Development Facility Details

2.0 Regulatory Context

The Water Quality Monitoring and Management Plan is one of 16 Management Plans implementing the DDP.

Table 2-1. Lower Klamath River Management Plans

1. Aquatic Resources Management Plan	9. Remaining Facilities Plan
2. Construction Management Plan	10. Reservoir Area Management Plan
3. Erosion and Sediment Control Plan	11. Reservoir Drawdown and Diversion Plan
4. Hatchery Management and Operations Plan	12. Sediment Deposit Remediation Plan
5. Health and Safety Plan	13. Terrestrial and Wildlife Management Plan
6. Historic Properties Management Plan	14. Waste Disposal and Hazardous Materials Plan
7. Interim Hydropower Operations Plan	15. Water Quality Monitoring and Management Plan
8. Recreation Facilities Plan	16. Water Supply Management Plan

2.1 Organizational Structure

The Water Quality Monitoring and Management Plan identifies measures that the Renewal Corporation will implement to assess potential water quality impacts relating to implementation of the Proposed Action. These proposed measures are part of the Proposed Action. The Water Quality Monitoring and Management Plan includes the following sub-plans.

- Appendix A: Oregon Water Quality Management Plan
- Appendix B: California Water Quality Monitoring Plan

2.2 Specific Regulatory Interests

The Renewal Corporation considered the following regulatory interests in the development of the Water Quality Monitoring and Management Plan:

- California Section 401 Water Quality Certification
- Oregon Section 401 Water Quality Certification
- Oregon MOU
- California Department of Fish and Wildlife MOU

2.3 Regulatory Review Process

The Renewal Corporation will implement the Water Quality Monitoring and Management Plan upon FERC approval, including any changes required in the FERC License Surrender Order. A consultation record for the Water Quality Monitoring and Management Plan is included as Appendix C.

2.4 Reporting

The Renewal Corporation will prepare and submit an Annual Report by February 15th of each year which will include information pertaining to implementation of the Water Quality Monitoring and Management Plan.

Appendix A

Oregon Water Quality Management Plan

KLAMATH RIVER RENEWAL CORPORATION

Lower Klamath Project
FERC Project No. 14803

Oregon Water Quality Management Plan

Klamath River Renewal Corporation
2001 Addison Street, Suite 317
Berkeley, CA 94704

Prepared By:
Camas LLC
680 G Street, Suite C
Jacksonville, OR 97530

February 2021

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Appendices

1.0 Introduction

The Oregon Water Quality Management Plan is a sub-plan of the Water Quality Monitoring and Management Plan that will be implemented as part of the Proposed Action for the Lower Klamath Project (Project).

1.1 Purpose of Water Quality Management Plan

The purpose of the Oregon Water Quality Management Plan is to state the methodology and procedures the Renewal Corporation will implement to evaluate water quality conditions associated the decommissioning of the J.C. Boyle Development. Water quality will be evaluated through monitoring and sampling to assess project-related effects and to inform adaptive management actions for the protection of aquatic resources and the beneficial uses of the Klamath River.

1.2 Relationship to Other Management Plans

The Oregon Water Quality Management Plan is supported by elements of the following management plans for effective implementation: Reservoir Area Management Plan and Erosion and Sediment Control Plan.

2.0 Background

2.1 Clean Water Act Section 303(d)

Several Klamath River reaches in Oregon are listed on the Clean Water Act Section 303(d) list of impaired water bodies. According to the Oregon Department of Environmental Quality (ODEQ), upstream of the Project and including J.C. Boyle Reservoir, the Klamath River is listed for ammonia, chlorophyll-a, dissolved oxygen, and pH. Downstream of J.C. Boyle Dam, the Klamath River is listed for dissolved oxygen, temperature, and arsenic (ODEQ 2012).

According to the California State Water Resources Control Board (SWRCB), the Klamath River from the Oregon border to the Pacific Ocean is listed for nutrients, dissolved oxygen, and temperature. In addition, Iron Gate and Copco No. 1 Reservoirs are listed for mercury and microcystin, the Klamath River from Copco No. 1 Reservoir to the Trinity River is listed for microcystin, the Klamath River from the Trinity River to the Pacific Ocean is listed for sediment, and the Klamath River from Iron Gate Dam to the Scott River is listed for aluminum (SWRCB 2018).

2.2 KHSA Interim Measure 15 Monitoring

As part of the Klamath River Hydroelectric Settlement (KHSA), PacifiCorp is funding long-term baseline water quality monitoring of the Klamath River from Upper Klamath Lake to the Klamath River Estuary (Interim Measure 15 – Water Quality Monitoring (IM 15) (KHSA 2020). The monitoring includes a combination of continuous water quality monitoring of physical water properties and discrete grab sampling for dissolved and suspended organic and inorganic

constituents. Under IM 15, twenty-two (22) stations have been monitored from 2009 through the present including stations on the mainstem Klamath River, in the reservoirs, and at the mouths of four major tributaries (KHSA 2020). Several of the water quality parameters and stations are similar to those that will be monitored as part of this Oregon Water Quality Management Plan.

2.3 Sediment Transport in the Klamath River Watershed

As stated in the Final Environmental Impact Report for the Lower Klamath Project License Surrender (EIR, SWRCB 2020), the majority of annual sediment delivery from the Klamath River to the ocean, a total of approximately 6,237,500 tons/year (tons/year) on average, is contributed by three major tributaries downstream of the Hydroelectric Reach. The average delivery from Keno Dam (Oregon) to Iron Gate Dam is estimated to be approximately 150,000 tons/year, while the Scott River supplies approximately 607,000 tons/year, the Salmon River 320,000 tons/year, and the Trinity River 3,300,000 tons/yr. These contributions change dramatically from year-to-year, with wet years contributing many times more sediment than dry years. The estimated total amount of sediment impounded behind the dams to be removed is approximately 3,600,000 tons (SWRCB 2020).

2.4 Impounded Sediment Analysis

An evaluation of sediment chemistry in J.C. Boyle, Copco No. 1, and Iron Gate Reservoirs was completed using samples collected in 2004-2005 and 2009-2010 (USDOI 2011). J.C. Boyle Reservoir contains an estimated 1.19 million cubic yards of impounded sediment, and the Renewal Corporation anticipates that 27 to 51 percent (320,000 to 607,000 cubic yards) of this sediment will erode as a result of dam removal (SWRCB 2020). As stated in the EIR, the results of chemical analyses and toxicological bioassay procedures indicate that, if released, the impounded sediments from the three reservoirs did not pose a significant adverse threat to the downstream environment (SWRCB 2020). The Renewal Corporation analyzed high-resolution bathymetric surveys conducted in 2002 and again in 2018 to estimate the total sediment volume in the reservoirs as well as the accumulation rate. Based on these analyses, the United States Environmental Protection Agency (EPA) determined that the existing data are adequate to proceed with project permitting (EPA 2020).

3.0 Monitoring and Sampling Program

3.1 Continuous Water Quality Monitoring

The Renewal Corporation will deploy a series of continuously recording data sondes at stations along the mainstem of the Klamath River. Stations were chosen based on proximity to existing/historical sensor locations and strategic locations between reservoirs to determine the source(s) of any water quality impacts during implementation of the Proposed Action. Each monitoring station will consist of a data sonde equipped with sensors.

3.1.1 Monitoring Locations

The locations of the continuous monitoring stations are listed here and are presented in Figure 3.1-1.

- Klamath River at USGS gage no. 11509500 (below Keno Dam)
- Klamath River at USGS gage no. 11510700 (below J.C. Boyle Dam)

3.1.2 Monitoring Parameters

The Renewal Corporation will monitor the following parameters at each location presented in Section 3.1.1.

- Temperature
- Conductance
- pH
- Dissolved oxygen (concentration and percent saturation)
- Turbidity
- River flow

Continuous monitoring stations will have telemetry capabilities and the data will be transmitted and stored in an online database. Each sonde will be configured to record data at 15-minute intervals and the sensors will undergo calibration and quality assessment/quality control measures detailed in the Quality Assurance Project Plan (QAPP, Appendix A). The QAPP also contains technical specifications of the sondes and contingency plans to avoid data gaps due to sensor damage, malfunction, power, or telemetry issues.

3.1.3 Monitoring Schedule and Frequency

The Renewal Corporation will initiate continuous monitoring one year prior to drawdown and will continue until water quality objectives are met as outlined in Section 3.4. Continuous water quality parameters will be recorded at 15-minute intervals. Continuous water quality parameters will be recorded at 15-minute intervals. The continuous water quality monitoring stations will be maintained and will continue collecting data for 4 years following the initiation of drawdown or as described in Section 3.4.

3.1.4 Monitoring Objectives

The Renewal Corporation will monitor water quality for compliance with the numeric water quality monitoring objectives of the ODEQ Oregon Administrative Rule (OAR) Chapter 340, Division 41 – Water Quality Standards: Beneficial Uses, Policies, and Criteria for Oregon, Rule 185 - Basin-Specific Criteria (Klamath): Water Quality Standards and Policies for this Basin. The Renewal Corporation will use these objectives, stated below, when comparing data from upstream and downstream of Project activities as well as comparing to data collected as part of IM 15. See Section 3.4 regarding the Compliance Schedule.

- **Temperature**: From June 1 to September 30, no NPDES point source that discharges to the portion of the Klamath River designated for cool water species may cause the temperature of the water body to increase more than 0.3°C above the natural background after mixing with 25% of the stream flow. Natural background for the

Klamath River means the temperature of the Klamath River at the outflow from Upper Klamath Lake plus any natural warming or cooling that occurs downstream.

- **Specific conductance**: The specific conductance may not exceed 400 micro-ohms at 77°F when measured at the Oregon-California Border (river mile 208.5).
- **pH**: Fresh waters except Cascade lakes: pH values may not fall outside the range of 6.5-9.0.
- **Dissolved oxygen**: Up to a 0.1 mg/l decrease in dissolved oxygen from the upstream end of a stream reach to the downstream end of the reach is not considered a reduction in water quality so long as it has no adverse effects on threatened and endangered species.
- **Turbidity**: No more than a ten percent cumulative increase in natural stream turbidities may be allowed, as measured relative to a control point immediately upstream of the turbidity causing activity.

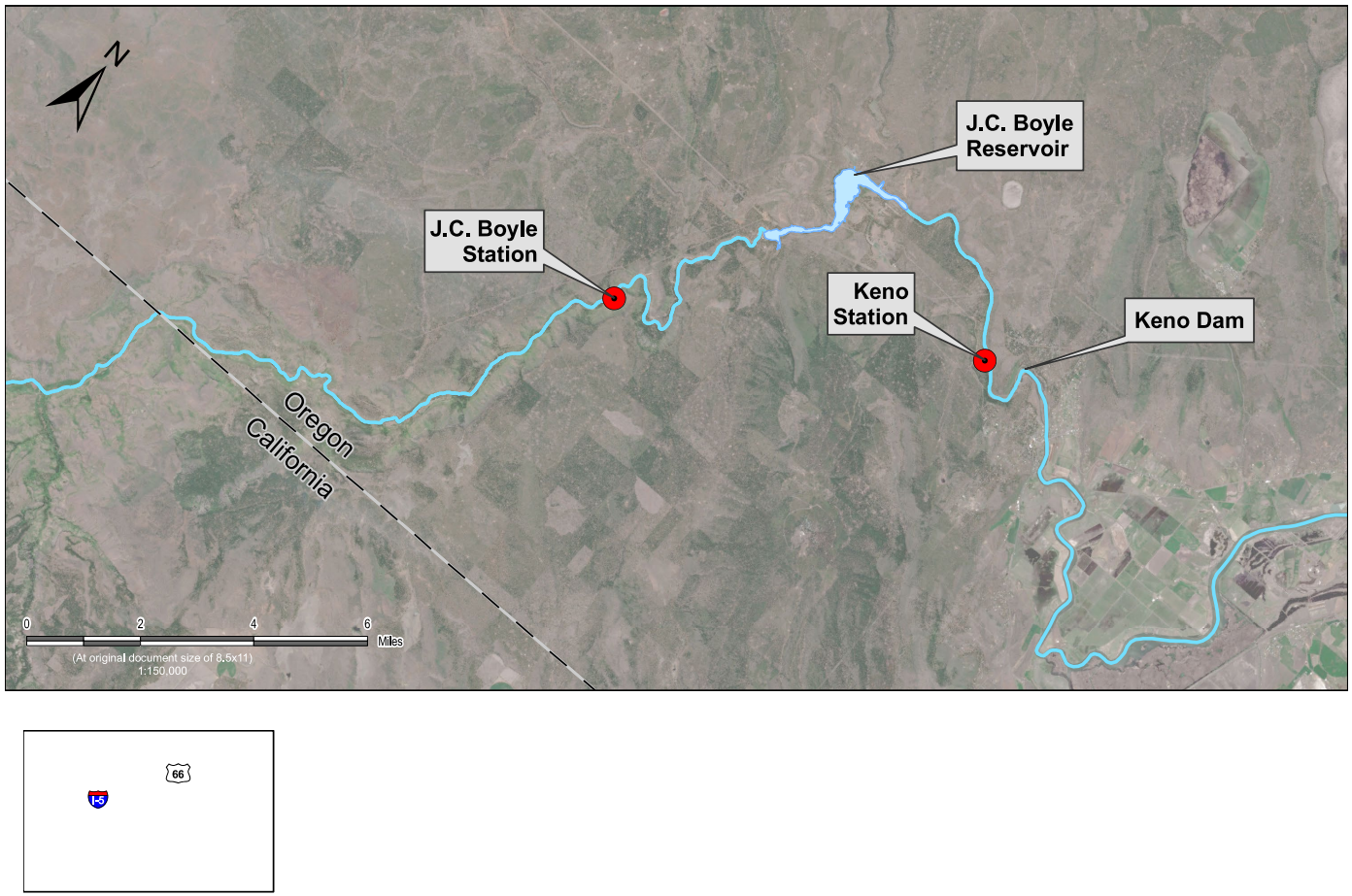

Figure 3.1-1. Water Quality Monitoring Stations

3.2 Water Quality Grab Sampling

The Renewal Corporation will collect and analyze water quality grab samples. The analytical parameters, sampling and collection methods, laboratory analytical methods, frequency and schedule, and objectives are provided in the following sections.

3.2.1 Sampling Locations

The locations of the water quality grab sampling stations are listed here and are presented in Figure 3.1-1.

- Klamath River at or near USGS gage no. 11509500 (below Keno)
- Klamath River at or near USGS gage no. 11510700 (below J.C. Boyle)

3.2.2 Sampling Parameters

The Renewal Corporation will analyze water quality grab samples for the following parameters.

- Nitrogen: ammonia, nitrate, nitrite, total nitrogen
- Phosphorus: orthophosphate, organic phosphorus, total phosphorus
- Carbon: dissolved organic carbon, particulate carbon
- Chlorophyll-a
- Suspended sediment concentration

3.2.3 Grab Sample Collection Methods

The Renewal Corporation will use sample collection methods as described in detail in the QAPP (Appendix A). These collection methods will be consistent with protocols developed and published by the EPA, USGS, California Department of Water Resources (DWR), California Department of Fish and Wildlife (CDFW), or California Surface Water Ambient Monitoring Program (SWAMP). The Renewal Corporation will use California sampling protocols in Oregon to maintain consistency with the protocols used to collect samples in California.

3.2.4 Laboratory Analytical Methods

The Renewal Corporation will use analytical methods as described in detail in the QAPP (Appendix A). These methods will comply with Code of Federal Regulations, Title 40, Part 136, or applicable methods approved by California's Environmental Laboratory Accreditation Program (ELAP). Samples that require laboratory analysis will be analyzed by ELAP-certified laboratories. The Renewal Corporation will use California methods in Oregon for consistency with the methods used for samples collected in California.

3.2.5 Schedule and Frequency

The Renewal Corporation will collect water quality grab samples monthly, beginning one year prior to drawdown at approximately the same time of day, and will continue monthly sampling for all parameters listed in Section 3.2.2 during and after drawdown. In addition, suspended sediment concentration samples will be collected every two weeks at the locations specified in

Section 3.2.1 during and after drawdown. Water quality grab samples will be collected for 4 years following the initiation of drawdown or as described in Section 3.4.

3.2.6 Sampling Objectives

Table 3.1 presents the water quality objectives for each grab sampling parameter identified in Section 3.2.2. For analytes where there is no ODEQ numeric value, the Renewal Corporation will compare water quality results with the numeric values of the Water Quality Control Plan objectives for the North Coast Region (North Coast Basin Plan; North Coast Regional Water Quality Control Board (RWQCB) 2018), similar to the downstream reaches of the Klamath Basin within the state of California. For the remaining analytes where there are no North Coast Basin Plan documented numeric values, the Renewal Corporation will compare water quality sampling data with: 1) pre-drawdown analytical results relative to general narrative statements made in the North Coast Basin Plan, 2) the results from pre-drawdown monitoring conducted as part of IM-15 and the pre-drawdown water quality grab sample results outlined in this Plan (Section 3.2.2), and 3) results from concurrent monitoring upstream of the Project at the Keno station.

When making comparisons of results for parameters with no numeric objective (Table 3.1), the Renewal Corporation will consider all available data to make a determination regarding whether the concentration of the given parameter is lower or higher than it would have been without implementation of the Proposed Action. For example, if results for a particular analyte are elevated at a station just downstream from a Proposed Action activity but not upstream, the Renewal Corporation will evaluate the event using data from other parameters and by consulting with regional water quality experts to determine the source. The Renewal Corporation will investigate deviations from upstream values and baseline conditions on a case-by-case basis. The Renewal Corporation expects many of these analytes to be elevated during and immediately following drawdown; see Section 3.4 regarding the Compliance Schedule.

Table 3.1. Water Quality Grab Sampling Objectives

ANALYTE	WATER QUALITY OBJECTIVES	NUMERIC VALUE SOURCE
Nitrite	1 mg/L	North Coast Basin Plan[1]
Nitrate	10 mg/L	North Coast Basin Plan[1]
Total Nitrogen	10 mg/L	North Coast Basin Plan[1]
Ammonia	Compare to pre-drawdown and upstream results[2]	NA
Total Phosphorus	Compare to pre-drawdown and upstream results[2]	NA

ANALYTE	WATER QUALITY OBJECTIVES	NUMERIC VALUE SOURCE
Organic Phosphorus	Compare to pre-drawdown and upstream results[2]	NA
Orthophosphate	Compare to pre-drawdown and upstream results[2]	NA
Particulate Carbon	Compare to pre-drawdown and upstream results[2]	NA
Dissolved Organic Carbon	Compare to pre-drawdown and upstream results[2]	NA
Chlorophyll-a	Compare to pre-drawdown and upstream results[2]	NA
Suspended Sediment Concentration	Compare to pre-drawdown and upstream results[2]	NA

Notes:

1. North Coast Basin Plan references Title 22 California Code of Regulations-Table 64431-A: Maximum Contaminant Levels – Inorganic Chemicals.
2. Sampling results will be compared to pre-drawdown analytical results for KHSA stations as part of IM-15 monitoring, to pre-drawdown water quality grab sample results, and to results taken from upstream of the Project at the Keno station.

3.3 California Water Quality Monitoring Plan Monthly Reporting

Prior to, during, and for a minimum of one year following completion of drawdown, the Renewal Corporation will issue monthly monitoring reports to FERC, SWRCB, ODEQ, and the RWQCB per the California Water Quality Monitoring Plan. These reports will contain water quality results collected as part of the California Water Quality Monitoring Plan, which includes the locations identified in Section 3.1.1 of this Plan. The Renewal Corporation will submit these reports between two- and three-months following data collection to allow for laboratory analysis, data management, and reporting. The Renewal Corporation will continue to submit monthly monitoring reports until water quality objectives have been met, as described and supported by data in the monitoring reports.

At a minimum, the Renewal Corporation will include the following information in the monthly monitoring reports.

- A summary of the results of the month's monitoring, including continuous water quality monitoring, water quality grab samples, and any sediment grab sampling that was completed within the reporting period (see the California Water Quality Monitoring Plan for description of sediment grab sampling locations and schedule).
- A Microsoft Excel spreadsheet containing all data collected during the reporting period.
- Highlights of any exceedances of water quality objectives.
- Highlights of observed trends.

- Reporting on any adaptive management measures taken and proposals of any additional or substitute adaptive management measures to address exceedances.
- Proposals to modify, reduce, or discontinue monitoring and reporting. The Renewal Corporation will use sampling results to support the rationale for modifications of the monitoring efforts described in this Plan.

3.4 Implementation Schedule

The Renewal Corporation expects many parameters to be elevated during and following drawdown, and as stated in the OR 401 WQC, the ODEQ has established a 24-month time schedule following the completion of drawdown for water quality to improve. If the objectives have not been met following the 24-month time schedule, the Renewal Corporation will adapt ongoing restoration activities to mitigate the source(s) of the water quality standards exceedance(s) as informed by the data.

In addition to the monthly reports discussed in Section 3.3, the Renewal Corporation will submit an Annual Compliance Report to FERC and the ODEQ by April 1 for the preceding calendar year. The Renewal Corporation will use the water quality results collected as part of this Plan to demonstrate whether water quality conditions in the Klamath River have met the standards described in Sections 3.1.4 and 3.2.6. The Renewal Corporation will discontinue water quality monitoring 4 years following the beginning of drawdown unless, based on the data, it expects that sediment-related water quality objectives will be exceeded beyond 4 years.

3.5 Method to Quantify Sediment within Reservoir Footprints

The Renewal Corporation calculated sediment quantities for J.C. Boyle Reservoir utilizing high-resolution bathymetric surveys conducted in 2002 and 2018 (SWRCB 2020). The volume of sediment that accumulated between these two surveys was used to estimate annual sediment deposition within the reservoir, and this annual load estimate was used to quantify how much sediment has accumulated since the 2018 survey in order to calculate the total sediment volume in the reservoir in 2020 (SWRCB 2020).

3.6 Method to Quantify Sediment Exporting Reservoir Footprints

Following drawdown, the Renewal Corporation will conduct sediment survey mapping at J.C. Boyle Reservoir via drones. The Renewal Corporation will compare the 2018 bathymetric survey to the post-drawdown drone data to evaluate the reduction in the volume of sediment within the reservoir footprint. Sediment shrinkage will be accounted for using the shrinkage factor of 60% assumed and presented in the Definite Plan Report (KRRC 2018).

4.0 Other Water Quality Project-Related Monitoring

There are currently no implementation activities projected to occur outside of the 24-month compliance time period. If an unanticipated activity occurs outside of the 24-month compliance period as described in Section 3.4, the Renewal Corporation will perform turbidity monitoring at

the location of actions that may discharge or increase sedimentation in runoff to the Klamath River and tributaries.

5.0 References

California State Water Resources Control Board. 2018. Final 2014 and 2016 California Integrated Report (Clean Water Act Section 303(d) List / 505(b) Report). Website: https://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2014_2016.shtml. *Accessed November 3, 2020.*

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River, 2009-2011. Prepared for the United States Department of the Interior Klamath Dam Removal Water Quality Sub Team by CDM. September.

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Appendix A

Quality Assurance Project Plan

Klamath River Renewal Corporation
Water Quality Monitoring Network for the Klamath River Renewal Project

Water Quality Sampling and Analysis

Quality Assurance Project Plan

February 2021

KLAMATH RIVER RENEWAL CORPORATION

USGS science for a changing world

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A. Project Management

A.1 Title and Approval Sheet

PROJECT TITLE:	Water Quality Monitoring for the Klamath River Renewal Project
LEAD ORGANIZATION:	Klamath River Renewal Corporation 2001 Addison Street, Suite 300, Office 317 Berkeley, California 94704
PRIMARY CONTACT:	Darrell Smolko RES Project Manager 22 Battery Street, Suite 508 San Francisco, CA 94111 Mobile: (510) 910-0916 dsmolko@res.us
EFFECTIVE DATE:	October 1, 2021 to Program End
VERSION:	01
PREFACE:	SWAMP-compliant QAPP for Klamath River water quality monitoring at 10 monitoring stations in preparation for the Klamath River Renewal Project. This document was produced using the SWAMP-EPA Review Checklist.
QAPP PREPARED BY:	Darrell Smolko, Restoration Engineer Resource Environmental Solutions, LLC Susan Fricke, Water Quality Manager Karuk Tribe Water Program Lisa DeRose Camas, LLC

Approvals

Darrell Smolko, RES
Klamath River Renewal Corporation Water Quality Monitoring Program Manager

_____Date_____

Lisa DeRose, Camas
Klamath River Renewal Corporation Water Quality Monitoring Program Coordinator

_____Date_____

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A.2.1 QAPP Information Sections

A.2.2 List of Tables and Figures

A.2.3 Appendices and Standard Operating Procedures

Appendix A	Karuk Tribe QAPP 2019
Appendix B	Karuk Tribe QAPP 2018
Appendix C	Field Operations and Sampling Forms
Appendix D	Standard Operating Procedures
Appendix E	YSI EXO Datasonde User and Calibration Manual

Distribution List

The final Quality Assurance Project Plan (QAPP) will be kept on file by the Karuk Tribe Water Program, Yurok Tribe Environmental Program, Resource Environmental Solutions (RES), and the United States Geological Survey (USGS). The following individuals will receive copies of the approved QAPP and any subsequent revisions. Field personnel will have a copy of the QAPP and Health and Safety Plan (HSP) during all field activities:

Table 1. Distribution List

Title	Contact Information
Darrell Smolko **RES** **Project Manager**	22 Battery Street, Suite 508 San Francisco, CA 94111 Mobile: (510) 910-0916 dsmolko@res.us
Laura Hazlett **KRRC** **Chief Operations Officer and Chief Financial Officer**	2001 Addison Street, Suite 317 Berkeley, CA 94704 Mobile: (510) 679-6928 lhazlett@klamathrenewal.org
Lisa DeRose **Camas** **Project Scientist**	680 G Street, Suite C Jacksonville, OR 97530 Mobile: (908) 229-6488 lisa@camasllc.com
Chauncey Anderson **USGS** **KRRP Monitoring Site & Sediment Monitoring Coordinator**	2130 SW 5th Avenue Portland, OR 97201 Office: (503) 251-3206 chauncey@usgs.gov
Scott Wright **USGS – California** **Program QA/QC Officer & Monitoring Team Leader**	USGS California Water Science Center 6000 J Street, Placer Hall Sacramento 95819 Office: (916) 278-3024 Mobile: (916) 862-0163 sawright@usgs.gov
Liam Schenk **USGS – Oregon** **Monitoring Team Leader**	2795 Anderson Avenue, Suite 106 Klamath Falls, Oregon 97603 Office: (541) 273-8689 x208 lschenk@usgs.gov
Alex Etheridge **USGS** **QA/QC and Program Data Manager**	6000 J Street, Placer Hall Sacramento, CA 95819 Office: (916) 995-0784 aetherid@usgs.gov
Dennis O'Halloran **USGS**	6000 J Street, Placer Hall Sacramento, CA 95819

Title	Contact Information
QA/QC	Office: (916) 278-3168 Mobile: (530) 412-0578 dohall@usgs.gov
Susan Fricke **Karuk Tribe Water Program** **WQ Monitoring Team Coordinator & Monitoring Team Lead**	P.O. Box 282 Orleans, CA 95556 Office: (530) 598-3414 sfricke@karuk.us
Grant Johnson **Karuk Tribe Water Program** **QA/QC**	P.O. Box 282 Orleans, CA 95556 Office: (530) 469-3258 gjohnson@karuk.us
Matt Hanington **Yurok Tribe Environmental Program** **Monitoring Team Leader & QA/QC**	15900 Hwy 101 N P.O. Box 1027 Klamath, CA 95548 Office: (707) 482-1822 ext. 1002 Mobile: (707) 954-7519 mhanington@yuroktribe.nsn.us
Stephen Low **USGS Sediment Lab** **Lab Manager**	2885 Mission Street Santa Cruz, CA 95060 Office: (831) 460-7500 stephlow@usgs.gov

A.3 Project Organization

A.3.1 Key Individual and Responsibilities

Resource Environmental Solutions, LLC (RES) is a prime consultant to the Klamath River Renewal Corporation ("Renewal Corporation"), for the Project and is managing the Water Quality Monitoring Program. As collaborators and partners with the Renewal Corporation, the Project Water Quality Monitoring Team comprised of RES, the Karuk and Yurok Tribes, and USGS, will conduct the data collection activities, perform field and laboratory analysis of samples and data, help to manage the program and contracts, and assist with the development of all reporting documents. The USGS Sediment Laboratory (USL) located in Santa Cruz, CA will perform suspended sediment concentration (SSC) analyses of the water samples. Camas is providing regulatory compliance oversight and reviewing all documents and plans related to the requirements within the California and Oregon 401 Water Quality Certifications for the Project. The Karuk Tribe, Yurok Tribe, and the USGS are sharing the monitoring responsibilities of the Water Quality Monitoring Plan based on monitoring site location and the type of monitoring to be conducted (see Section A.6).

The key individuals involved in all major aspects of the project, including contractors, and outlined in Table 2 and includes their responsibilities. Figure 1 provides an organizational chart that shows lines of authority and reporting responsibilities.

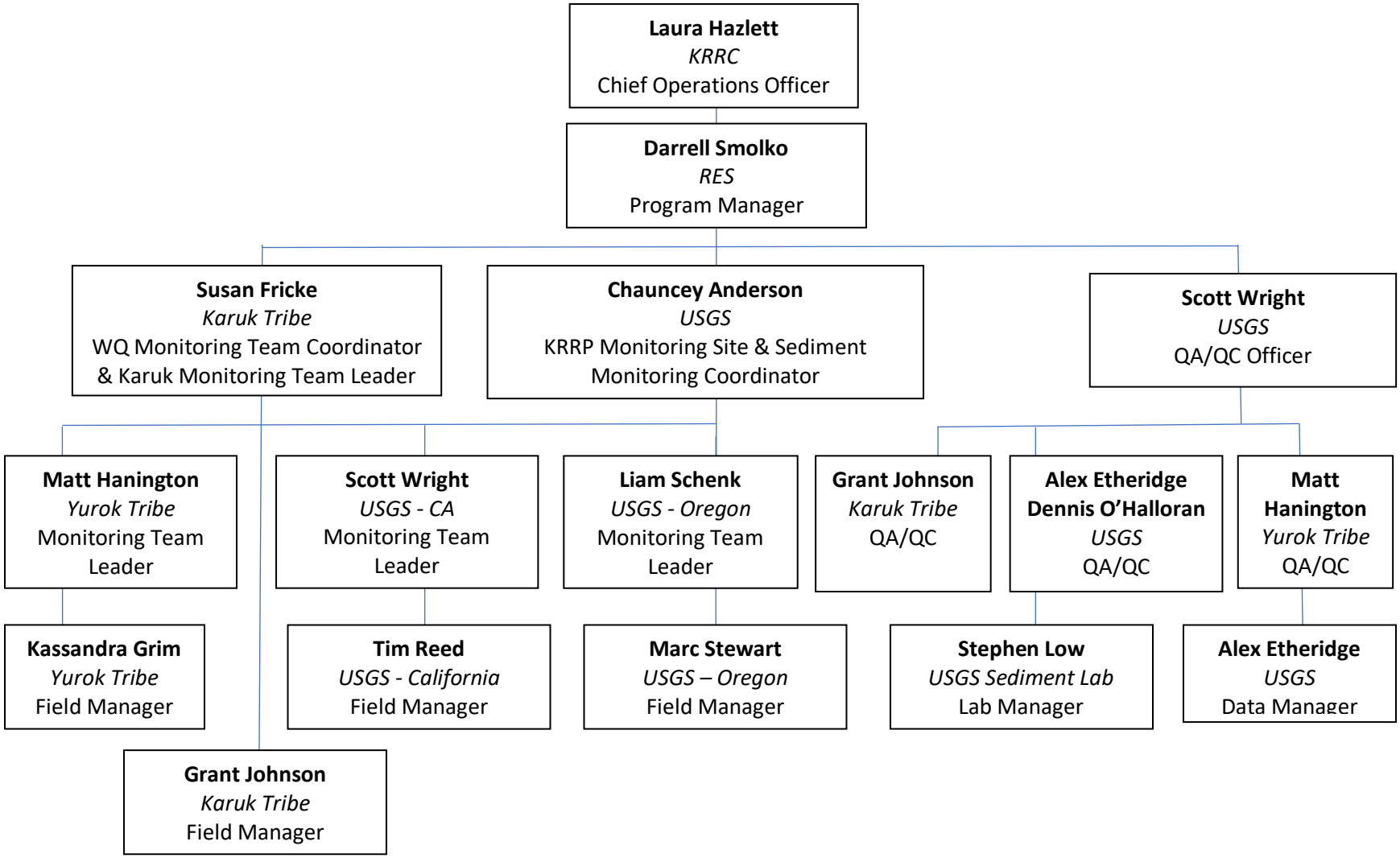
Table 2. Personnel, contact information, and responsibilities.

Program Team Member	Contact Information	Responsibility
Program Management/Administration		
Laura Hazlett KRRC	(510) 679-6928 lhazlett@klamathrenewal.org	Chief Operations Officer
Darrell Smolko RES	(510) 910-0916 dsmolko@res.us	Program Manager
Water Quality Monitoring Team		
Susan Fricke, Karuk Tribe Water Program	(530) 598-3414 sfricke@karuk.us	WQ Monitoring Team Coordinator & Karuk Tribe Monitoring Team Leader
Chauncey Anderson, USGS	(503) 251-3206 chauncey@usgs.gov	KRRP Monitoring Site & Sediment Monitoring Coordinator
Scott Wright USGS - California	(916) 862-0163 sawright@usgs.gov	USGS California Monitoring Team Leader
Liam Schenk, USGS - Oregon	(541) 273-8689 ext. 208 lschenk@usgs.gov	USGS Oregon Monitoring Team Leader
Matt Hanington, Yurok Tribe Environmental Program	(707) 482-1822 ext. 1002 mhanington@yuroktribe.nsn.us	Yurok Tribe Monitoring Team Leader
Grant Johnson Karuk Tribe Water Program	(530) 469-3258 gjohnson@karuk.us	Karuk Tribe Field Manager
Tim Reed USGS California	(530) 246-5282 treed@usgs.gov	USGS California Field Manager
Marc Stewart USGS Oregon	(541) 776-4258 mastewar@usgs.gov	USGS Oregon Field Manager
Kassandra Grim Yurok Tribe Environmental Program	(707) 482-1822 ext. 1003 kgrimm@yuroktribe.nsn.us	Yurok Tribe Field Manager
Quality Assurance/Quality Control		
Scott Wright USGS	(916) 862-0163 sawright@usgs.gov	Program QA/QC Officer
Grant Johnson, Karuk Tribe Water Program	(530) 469-3258 gjohnson@karuk.us	Karuk Tribe QA/QC

Program Team Member	Contact Information	Responsibility
Alex Etheridge, USGS	(916) 995-0784 aetherid@usgs.gov	USGS QA/QC – Sondes
Denis O'Halloran, USGS	(916) 278-3168 dohall@usgs.gov	USGS QA/QC - Sediment
Matt Hanington, Yurok Tribe Environmental Program	(707) 482-1822 ext. 1002 mhanington@yuroktribe.nsn.us	Yurok Tribe QA/QC
Laboratory Manager		
Stephen Low, USGS Sediment Laboratory	(831) 460-7500 stephlow@usgs.gov	Oversee USL analysis of SCC samples
Data Manager		
Alex Etheridge USGS	(916) 995-0784 aetherid@usgs.gov	Monitoring Data Management and Validation

A.3.2 Organizational chart that shows lines of authority and reporting responsibilities

Figure 1.



A.3.3 Project Quality Assurance Officer

The Quality Assurance/Quality Control (QA/QC) Officer role is independent of data generation. This individual's role is to establish the quality QA/QC procedures found in this QAPP as part of the sampling, field analysis, and laboratory analysis procedures (Figure 1). The QA/QC Officer will also work with the Laboratory Manager from USL by communicating all quality assurance and quality control issues contained in this QAPP. The QA/QC Officer will also review and assess all procedures during the life of this project against QAPP requirements. The QA/QC Officer will report all findings to the Water Quality Team Coordinator, including all requests for corrective action. The QA/QC Officer may stop all actions, including those conducted by subcontractors if there are significant deviations from required practices or if there is evidence of a systematic failure, (Table 2. Personnel, contact information, and responsibilities).

A.4 Project Background

The Lower Klamath River Project (Lower Klamath Project) Federal Energy Regulatory Commission (FERC) No. 14803 is located on the Klamath River in Klamath County in south-central Oregon, and Siskiyou County in north-central California. The Lower Klamath Project consists primarily of four dams and associated facilities, listed from upstream to downstream: (1) J.C. Boyle (Oregon); (2) Copco No. 1 (California); (3) Copco No. 2 (California); and (4) Iron Gate (California) (Figure 1 1).

The Renewal Corporation has applied to the FERC to surrender the license for the Lower Klamath Project for the purpose of implementing the Klamath River Hydroelectric Settlement (KHSA). Among other goals the KHSA was established to create a free-flowing river that allows volitional fish passage. The Proposed Action includes the deconstruction of the J.C. Boyle Dam and Powerhouse, Copco No. 1 Dam and Powerhouse, Copco No. 2 Dam and Powerhouse, and Iron Gate Dam and Powerhouse, as well as associated features. Associated features vary by development, but generally include powerhouse intake structures, embankments, and sidewalls, penstocks and supports, decks, piers, gatehouses, fish ladders and holding facilities, pipes and pipe cradles, spillway gates and structures, diversion control structures, aprons, sills, tailrace channels, footbridges, powerhouse equipment, distribution lines, transmission lines, switchyards, original cofferdam, portions of the Iron Gate Fish Hatchery, residential facilities, and warehouses.

The Water Quality Monitoring and Management Plan (WQMMP) identifies the methodology and procedures the Renewal Corporation will implement to evaluate water quality conditions associated with the decommissioning of J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate developments. Water quality will be evaluated through monitoring and sampling to assess project-related effects and to inform adaptive management actions for the protection of aquatic resources and the beneficial uses of the Klamath River.

The WQMMP is being implemented by a multi-agency working group in accordance with the Oregon Clean Water Act (CWA) Section 401 Water Quality Certification (Oregon Department of Environmental Quality 2018) and the California CWA Section 401 Water Quality Certification (California State Water Resources Control Board 2019). The purpose of this QAPP is to describe the Project's monitoring goals, data needs and assessment, responsible individuals, quality assurance plan, equipment maintenance,

quality control measures, and reporting deadlines. This QAPP reflects conditions stated within the Oregon 401 WQ Certification and the California 401 WQ Certification.

A.5 Project Description

A.5.1 Geographic Setting

The Klamath River flows 257 miles through Oregon and California to the Pacific Ocean and is the second largest river in California. It originates in the high desert of south-central Oregon and moves through the Klamath Mountains. **Error! Reference source not found.** shows the overall geographic location of selected sites. A total of 12 monitoring sites were selected to develop a longitudinal profile of the Klamath River from below Keno Dam to the Klamath River estuary.

Monitoring site locations were determined by considering existing water quality monitoring stations in the Klamath River Basin, site access, land use, and input received during consultation. Six existing USGS stream gage sites along the mainstem of the Klamath River within California and Oregon are being utilized to conduct continuous water quality monitoring. Two additional continuous monitoring sites will be established leading up to reservoir drawdown. Additional sites were selected for water and sediment grab samples after the considerations above. These 12 site locations are provided in Table 3 and Figure 2.

A.5.2 Summary of Work to be Performed

Under this QAPP, three types of water quality monitoring will be conducted: Continuous Monitoring, Water Quality Grab Sampling, and Sediment Grab Samples. The types of monitoring to be conducted and monitoring site locations are outlined in Table 3. Different parameters will be analyzed depending on the type of sampling conducted. These parameters are provided in Table 4. All information collected under this QAPP is critical for the Project and there are no collections outlined below that are for informational purposes only.

Figure 2. Site Layout and Sampling Locations

KLAMATH RIVER RENEWAL CORPORATION

Lower Klamath Project

Water and Sediment Quality Monitoring Stations

January 2021

PRELIMINARY DESIGN (NOT FOR CONSTRUCTION)

Monitoring Locations

- Continuous
- Continuous, Grab
- Continuous, Grab, Sediment
- Sediment

Klamath River

N

0 10 20 40 Miles

Notes

1. Coordinate System: WGS 1984 UTM Zone 10N

2.Data Sources: Klamath River: USGS National Hydrography Dataset; Surface Water Diversions: Camas LLC

3. Background: USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, National Structures Dataset, and National Transportation Dataset; USGS Global Ecosystems; U.S. Census Bureau TIGER/Line data; USFS Road Data; Natural Earth Data; U.S. Department of State Humanitarian Information Unit; and NOAA National Centers for Environmental Information, U.S. Coastal Relief Model. Data refreshed May, 2020.

Table 3. Sampling locations and the associated type(s) of water quality monitoring to be conducted.

Sampling Location	Continuous Monitoring	Water Quality Grab Sampling	Sediment Grab Samples
Klamath River at or near USGS gage no. 11509500 (below Keno)	X	X	
Klamath River at or near USGS gage no. 11510700 (below J.C. Boyle)	X	X	
Klamath River upstream of Copco No. 1 Reservoir, and downstream of Shovel Creek	X	X	X
Three locations in the Copco No. 1 Reservoir footprint, in areas where sediments will likely be terraced.[1]			X
Klamath River downstream of Copco No. 2 Powerhouse, no further downstream than the Daggett Road bridge crossing of the Klamath River	X	X	X
Three locations in the Iron Gate Reservoir footprint, in areas where sediments will likely be terraced.1			X
Klamath River at or near USGS gage no. 11516530 (below Iron Gate)	X	X	X
Klamath River at or near Walker Bridge	X		
Klamath River at or near USGS gage no. 11520500 (below Seiad Valley)	X	X	
Klamath River at or near USGS gage no. 11523000 (Orleans)	X	X	X
Klamath River at or near USGS gage no. 11530500 (Klamath)	X	X	
Klamath Estuary near the mouth of the Klamath River	X	X	X

[1] If terracing does not occur at the previously sampled location, the sample location will be moved to a location with terraced sediments.

Table 4. Parameters to be monitored under the three different monitoring type under this QAPP.

Continuous Monitoring	Water Quality Grab Sampling	Sediment Grab Samples
• Temperature • Conductivity • pH • Dissolved oxygen (concentration and percent saturation) • Turbidity	• Total Nitrogen • Nitrate • Nitrite • Ammonia • Total Phosphorus • Particulate Organic Phosphorus • Orthophosphate • Particulate Organic Carbon • Dissolved Organic Carbon • Chlorophyll-A • Turbidity • Microcystin • Suspended Sediment Concentrations • Methylmercury • Settleable Solids • Particulate and Dissolved Aluminum	• Arsenic • Lead • Copper • Nickel • Iron • Aluminum • Dioxin • Cyanide • Mercury • Ethyl Benzenes • Total Xylenes • Dieldrin • 4,4’-dichlorodiphenyltrichloroethane (DDT) • 4,4’-dichlorodiphenyldichloroethane (DDD) • 2,3,7,8-tetrachlorodibenzodioxin (TCDD) • 4,4’-dichlorodiphenyldichloroethylene (DDE) • 2,3,4,7,8-pentachlordibenzofuran (PECDF)

A.5.3 Work Schedule

The work schedule, indicating critical project points, is provided in Table 5.

Table 5. Work schedule.

Task/Deliverables	Anticipated date of Completion
Task 1: Perform Field Data Collection Activities	
Continuous Water Quality Monitoring	• For sonde locations in California monitoring shall begin one year prior to drawdown and shall continue unless otherwise approved by the Deputy Director in CA. • For sonde locations in Oregon monitoring shall begin one year prior to drawdown and shall continue for a minimum of four years after initiating drawdown unless otherwise approved by ODEQ.
Water Quality Grab Sampling	• Sampling in California shall occur on a monthly basis, at the same time of day, beginning one year prior to drawdown and will continue unless otherwise approved by the Deputy Director in CA. • Suspended sediment concentration samples collected in California shall be collected every two weeks. • Sampling in Oregon shall occur on a monthly basis, at the same time of day, beginning one year prior to drawdown and shall continue for a minimum of four years after initiating drawdown unless otherwise approved by ODEQ. • Suspended sediment concentration samples collected in Oregon shall be collected every two weeks from January 2022 through September 2023 and monthly beginning October 2023.
Sediment Grab Samples	One sediment grab sampling event will be conducted prior to drawdown activities and one event within 12 to 24 months of completing drawdown activities.
Task 2: Data Management and Analysis	
Continuous provisional Karuk and Yurok data published in real-time	Ongoing through contract
Laboratory Analysis	2-3 months after sample collection
Task 3: Annual Progress Reporting	
Monthly monitoring reports will be issued to the following California agencies: SWRCB, ODEQ, DEQ, and the RWQCB.	Prior to, during, and for a minimum of one year following completion of drawdown, until otherwise approved by the CA Deputy Director.
Annual Compliance Report submitted to ODEQ	Annually, on April 1 for at least two years.

A.5.4 Resource and Time Constraints

Every effort will be made to collect storm event samples for SSC. Personnel availability may create challenges in collecting samples if multiple sites require sampling at the same time. However, automated pump samplers (ISCO) are deployed to collect samples when the sites cannot be visited. High flow events will be captured to the best of the Project teams' ability. Weather conditions will dictate sampling events, and the safety of the crews collecting the samples will be the top priority. If weather conditions create unsafe working environment for sampling crews, the samples will be collected by the automated samplers described above.

A.6 Quality Objectives and Criteria

This section discusses the quality objectives for the project and the performance criteria to achieve those objectives.

For continuous time-series measurements, the data quality criteria to be assessed quantitatively include precision and accuracy alone. These assessments will be different for water and sediment grab sample data. The associated acceptance criteria (types and frequencies of QC checks and acceptance limits) for the Project follow SWAMP guidelines and are summarized in Table .

A.6.1 Measurement Quality Objectives

This section discusses the quality objectives for the project and the performance criteria to achieve those objectives.

For continuous time-series measurements, the data quality criteria to be assessed quantitatively include precision and accuracy, as outlined below.

These assessments will be different for grab water quality and sediment samples, which involve laboratory analyses. The measurement quality objectives for these sampling types follow SWAMP guidance and are summarized in Table 6.

A.6.2 Precision and Accuracy

Precision is a measure of agreement among replicate measurements of the same property, under prescribed similar conditions.

Precision will be assessed quantitatively with duplicate samples and expressed as relative percent difference (RPD) by the following equation:

$$RPD(\%) = \frac{\frac{|x1 - x2|}{(x1 + x2)}}{2} X\ 100$$

where,

RPD (%) = relative percent difference

x1 = Original sample concentration

x2 = Duplicate sample concentration

|x1 - x2| = Absolute value of x1 - x2

To assess precision associated with all steps of the project (from sample collection through analysis), field duplicates will be collected and analyzed for all water and sediment grab samples. Composite (cross-section) grab samples will always be collected in duplicate and are referred to as A and B sets in USGS terminology. An A set represents one cross-section sample, and a B set is collected directly after, representing a duplicate cross-section sample. To assess laboratory precision alone, the USGS QA Plan for the Analysis of Fluvial Sediment by the USGS California Water Science Center (CAWSC) will be followed (Appendix D).

Precision of field results will be tested using duplicate samples, with a target of less than 20% RPD, as described previously.

Accuracy is the degree of agreement of a measurement with the true value. Accuracy includes a combination of random error (precision) and systematic error (bias) that result from sampling and analytical operations. Accuracy of water quality measurements contained in this QAPP are a function of the equipment used during sampling, and of the sampling methods.

For automatic (pump) samples, single bottle samples collected in conjunction with cross-section samples will be collected at a frequency of 5% (1 duplicate/20 field samples). Collecting a pump sample in conjunction with a cross-section sample allows for accuracy testing of the pump samples, by determining if the pump samples are representative of the cross section as a whole. If the pump samples and cross section samples differ in concentrations, then a box coefficient is applied to the pump samples. The box coefficient is simply a multiplier that is applied to the pump sample to adjust the concentration of that sample to the concentration of the cross-section sample that was collected in conjunction with the pump sample. Applying box coefficients to pump samples is a common practice by USGS, and more documentation can be found in Edwards and Glysson (1999).

A.6.3 Bias

Bias describes the tendency for under or over prediction of sampled or measured values relative to the true value. Bias is typically assessed using matrix spikes and reference materials. Samples of known sediment concentrations are routinely tested as described in the QA Plan for the Analysis of Fluvial Sediment by the USGS California Water Science Center Sediment Laboratory (Appendix D), and as described in the USGS Office of Surface Water technical memo 98.05 (USGS, 1998). Bias is also assessed in the lab through negative controls (Blanks). Detectable quantities in the blank would indicate positive bias. The CAWSC Santa Cruz Sediment Lab bi-annually participates in the Sediment Lab QA Plan described in Appendix D.

A.6.4 Representativeness

This is the expression of the degree to which data accurately and precisely represent a characteristic of an environmental condition or a population. Field crews collecting samples will maximize

representativeness of samples by selecting sites and employing methodologies to best characterize environmental conditions.

A.6.5 Completeness

Completeness on this project with regards to expected number of collected SSC samples is expected to be approximately 90%. Completeness with regards to continuous water quality data is expected to be as close to a complete record as possible (a complete record is retaining all unit values over a water year), recognizing that data loss can occur for several reasons. These reasons include loss of data during field visits and on-site calibrations, potential issues with data transmission, and other unforeseen circumstances that could result in loss of data.

Table 6. Quality control measures, frequency analyses, and measurement quality objectives for water and sediment grab samples.

Laboratory Quality Control	Frequency of Analysis	Measurement Quality Objective
Laboratory Blank	Per 20 samples or per analytical batch, whichever is more frequent	<RL for target analyte
Matrix Spike and Matrix Spike Duplicate	Per 20 samples or per analytical batch, whichever is more frequent (n/a for chlorophyll a)	Conventional Parameters: 80-120% recovery Inorganic Analytes: 75-125% recovery Nutrients: 80-120% recovery RPD<25% for duplicates
Laboratory Duplicate	Per 20 samples or per analytical batch, whichever is more frequent (chlorophyll a: per method)	RPD<25% (n/a if native concentration of either sample<RL)
Field Quality Control	**Frequency of Analysis**	**Measurement Quality Objective**
Field Duplicate	5% of total project sample count	RPD<25% (n/a if native concentration of either sample<RL)
Field Blank, Travel Blank, Equipment Blank	Per method	Blanks<RL for target analyte

A.7 Special Training /Certifications

There are no certifications that apply to this work. However, informal training has been conducted for the Karuk and Yurok tribal staff on collection of samples. Similar training will be conducted for any new staff that will conduct field sampling.

In July 2018, USGS conducted training for the Karuk and Yurok tribal staff on collection of samples for grab samples. Additional sampling training is offered annually through USGS in Castle Rock, WA, which could be attended by new staff within USGS or the Tribes.

For operation of continuous monitoring sondes, the USGS California Water Science Center (CAWSC) is planning to offer a water quality data collection training class, which includes turbidity as well as the other water quality parameters, to the relevant Tribal and USGS staff. In November 2018, the Yurok Tribe hosted training on YSI data sonde operation, which was available to all project participants.

Monitoring team leaders for Karuk tribal staff, Yurok tribal staff, and USGS will be responsible for ensuring sufficient training and certification for their team members. All relevant training and certification documentation will be stored by respective organization in accordance with their standard operating procedure.

A.8 Documentation and Records

All USGS data will be maintained and served publicly through the National Water Information System (NWIS) database. Provisional continuous time series data will be published in real-time on the USGS NWIS website, with final approved records for water years will be available by April 1 the following year. Laboratory results will be provided by the USGS via the NWIS web database. Laboratory results may also be provided electronically for inclusion in a separate project database.

Continuous water quality data collected by the Karuk and Yurok Tribe will be available on the Karuk website and be submitted electronically for inclusion in the project database. The Karuk and Yurok continuous data and associated field data will be stored on their individual servers indefinitely in addition to the project database. Any SSC samples collected by the Karuk and Yurok tribes will be sent to nearest USGS field office under a Chain of Custody (COC) (Appendix C) where a Sediment Laboratory Analysis Request (SLAR) electronic form can be filled out by USGS staff and then sent to USGS Santa Cruz sediment lab, so those records will be available through the USGS NWIS database.

All monitoring entities will provide a summary of data collected each month in quarterly reports to be submitted to RES for review and then to the Renewal Corporation Technical Team.

Field records will include a written (Appendix C) or electronic record (Aquarius Software) of site visits documenting field observations, site conditions, calibration and maintenance conducted. A field visit summary will be provided in the quarterly reports. Field crews will also collect dated photo documentation of site conditions from each visit showing the condition of equipment and gage and unusual site and river conditions. Additionally, field staff will fill out a Field Inspection Sheet for SSC sampling (Appendix C) including all monitoring sites where SSC samples are collected with information including date, time, number of samples collected, and notes on site conditions.

The Karuk Tribe, Yurok Tribe and USGS will prepare and submit an annual monitoring season summary that covers work completed including upgrades and development of monitoring locations, samples collected, all other monitoring conducted, photos, and recommendations for program modifications. The annual season summaries will be compiled in an Annual Progress Report that will include site

descriptions with photos, mapping, and coordinates, summarize monitoring activities, and provide links to data and results. The report will also present recommendations for program modifications needed to prepare for the required monitoring activities during successive years.

Each sampling entity's QA/QC staff will be tasked with ensuring that all relevant personnel have the most recent version of this QAPP.

Table 2. Document and Record Retention, Archival, and Disposition Information

	Identify Type Needed	Retention	Archival	Disposition
Station Log	Station Description files (record of site visits and conditions – road logs, ownership, equipment, etc.)	Onsite and copy retained in CAWSC and ORWSC (Oregon Water Science Center) Data Program Offices	Archived according to USGS policy SM 502.9 and/or in accordance with this QAPP	Indefinite
Field Visit and Sample Collection Records	Field notes for (1) monitor calibration, (2) Grab Sample collection	Retained in CAWSC and ORWSC Data Program Offices, and Karuk and Yurok Tribal offices.	Archived according to USGS policy and/or in accordance with this QAPP	Indefinite
Analytical Records	Laboratory analyses for water and sediment grab samples	Stored at USL, Santa Cruz, CA	Archived according to USGS policy and in accordance with this QAPP	Indefinite
Data Records	Time Series Data	Retained in CAWSC and ORWSC Data Program Offices, and Karuk and Yurok Tribal offices and project database.	Archived according to USGS policy and in accordance with this QAPP	Indefinite
Assessment Records	Surrogate Model Archives, WQ Station Analyses	Retained in CAWSC and ORWSC Data Program Offices	Archived according to USGS policy	Indefinite

B. Data Acquisition

B.1 Sampling Design

Site selection criteria included the use of existing USGS gaging stations, located to enable measurement of changing water quality conditions below project actions.

B.1.1. Continuous Water Quality Monitoring

Continuous water quality monitoring will begin one year prior to drawdown and will continue in California until otherwise approved by the SWB Deputy Director and for a minimum of four years in OR unless otherwise approved by ODEQ (Table 5). This monitoring will be conducted at ten locations on the Klamath River from below Keno Dam to near Klamath, CA (Table 3). These locations are presented in Figure 2. Continuous monitoring stations will have telemetry capabilities and the data will be transmitted and stored in online databases held and managed by the Karuk Tribe and USGS. Each sonde will be configured to record data at 15-minute intervals for the stations located in Oregon and 30-minute intervals for the stations located in California. All information collected from continuous monitoring sondes is critical for the Project.

All continuous monitoring will be conducted uniformly and in accordance with the USGS protocols and EPA-approved Karuk and Yurok protocols (Wagner *et al.*, 2006; Rasmussen *et al.*, 2009; Appendix A; Appendix B).

If a sonde becomes inoperable during the monitoring period, appropriate actions will take place to repair the sonde and resume continuous monitoring as soon as possible (Appendix E). One potential source of misrepresentation may arise from sondes that have not been calibrated correctly or frequently enough. This potential will be minimized by regular bi-monthly (every two weeks) calibrations of monitoring sondes in accordance with manufacturers standard (Appendix E).

B.1.2. Grab Water Samples

Water quality samples will be collected one year prior to drawdown at a minimum frequency of once per month, at the same time of day, during and following drawdown. Suspended sediment concentration samples will be collected bi-monthly (every two weeks). For a complete compliance schedule including determination of cessation of sampling refer to Table 5.

Water quality grab samples will be collected from the locations outlined in Table 3. Water quality grab samples will be collected at CA sampling locations until otherwise approved by the SWB Deputy Director and for a minimum of four years in OR unless otherwise approved by ODEQ.

One potential source of bias or misrepresentation may arise from grab samples being collected from different locations within a site or from a location not representative of river conditions (e.g., eddy or backwater). This potential will be minimized by standardizing grab sample locations that are sufficiently within the river channel.

B.1.3. Sediment Grab Samples

Sediment grab samples will be collected in California only. One sediment grab sampling event will be conducted prior to drawdown activities and one event within 12 to 24 months of completing drawdown activities. Sediment grab samples will be collected at locations detailed in Table 3.

If a sampling site becomes inaccessible, the Renewal Corporation will collect a sediment grab sample when the site becomes accessible again. This should not pose an issue, given the required time frame of

12 to 24 months following reservoir drawdown. One potential source of bias or misrepresentation may arise from grab samples being collected from different locations within a site. This potential will be minimized by standardizing grab sample locations to occur at the same location between sampling events. However, at sampling locations within reservoir footprints, it is possible that terracing may not occur at the previously sampled location. In this case, the sample location will be moved to a location with terraced sediments.

B.2 Sampling Methods

B.2.1. Procedures

The procedures for calibrating sondes are in the protocols, SOPs (Appendices D and E) and the Karuk Tribe and Yurok Tribe QAPPs, summarized in Section B.7. They are also described in Wagner *et al.* (2006) and Rasmussen *et al.* (2009) for USGS sites.

B.2.2. Continuous Water Quality Monitoring

Continuous water quality monitoring will be conducted with YSI EXO2 data sondes. Data collection by USGS at the Keno and JC Boyle sites will follow protocols detailed in Wagner *et al.* (2006), and Rasmussen *et al.* (2009). The USGS, Karuk and Yurok Tribe will perform all data collection and equipment maintenance as outlined by manufacturer specifications, this QAPP and in accordance with their respective EPA approved QAPPs, and SOPs (Appendices A, B, D, and E). The sondes will be housed within a protective PVC perforated pipe, which will secure the sondes in the water column to avoid damage to equipment. Communication cables will be attached to the submerged sondes and routed to the gage house where they will be connected to a datalogger. The datalogger will send USGS data to the database through a GOES satellite window. The Karuk and Yurok Tribes sondes are connected to FTS Axiom data loggers with an SDI-12 cable. Once data is recorded by sonde it is sent to data logger. Both the data logger and sonde retain data. The data logger will transmit data via the GOES satellite network and will be available on Karuk and USGS servers. In addition, Karuk and Yurok data will be made available on the Karuk water quality web portal in real time. Sondes will record data at a 15-minute interval.

USGS will deploy and operate high-range continuous turbidity sensors at the JC Boyle, Iron Gate, Seiad, Orleans, and Klamath sites. The sensors will be ANALITE NEP-5000 180-degree backscatter sensors, and will be calibrated and operated by the published protocols referenced in Section **Error! Reference source not found.**2.

B.2.3. Grab Water Samples

Sample collection methods will be consistent with protocols developed and published by the EPA, USGS, California Department of Water Resources (DWR), California Department of Fish and Wildlife (CDFW), or California Surface Water Ambient Monitoring Program (SWAMP). Sampling equipment and proper use of field equipment to ensure collection of a representative sample are detailed in Section B.4.1.

B.2.4. Sediment Grab Samples

Sample collection methods will be consistent with protocols developed and published by the EPA, USGS, DWR, CDFW, or SWAMP. Sampling equipment and proper use of field equipment to ensure collection of a representative sample are detailed in Section B.4.1.

B.3 Sample Handling and Custody

Water and sediment grab samples will be delivered to the appropriate laboratory dependent upon analysis and media as detailed in Table 9 within designated hold times (Table 8) of sample collection for analysis. Samples will be stored, packaged and shipped on ice. Samples collected by Karuk and Yurok Tribes will be either directly shipped to the lab or physically transferred to USGS personnel under a COC, who will then transport the samples to the lab. Analytical service request forms (ASR) will be filled out by USGS personnel using field forms from USGS, Karuk, and Yurok personnel. The sample bottles will be labeled by Site ID, Date, median sample time (the median time between the start and stop time of the samples), gage height at time of sample, and the sample set (A or B). USGS personnel will fill out necessary information into the electronic forms prior to submitting samples to the lab.

Table 8. Sample Handling

Analyte	Bottle Size/Type (1 bottle per event)	Preservative Requirements (Chemical, Temperature, and Light)	Maximum Hold Time
Total Nitrogen	250ml, polyethylene bottle	4◦C	48 hours
Nitrate			
Nitrite			
Ammonia			
Total Phosphorus			
Particulate Organic Phosphorus			
Orthophosphate			
Particulate Organic Carbon	100ml, glass bottle	Filter and preserve to pH<2 within 48 hours of collection; cool to ≤6	28 days
Dissolved Organic Carbon		Cool to ≤6 ◦C; acidify to pH<2 with HCl, H_3PO_4, or H_2SO_4	
Chlorophyll *a*	1L, polyethylene bottle	Filter as soon as possible after collection; keep samples at ≤6C	Samples must be frozen or analyzed within 4 hours of collection; filters can be stored frozen for 28 days
Turbidity	1L, polyethylene bottle	4◦C	48 hours
Microcystin	250ml, clear glass bottle	Freeze and ship at <4◦C	14 days
Suspended Sediment Concentrations	250ml, polyethylene bottle	4◦C	7 days

Methylmercury	250ml, polyethylene bottle	Immediately after collection, cool to ≤6 ◦C in the dark; acidify to 0.5% with pre-tested HCl within 48 hours; if salinity is >0.5 ppt, acidify with H2SO4	6 months at to ≤6 ◦C in the dark following acidification
Settleable Solids	250ml, polyethylene bottle	4◦C	7 days
Particulate and Dissolved Aluminum	250ml, polyethylene bottle	HNO3 to pH<2 within 48 hours and at least 24 hours prior to analysis	6 months at room temperature following acidification

B.4 Equipment, Analytical Methods and Field Measurements

Samples will be collected and analyzed as outlined below.

B.4.1 Field Equipment

Continuous Monitoring Methods

The EXO2 sondes contain sensors that continuously record observations of water temperature, pH, dissolved oxygen, specific conductance, and turbidity. Water temperature and specific conductance are located on the same probe. The temperature thermistor is a calibrated with a NIST-traceable wet calibration and an accuracy specification of 0.01 degrees Celsius and a resolution of 0.001 degrees Celsius. The specific conductance sensor reports water conductance compensated to 25 degrees Celsius and uses four internal pure-nickel electrodes to measure solution conductance. Conductance resolution is 0.0001 to 0.01 ms/cm. The dissolved oxygen sensor is an optical sensor and operates by shining a blue light of a specified wavelength onto a luminescent dye which is immobilized in a matrix and formed to a disk. Accuracy of the dissolved oxygen sensor is increased by irradiating a red light during the measurement cycle to act as a reference in the determination of the luminescence lifetime. Dissolved oxygen resolution is 0.01 mg/L, or 0.1% air saturation. pH is measured using two electrodes combined into the same probe: one for hydrogen ions and one for a reference. The sensor is a glass bulb filled with a solution of stable pH. pH range is 0 to 14 units with a resolution of 0.01 units. The turbidity sensor employs a near-infrared light source and detects scattering at 90 degrees of the incident light beam, also characterized as a nephelometric near-IR turbidimeter, non-radiometric. As such, units are reported as formazin nephelometric units (FNU). The sensor range is 0-4000 FNU with a resolution of 0.01 FNU for 0-999 FNU, and 0.1 FNU for 1000-4000 FNU. The high-range ANALITE NEP-5000 turbidity sensor is a backscatter sensor that detects scattering at 180 degrees of the incident light beam. The units are reported as nephelometric turbidity units (NTUs). The ANALITE NEP-5000 sensor range is 0-30,000 NTU with a resolution of +/- 1.5 NTU for 0-5,000 NTU, +/- 3.0 NTU for 5,000-10,000 NTU, +/- 9.0 NTU for 10,000-30,000 NTU.

For calibration, maintenance, see manufacturer's instructions (Appendix E), and auditing procedures. Raw data from sondes will be collected and stored on dataloggers in the USGS gage houses. This data will also be transmitted via the GOES network and made publicly available.

Automated Samplers

The Teledyne ISCO automated pump samplers function using a peristaltic pump head that is capable of pumping volumes of water up to 26 vertical feet from the point of pumping to the pump head, and at manufacturer-recommended velocities. The sampler can be configured to hold bottles sized from 1-L to 5.5 gallons if needed. No measurement principle is associated with this equipment. Major attributes include the ability to program the sampler to collect samples at specified temporal frequencies and at specified turbidity thresholds. An SDI-12 interface allows connection with the YSI EXO2 sondes via the data logger to trigger the samples at specified turbidity thresholds without disrupting the transmission of continuous water quality data from the sondes.

Grab Water Sampling

Standard water quality grab sample procedures will be used for collection of water quality parameters, nutrients, chlorophyll, and microcystin, using a churn to mix samples and following an appropriate regimen of blanks, duplicates and other steps to assure quality. Calibration and maintenance of data sondes adheres to protocols established by USGS and the manufacture. To ensure reliability YSI multi-channel data sondes are calibrated in the field on a daily basis before use following YSI instructions and other standard procedures for calibration (U.S. EPA, 2001) that are attached as Appendix E.

Grab water samples will be collected at nine discrete locations (Table 3), collected with a churn splitter to ensure that the sample is homogeneously mixed before the sample bottles are filled. Depending on location with or without bridge access, two collection methods may be used. For most sites, the churn is fully submerged into the stream and filled to the lid with flowing water, not stagnant water. For sites from a bridge (Daggett Road and Walker), a Van Dorn sampler can be used to collect three samples from across the channel. The samples are poured into the churn and treated the same as all other sites. Prior to filling the churn for nutrient, chlorophyll, or microcystin sampling, the churn will be decontaminated by rinsing three times with distilled water. After rinsing with distilled water, the churn will be rinsed three times with stream water. Samples shall be collected from uniformly mixed water with the churn fully submerged into the stream and filled to the lid with sample water. Completely filling the churn allows for all sample bottles to be filled from one churn; thereby minimizing differences in water properties and quality between samples. The churn should be stirred at a uniform rate by raising and lowering the splitter at approximately 9 inches per second while bottles are being filled (Bel-Art Products, 1993). Care must be taken to avoid breaking the surface of the water as the splitter rises toward the top of the water in the churn.

Sample bottles are filled directly from the churn and collected samples are placed on ice in coolers with completed and signed chain of custody for transport to accredited laboratory for analysis. For quality assurance/ quality control (QA/QC) purposes duplicate, and blank bottle sets are prepared and collected

according to the schedule outlined in Table 6. These additional bottle sets are handled, prepared and filled following the same protocol used for regular bottle sets and samples.

Isokinetic Suspend-Sediment Sampling

Composite and individual analyses suspended-sediment sampling will be conducted from bridges, boats, cableways, and by wading the stream cross section following methods described in Edwards and Glysson (1999). For bridge, cableway, and boat samples, a USGS D-49, D-96, D-74, D-95, DH-95 or DH-59 sediment sampler with appropriate glass or plastic bottles or plastic bags for the D-96 bag sampler will be used to collect the samples. These samplers will be lowered and raised through the water column using cable and reel devices. For wading samples, a hand-held DH-81 sediment sampler enclosing a 1-L Nalgene plastic bottle, or a DH-48 sediment sampler enclosing a glass pint bottle will be used. These samplers will be manually lowered and raised through the water column during sample collection. Individual sample bottles will be sent to the Santa Cruz lab for analysis. The measurement principle of these samplers follows isokinetic sampling theory, which states that the water approaching and entering the sampler intake does not change velocity while the sampler is being moved through the water column and collecting the sample. Isokinetic samplers are limited to water velocities greater than 1.5 feet per second and depths less than 15-ft for samplers with rigid bottles (D-74, D-95, DH-95, DH-59). The D-96 bag sampler can be used in velocities from 2.0 to 12.5 ft/s and depths up to 110-ft depending on the nozzle diameter.

Two cross-section composite samples will be collected per sampling event generating 10 1-L sample containers. The first sample (A-set) will generate 5 sample bottles that will be analyzed individually for SSC and percent of sample finer than 63 microns (percent fines). The second sample will composite all of the 5 containers resulting in one SSC and percent fines value and will be analyzed for full particle size distribution.

Grab Sediment Streambed Sampling

Obtaining sediment samples that are representative of the river reach is essential to maintain data and sampling program integrity. The sediment sample collection strategy focuses on obtaining samples of fine-grained surficial sediments from natural depositional zones, in part because specific trace elements that are part of the sampling program, such as methylmercury have a strong affinity to organic carbon content and fine grain sediment *(*Ravichandran, 2004; Lambertsson and Nilsson, 2006). In wadeable sections, sediment sample locations should include the insides and outsides of meander bends, crossovers, as well as forewater and backwater side habitats (USGS 2008). Sample locations will be chosen in areas outside the hydraulic effects of bridges and other man-made objects.

The surficial 0 to 3 centimeter of bed sediment within each sample location or zone will be subsampled several times in the same reach and combined to create a composite sample for each sample location. Compositing subsamples from different depositional areas within the same reach or zone will smooth the local scale variability and provide samples that are more representative of the average or mean contaminant concentrations (USGS 1994). To minimize possible contamination, sediment samples should be collected with non-metallic materials or from the center of the grab sampler, avoiding areas that are near or directly contacting metal surfaces. In addition to sediment-sampling activities, stream-

water field measurements of pH, specific conductance, dissolved oxygen (DO), temperature, and streamflow also are collected at the time of sampling. (USGS 2008). In addition, locational information should be supplemented with Global Positioning System (GPS) coordinates recorded at each sampling area (2008 USGS). Sample equipment decontamination between all collection locations in accordance with USGS and EPA SWAMP shall be completed to minimize cross contamination.

B.4.2 Analytical Methods and Field Measurements

This QAPP requires laboratory analysis for grab water and grab sediment samples collected at locations described in section B.1.2 and B.1.3, respectively for analytes listed in Table 11 and Table 12, respectively. All laboratory analysis will be completed in accordance with 40 CFR 136 methodology by California Environmental Laboratory Accreditation Program (ELAP) or Oregon Environmental Laboratory Accreditation Program (ORELAP) certified laboratories as necessary. Grab water analysis with the exception of microcystin will be performed at ELAP accredited Aquatic Research Laboratories in Seattle, WA. Microcystin analysis will be performed by EPA Region 9 Laboratory in Richmond, CA. Suspended Sediment Concentration will be analyzed by the USGS Sediment Laboratory in Santa Cruz, CA. Grab sediment samples will be analyzed by Aquatic Research Laboratories in Seattle, WA. Table 10 provides a detailed list of analytes, laboratories, and reporting limits.

Table9. Laboratories & Reporting Limits

Analyte	Media	Reporting* Limits	Unit	Laboratory
Arsenic	Sediment		mg/kg	Aquatic Research
Lead	Sediment		mg/kg	Aquatic Research
Copper	Sediment		mg/kg	Aquatic Research
Nickel	Sediment		mg/kg	Aquatic Research
Iron	Sediment		mg/kg	Aquatic Research
Aluminum	Sediment		mg/kg	Aquatic Research
Dioxin	Sediment		mg/kg	EMA
Cyanide	Sediment		mg/kg	Aquatic Research
Mercury	Sediment		mg/kg	Aquatic Research
Ethyl Benzenes	Sediment		mg/kg	Aquatic Research
Total Xylenes	Sediment		mg/kg	Aquatic Research
Dieldrin	Sediment		mg/kg	EMA
4,4'-dichlorodiphenyltrichloroethane (DDT)	Sediment		mg/kg	EMA
4,4'-dichlorodiphenyldichloroethane (DDD)	Sediment		mg/kg	EMA
2,3,7,8-tetrachlorodibenzodioxin (TCDD)	Sediment		mg/kg	EMA
4,4'-dichlorodiphenyldichloroethylene (DDE)	Sediment		mg/kg	EMA
2,3,4,7,8-pentachlordibenzofuran (PECDF	Sediment		mg/kg	EMA
Total Nitrogen	Water		mg/L	Aquatic Research

Nitrate	Water		µg/L	Aquatic Research
Nitrite	Water		µg/L	Aquatic Research
Ammonia	Water		µg/L	Aquatic Research
Total Phosphorus	Water		µg/L	Aquatic Research
Particulate Organic Phosphorus	Water		µg/L	Chesapeake Biological
Orthophosphate	Water		µg/L	Aquatic Research
Particulate Organic Carbon	Water		mg/L	Chesapeake Biological
Dissolved Organic Carbon	Water		mg/L	Aquatic Research
Chlorophyll-A	Water		µg/L	Aquatic Research
Microcystin	Water		µg/L	EPA Region 9 Laboratory
Methylmercury	Water		µg/L	Aquatic Research
Particulate and Dissolved Aluminum	Water		mg/L	Chesapeake Biological
Settleable Solids	Water		mg/L	Aquatic Research
Suspended Sediment Concentration	Water		mg/L	USGS Sediment Laboratory
Turbidity	Water		NTU	Aquatic Research

*Reporting limits to be confirmed with contracted laboratories

Chemistry

SSC will be analyzed using method, ASTM D 3977-97, Standard Test Method for Determining Sediment Concentration in Water Samples (ASTM, 1999). This is the USGS standard for determining concentrations of suspended material in surface water samples. This method is used by all USGS sediment laboratories, and by cooperating laboratories certified to provide suspended-sediment data to the USGS. The laboratory will report both concentration in mg/L and percent of sample less than 63 microns, operationally defined as the break between silt and sand.

Table 10. Analytical Methods – Grab Water

Analyte	Unit	Analytical Method or Standard
Total Nitrogen	mg/L	EPA 351.2
Nitrate	mg/L	EPA 353.2
Nitrite	mg/L	EPA 353.2
Ammonia	mg/L	SM 4500 C/G
Total Phosphorus	mg/L	EPA 365.4
Particulate Organic Phosphorus	mg/L	EPA 200.7
Orthophosphate	mg/L	EPA 365.3
Particulate Organic Carbon	mg/L	ASTM D4129
Dissolved Organic Carbon	mg/L	ASTM D7573
Chlorophyll-A	CFU	EPA 446
Microcystin	µg/L	Enzyme-Linked ImmunoSorbent Assay (ELISA) Microcystin-ADDA Method
Methylmercury	µg/L	EPA 245.1 / SW-846 Method 7470
Particulate and Dissolved Aluminum	mg/L	EPA 200.7
Settleable Solids	mg/L	SM 2540F
Suspended Sediment Concentration	mg/L, % < 63 microns	ASTM D 3977-97

Turbidity	NTU	EPA 180.1

Table 11. Analytical Methods – Sediment

Analyte	Unit	Analytical Method or Standard
Arsenic	mg/kg	EPA 6010B
Lead	mg/kg	EPA 6010B
Copper	mg/kg	EPA 6010B
Nickel	mg/kg	EPA 6010B
Iron	mg/kg	EPA 6010B
Aluminum	mg/kg	EPA 6010B
Dioxin	mg/kg	EPA 8290A
Cyanide	mg/kg	EPA 335.4
Mercury	mg/kg	EPA 7470
Ethyl Benzenes	mg/kg	EPA 8260B
Total Xylenes	mg/kg	EPA 8260B
Dieldrin	mg/kg	EPA 8081
4,4'-dichlorodiphenyltrichloroethane (DDT)	mg/kg	EPA 8081
4,4'-dichlorodiphenyldichloroethane (DDD)	mg/kg	EPA 8081
2,3,7,8-tetrachlorodibenzodioxin (TCDD)	mg/kg	EPA 8290A
4,4'-dichlorodiphenyldichloroethylene (DDE)	mg/kg	EPA 8081
2,3,4,7,8-pentachlordibenzofuran (PECDF)	mg/kg	EPA 8081

Sample Disposal

This section does not apply to any type of sampling conducted under this QAPP.

B.5 Quality Control

B.5.1 Quality Control Activities

Quality control activities are outlined in Table 6 for conventional parameters, nutrients, and inorganic analytes. This includes laboratory blanks, spikes, and duplicates, and field duplicates and blanks.

If control limits are exceeded, corrective actions will be assessed and documented following guidance in SWAMP Quality Control and Sample Handling Tables.

Procedures and formulas for calculating quality control results are outlined in Section A.7.

B.6 Instrument/Equipment Testing, Inspection, and Maintenance

B.6.1 Sampling Equipment

Sampling equipment will be inspected regularly prior to use for safety and operational reasons. Cable reels will also be inspected to ensure crew safety during sample collection. The full lists of all sampling equipment are described in the SOPs (Appendix D).

Table 12 outlines field and laboratory equipment maintenance activities, frequencies, criteria, and corrective actions.

Calibration and maintenance of field equipment/instruments will be performed according to the manufacturer's instructions (Appendix E) and sampling organizations' SOPs (Appendix D) and recorded in an instrument/equipment logbook.

The project-specific criteria for calibration (frequency, acceptance criteria, and corrective actions associated with exceeding the acceptance criteria) are provided in Table 12. Field Equipment Calibration, Maintenance, Testing, and Inspection.

The chemistry analytical laboratory maintains its equipment in accordance with its SOPs, which include those specified by the manufacturer and those specified by the method. Problems with the instrumentation during analysis will require repair, recalibration, and re-analysis of the sample. Table 12 outlines analytical equipment, maintenance frequencies, and the responsible person.

Table 12. Field Equipment Calibration, Maintenance, Testing, and Inspection

Analytical Parameter	Instrument	Calibration Activity	Maintenance & Testing/ Inspection Activity	Frequency	Acceptance Criteria	Corrective Action
Temperature (Sensor)	EXO2 MPS Multi Probe System: YSI Precision ™ Thermistor		According to Wagner *et al.* (2006) Manufacturer's manual Karuk QAPP[1] Yurok QAPP[2]	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	± 0.15°C of true value at both endpoints or as dictated in Wagner *et al.* (2006)	Remove from use and replace with backup sensor if doesn't pass calibration criteria
pH (electrode)	EXO2 MPS Multi Probe System: YSI Glass Combination electrode	Initial: Two-point calibration bracketing expected field sample range (using 7.0 and 10.0 pH buffer) Post: single-point check with 7.0 pH buffer	According to Wagner *et al.* (2006) and Manufacturer's manual Karuk QAPP Yurok QAPP	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	Initial: Two- point calibration done electronically Post: ±0.1 pH units of true value or as dictated in Wagner *et al.* (2006)	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria and replace with backup sensor.
Dissolved oxygen (sensor)	EXO2 MPS Multi Probe Optical Sensor	Initial: One-point calibration with saturated air (need temp, barometric pressure). Post: single-point check at full saturation	According to Wagner *et al.* (2006) and Manufacturer's manual Karuk QAPP Yurok QAPP	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	Initial: One-point calibration done electronically Post: ±0.5 mg/L of true saturated value or as dictated in Wagner *et al.* (2006)	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria and replace with backup sensor.
Turbidity (sensor)	EXO2 MPS Multi Probe System	Initial: 2 or 3-point calibration using 0, 124, 1010 FNU copolymer beads Post: same calibration as pre-deployment	According to Wagner *et al.* (2006) and Manufacturer's manual Karuk QAPP Yurok QAPP	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	Initial: One-point calibration done electronically Post: ±1 NTU of true value or as dictated in Wagner *et al.* (2006) and Rasmussen *et al.* (2009)	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria and replace with backup sensor.

Analytical Parameter	Instrument	Calibration Activity	Maintenance & Testing/ Inspection Activity	Frequency	Acceptance Criteria	Corrective Action
Conductivity (sensor)	EXO2 MPS Multi Probe System: YSI 4-electrode cell with auto ranging	Initial: One- point calibration at high end of expected field sample range (1000 mS/cm standard)	According to Wagner *et al.* (2006) and Manufacturer's manual Karuk QAPP Yurok QAPP	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	Initial: one-point calibration done electronically	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria and replace with backup sensor.
		Post: two-point check with high (1000 mS/cm) and low (0 mS/cm) standards			Post: high standard ±5% of true value and low standard ±10% of true value, or as dictated in Wagner *et al.* (2006)	

[1]Karuk Tribe Water Quality Program 2018; [2]Yurok Tribe Environmental Program 2017

Table 13. Testing, Inspection and Maintenance of Analytical Instruments

Equipment / Instrument	Responsible Person	Frequency	SOP Reference
Sartorius Analytical Balance LA230S	Lab Manager	Daily during periods of operation	Knott *et al.* (1992)
Sartorius Macro Balance AZ4101	Lab Manager	Daily during periods of operation	Knott *et al.* (1992)
Fisher Scientific Isotemp Premium Oven 700 Series 13247750F	Lab Manager	Weekly during periods of operation	Knott *et al.* (1992)
Filtration Equipment	Lab Manager	Weekly during periods of operation	Knott *et al.* (1992)

B.7 Instrument/Equipment Calibration and Frequency

For a description of equipment, tools, and instruments and the frequency of calibration see Appendices A and B for Karuk protocols, Table 12. Field Equipment Calibration, Maintenance, Testing, and Inspection and Table 13. Testing, Inspection and Maintenance of Analytical Instruments. Calibration of EXO2 sondes and documentation of the calibrations will follow procedures outlined in Wagner *et al.* (2006) and Rasmussen *et al.* (2009) for the USGS sites at Keno and JC Boyle. At Iron Gate, Seiad Valley and Orleans calibrations will follow the SOPs outlined in Karuk QAPP (Karuk Tribe Water Quality Program 2018) and at the Klamath site procedures will follow the Yurok QAPP (Yurok Tribe Environmental Program 2017). Any deficiencies in sampling will be documented in quarterly report and resolved by individual sampling entities.

B.8 Inspection/Acceptance for Supplies and Consumables

USGS hydrographers from the Klamath Falls field office will be responsible for the purchase of consumables necessary for the operation and maintenance of continuous water quality sondes at Keno and JC Boyle. Acceptance criteria are addressed by the internal USGS supply store prior to shipping to field offices. Tracking and storing of the materials is conducted by USGS hydrographers at the field office.

The field measurement supplies the Karuk and Yurok Tribe will use, such as calibration solutions, will be acquired from standard traceable sources, such as the instrument manufacturer or reputable suppliers. The Karuk Tribe will obtain calibration standards from Fondriest Environmental, Inc. The lot number and expiration date on standards and reagents will be checked prior to use. Expired solutions will be discarded and replaced. The source, lot number, and expiration dates of all standards and reagents will be recorded in the field log books.

B.9 Non-direct Measurements

For comparison purposes, previous field measurements and laboratory analytical results collected from the Project area may be reviewed through Annual Reports and online databases. These sources could

include, but are not limited to, the U.S. Geological Survey, the United States Forest Service, the Karuk Tribe, the Hoopa Tribe, and the Yurok Tribe.

Previously collected data that will be used for comparison purposes will have gone through the QAPP review process (Karuk QAPP 2019, Yurok QAPP 2017). However, for data that has not been EPA-SWB-approved, it will first be reviewed to verify that they are of sufficient quality to meet the needs of the project by examining:

- the sample collection and location information;
- the data to see whether they are consistent with data collected from other Tribal monitoring programs from the same general vicinity; and
- the QA/QC information associated with the data.

If the data are of insufficient or unknown quality, limitations will be placed on its use in supporting project decisions. In general, it is anticipated that decisions for the current project will be based on data collected by the Tribe following this current QA Project Plan.

B.10 Data Management

Management of data collected by USGS will follow established protocols, and will be stored in the NWIS database, which is publicly accessible. USGS databases retain all original raw data, and records processing and management follows guidelines detailed in Wagner *et al.* (2006) and Rasmussen *et al.* (2009).

The Karuk Tribe will ensure that all field collected audit and calibration data will be recorded on paper and digitally. All raw continuous monitoring data collected by the Karuk and Yurok Tribe will be stored on their individual servers or the Karuk server and made available to the Renewal Corporation. Filling of project related documents will follow the guidelines in the Karuk and Yurok Tribes QAPPs (Karuk 2018, Yurok 2017). Raw continuous time series data will be entered into Aquatic Informatics, Inc. Time Series software to be evaluated and corrected based upon procedures outlined in the Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and Data Reporting (Wagner *et al.*, 2006, and Rasmussen *et al.*, 2009) by the USGS. Both real time and corrected data will be made available on the Karuk Tribes Water Quality Web Portal and submitted to the project database.

C. Assessment and Oversight

During the course of the Project, it is important to assess the Projects' activities to ensure that the QAPP is being implemented as planned. This helps to ensure that everything is on track and serves to minimize learning about critical deviations toward the end of the project when it may be too late to remedy the situation. For the current project, the ongoing assessments will include:

- Field Oversight;
- Readiness review of the field team prior to starting field efforts;
- Field activity audits;

- Review of field sampling and measurement activities methodologies and documentation at the end of each event; and
- Laboratory Oversight - evaluation of laboratory data generated for each quarterly sampling event.

Monitoring team leaders for Karuk tribal staff, Yurok tribal staff, and USGS will be responsible for conducting assessments. These individuals have the authority to issue stop work orders if it is found that quality control measures are insufficient. These individuals will also be responsible for submitting these assessments to the Klamath River Renewal Corporation Water Quality Monitoring Program Manager. Monitoring team leasers will implement corrective actions, either as they see fit, or upon discussions with the Program Manager.

C.1 Reports to Management

Prior to, during, and for a minimum of one year following completion of drawdown, monthly monitoring reports will be issued to the following California agencies: SWRCB, ODEQ, DEQ, and the RWQCB until otherwise approved by the CA Deputy Director.

At least two annual progress reports will also be prepared and submitted to the ODEQ by April 1. The annual progress reports will describe equipment installation and site reinforcement with photos, mapping and site coordinates, all monitoring activities, links to USGS, Karuk and Yurok data results or an established repository with all the results, and recommended QAPP revisions and site modifications, as necessary. Note that a detailed report of data trends and analysis will not be included in this report.

D. Data Validation and Usability

Prior to utilizing data to make project decisions, the quality of the data needs to be reviewed and evaluated to determine whether the data satisfy the projects' objectives. This process involves technical evaluation of the off-site laboratory data, as well as, review of the data in conjunction with the information collected during the field sampling and field measurement activities. This latter, more qualitative review provides for a clearer understanding of the overall usability of the projects' data and potential limitations on their use. Section A.7: Quality Objectives and Criteria outline various criteria that will be used to evaluate project data.

D.1 Data Review, Verification, and Validation

Section A.7 discusses the quality objectives for the project and the performance criteria used for accepting, rejecting, or qualifying project data.

For continuous time-series measurements, the data quality criteria to be assessed quantitatively include precision and accuracy alone. These assessments will be different for water and sediment grab sample data. The associated acceptance criteria (types and frequencies of QC checks and acceptance limits) for the Project follow SWAMP guidelines and are summarized in Table .

D.2 Verification and Validation Methods

The setting of data review, verification, and validation requirements helps to ensure that project data are evaluated in an objective and consistent manner. For the current project, such requirements have been defined for information gathered and documented as part of field sampling and field measurement activities, as well as for data generated by the off-site laboratory.

Individual monitoring agencies will be responsible for validating various components of project information in accordance with their respective QAPPs (Karuk 2018, Yurok 2017).

D.3 Reconciliation with User Requirements

The Karuk and Yurok tribes will flag data that does not meet the acceptance criteria outlined in Section A.7.

Uncertainty for data collected by USGS is reported and quantified as part of the records processing that is required for all USGS data sets. Data limitations are reported by flagging of data and qualitative rating of water quality records. These flags and ratings are retained with the data when retrieved from the USGS database.

Once all the data from the field and laboratory have been evaluated, the QA Officers will make an overall assessment concerning the final usability of the data (and any limitations on its use) in meeting the projects' needs. The initial steps of this assessment will include, but are not necessarily limited to:

- Discussions with the Field Technicians,
- Review of deviations from the QAPP or associated SOPs to determine whether these deviations may have impacted data quality (and determining whether any impacts are widespread or single incidents, related to a few random samples or a batch of samples, and/or affecting a single or multiple analyses),
- Evaluation of the field and laboratory results and QC information,
- Review of any other external information which might influence the results, such as activities up stream, meteorological conditions, wildfires, and data from other sources,
- Evaluation of whether the completeness goals defined in this QA Project Plan have been met,
- Examination of any assumptions made when the study was planned, if those assumptions were met and, if not, how the project's conclusions are affected.

In addition, the Monitoring Management Team will assess the effectiveness of the monitoring program and data collection at the end of each calendar year. Sampling locations, frequency, list of analytical parameters, field measurement protocols, choice of the analytical laboratory, etc. will be modified as needed to reflect the changing needs and objectives of the KRRP. This QAPP will be revised and/or amended accordingly.

E. References

California State Water Resources Control Board. 2018. Draft Water Quality Certification – Klamath River Renewal Corporation's Lower Klamath Project Federal Energy Regulatory Commission Project No. 14803. June 18, 2018.

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APPENDIX A

Karuk Tribe QAPP 2019

Klamath River Renewal Corporation
Water Quality Monitoring Network for the Klamath River Renewal Project

Water Quality Sampling and Analysis

Quality Assurance Project Plan

April 2019

KLAMATH RIVER RENEWAL CORPORATION

USGS science for a changing world

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A. Project Management

A.1 Title and Version

PROJECT TITLE:	Water Quality Monitoring for the Klamath River Renewal Project – Water Year 2019
LEAD ORGANIZATION:	Klamath River Renewal Corporation 2001 Addison Street, Suite 300, Office 317 Berkeley, California 94704
PRIMARY CONTACT:	Seth Gentzler AECOM Program Manager 300 Lakeside Drive, Suite 220 Oakland, CA 94612 Office: (510) 874-3018 Mobile: (415) 722-5129 Seth.gentzler@aecom.com
EFFECTIVE DATE:	October 1, 2018 to Program End
VERSION:	00
PREFACE:	SWAMP-compliant QAPP for Klamath River water quality monitoring at 6 monitoring stations in preparation for the Klamath River Renewal Project. This document was produced using the SWAMP-EPA Review Checklist.
QAPP PREPARED BY:	Susan Fricke, Water Quality Manager Karuk Tribe Water Program Grant Johnson Karuk Tribe Water Program Chauncey Anderson, Water Quality Specialist US Geological Survey, Oregon Water Science Center Matthew Hanington, Water Division Manager Yurok Tribe Environmental Program Suzanne Wilkins, Senior Environmental Planner CDM Smith Inc. Stefan Schuster, Associate CDM Smith Inc.

A.2 Approvals

Seth Genzler, AECOM
Klamath River Renewal Corporation Water Quality Monitoring Program Manager

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Benjamin Swann, CDM Smith
Klamath River Renewal Corporation Water Quality Monitoring Program Coordinator

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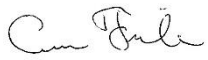
Susan Fricke, Karuk Tribe Water Program
Water Quality Monitoring Team Coordinator and Karuk Tribe Monitoring Team Leader



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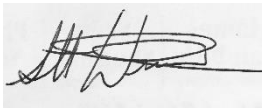
Chauncey Anderson, USGS
Monitoring Site & Sediment Monitoring Coordinator

_____

Matt Hanington, Yurok Tribe Environmental Program
Yurok Tribe Monitoring Team Leader

_____

Scott Wright, USGS
Program Quality Assurance/Quality Control Manager



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Stephen Low
USGS Sediment Lab Manager

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A.3 Table of Contents

A.3.1 QAPP Information Sections

A.3.2 List of Tables

A.3.3 List of Figures

A.3.4 Appendices and Standard Operating Procedures

List of Abbreviations and Acronyms

ASR	Analytical Service Request
ASTM	American Society of Testing Materials
CAWSC	California Water Science Center
COC	Chain of Custody
CWA	Clean Water Act
DO	Dissolved Oxygen
DWR	Department of Water Resources
EPA	Environmental Protection Agency
FNU	Formazin Nephelometric Units
FPS	Federal Priority Stream gages
HSP	Health and Safety Plan
ISCO	Automated Pump Samplers
JHA	Job Hazard Analysis
KRRC	Klamath River Renewal Cooperation
KRRP	Klamath River Renewal Project
NTU	Nephelometric Turbidity Units
NWIS	National Water Information System
ORWSC	Oregon Water Science Center
pH	Potential Hydrogen
QA	Quality Assurance
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	Quality Control
RPD	Relative Percent Difference
SOP	Standard Operating Procedure
SRM	Standard Reference Material
SSC	Suspended Sediment Concentration
SWAMP	Surface Water Ambient Monitoring Program
TM1D3	Techniques and Methods 1-D3
USGS	United States Geological Survey
USL	USGS Sediment Laboratory
YSI	Yellow Springs Instrument

A.4 Distribution List

The final QAPP will be kept on file by the Karuk Tribe Water Program, Yurok Tribe Environmental Program, and the United States Geological Survey (USGS). The following individuals will receive copies of the approved QAPP and any subsequent revisions. Field personnel will have a copy of the QAPP and Health and Safety Plan (HSP) during all field activities:

Table 1. Distribution List

Title	Contact Information
Seth Gentzler **AECOM** **Program Manager**	300 Lakeside Drive, Suite 220 Oakland, CA 94612 Office: (510) 874-3018 Mobile: (415) 722-5129 Seth.gentzler@aecom.com
Benjamin Swann **CDM Smith Inc.** **Program Coordinator**	1755 Creekside Oaks Drive, Ste. 200 Sacramento, CA 95833 Office: (916) 576-7479 Mobile: (916) 2012647 swannbm@cdmsmith.com
Suzanne Wilkins **CDM Smith** **WQ Monitoring Regulatory Compliance Lead**	12313 Soaring Way, Suite 2D Truckee, CA 96161 Office: (530) 582-2224 Mobile: (530) 545-2563 wilkinssm@cdmsmith.com
Stefan Schuster **CDM Smith** **WQ Monitoring Expert Resource**	12313 Soaring Way, Suite 2D Truckee, CA 96161 Office: (530) 582-2221 Mobile: (775) 690-0850 schustersl@cdmsmith.com
Chauncey Anderson **USGS** **KRRP Monitoring Site & Sediment Monitoring Coordinator**	2130 SW 5th Avenue Portland, OR 97201 Office: (503) 251-3206 chauncey@usgs.gov
Scott Wright **USGS – California** **Monitoring Team Leader & Program QA/QC Manager**	USGS California Water Science Center 6000 J Street, Placer Hall Sacramento 95819 Office: (916) 278-3024 Mobile: (916) 862-0163 sawright@usgs.gov
Liam Schenk **USGS – Oregon** **Monitoring Team Leader**	2795 Anderson Avenue, Suite 106 Klamath Falls, Oregon 97603 Office: (541) 273-8689 x208 lschenk@usgs.gov

Title	Contact Information
Alex Etheridge **USGS** **QA/QC and Program Data Manager**	6000 J Street, Placer Hall Sacramento, CA 95819 Office: (916) 995-0784 aetherid@usgs.gov
Dennis O'Halloran **USGS** **QA/QC**	6000 J Street, Placer Hall Sacramento, CA 95819 Office: (916) 278-3168 Mobile: (530) 412-0578 dohall@usgs.gov
Susan Fricke **Karuk Tribe Water Program** **WQ Monitoring Team Coordinator & Monitoring Team Lead**	P.O. Box 282 Orleans, CA 95556 Office: (530) 598-3414 sfricke@karuk.us
Grant Johnson **Karuk Tribe Water Program** **QA/QC**	P.O. Box 282 Orleans, CA 95556 Office: (530) 469-3258 gjohnson@karuk.us
Matt Hanington **Yurok Tribe Environmental Program** **Monitoring Team Leader & QA/QC**	15900 Hwy 101 N P.O. Box 1027 Klamath, CA 95548 Office: (707) 482-1822 ext. 1002 Mobile: (707) 954-7519 mhanington@yuroktribe.nsn.us
Stephen Low **USGS Sediment Lab** **Lab Manager**	2885 Mission Street Santa Cruz, CA 95060 Office: (831) 460-7500 stephlow@usgs.gov

A.5 Project Organization and Schedule

A.5.1 Involved Parties and Roles

The Water Quality Monitoring Program for the Klamath River Renewal Project is being implemented by a multi-agency working group in accordance the Final Oregon Clean Water Act (CWA) Section 401 Water Quality Certification and in preparation for the Final California 401 Water Certification anticipated to be released in 2019. The goal of the program is to gather the necessary scientific information to evaluate the water quality and suspended-sediment transport impacts of implementing the Klamath River Renewal Project (Project) and to comply with federal and state regulatory requirements for water quality monitoring. The Project will remove four dams, including Iron Gate Dam, Copco 1, Copco 2 and J.C. Boyle Dam which impound water on the Klamath River within California and Oregon.

As collaborators and partners with the Klamath River Renewal Corporation (KRRC), the Project Water Quality Monitoring Team comprised of the Karuk Tribe, Yurok Tribe and USGS, will conduct the data

collection activities, perform field and laboratory analysis of samples and data, help to manage the program and contracts, and assist with the development of all reporting documents. The USGS Sediment Laboratory (USL) located in Santa Cruz, CA will perform suspended sediment concentration (SSC) analyses of the water samples. AECOM is the prime consultant to KRRC for the Project and is managing the Water Quality Monitoring Program. CDM Smith Inc., as a subconsultant to AECOM, is providing regulatory compliance oversight and will be managing the monitoring program and reviewing all documents and plans related to the requirements within the California and Oregon 401 Water Quality Certifications for the Project. The Karuk Tribe, Yurok Tribe and the USGS are sharing the monitoring responsibilities of the Water Quality Monitoring Plan based on monitoring site location and the type of monitoring to be conducted as follows:

Table 2. Parties and Monitoring Activities Roles

Monitoring Site	Karuk Tribe	Yurok Tribe	USGS
Keno			Water Quality (including Turbidity)
J.C. Boyle			Water Quality (including Turbidity)
Iron Gate	Water Quality		Turbidity
Seiad Valley	Water Quality, Turbidity & SSC		Turbidity & SSC
Orleans	Water Quality, Turbidity & SSC		Turbidity & SSC
Klamath		Water Quality, Turbidity & SSC	Turbidity & SSC

SSC = Suspended Sediment Concentration

The project team for planning and conducting the study is outlined in (Table 3. Personnel Responsibilities, Figure 1. Organization Chart).

A.5.2 Quality Assurance/Quality Control Manager

The Quality Assurance/Quality Control (QA/QC) Manager role is to establish the quality QA/QC procedures found in this QAPP as part of the sampling, field analysis, and laboratory analysis procedures. The QA/QC Manager will also work with the Laboratory Manager from USL by communicating all quality assurance and quality control issues contained in this QAPP. The QA/QC Manager will also review and assess all procedures during the life of this project against QAPP requirements. The QA/QC Manager will report all findings to the Water Quality Team Coordinator, including all requests for corrective action. The QA/QC Manager may stop all actions, including those conducted by subcontractors if there are significant deviations from required practices or if there is evidence of a systematic failure, (Table 3. Personnel Responsibilities).

A.5.3 Persons Responsible for QAPP Update and Maintenance

The Project will span multiple years and changes and updates to this QAPP shall be made during the different phases of the project to align with schedule and water quality monitoring requirements described within the California and Oregon 401 Water Quality Certifications. The Water Quality Monitoring Team Coordinator will be responsible for making the changes, submitting drafts for review by CDM Smith, preparing a final copy, and submitting the final for signature. The QAPP will be updated as needed for each new monitoring period.

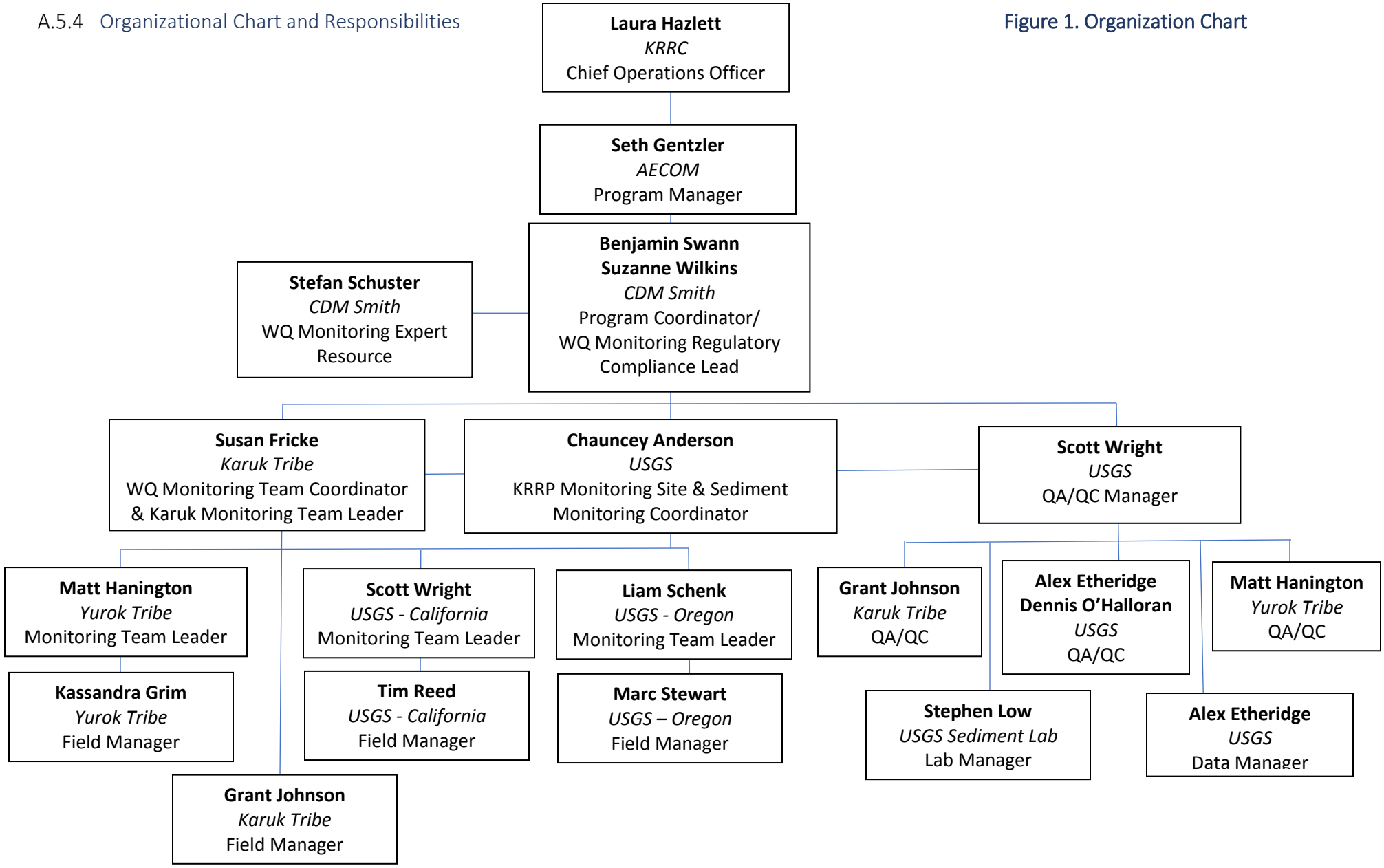
Table 3. Personnel Responsibilities

Program Team Member	Contact information (Telephone number, email)	Responsibility
Program Management/Administration		
Laura Hazlett KRRC	(510) 679-6928 lhazlett@klamathrenewal.org	Chief Operations Officer
Seth Genzler AECOM	(510) 874-3018 seth.gentzler@aecom.com	Program Manager
Benjamin Swann CDM Smith	(916-576-7479) swannbm@cdmsmith.com	Program Coordinator
Suzanne Wilkins CDM Smith	(530) 582-2224 wilkinssm@cdmsmith.com	WQ Monitoring Regulatory Compliance Lead
Stefan Schuster CDM Smith	(530) 582-2221 schustersl@cdmsmith.com	WQ Monitoring Expert Resource
Water Quality Monitoring Team		
Susan Fricke, Karuk Tribe Water Program	(530) 598-3414 sfricke@karuk.us	WQ Monitoring Team Coordinator & Karuk Tribe Monitoring Team Leader
Chauncey Anderson, USGS	(503) 251-3206 chauncey@usgs.gov	KRRP Monitoring Site & Sediment Monitoring Coordinator
Scott Wright USGS - California	(916) 862-0163 sawright@usgs.gov	USGS California Monitoring Team Leader
Liam Schenk, USGS - Oregon	(541) 273-8689 ext. 208 lschenk@usgs.gov	USGS Oregon Monitoring Team Leader
Matt Hanington, Yurok Tribe Environmental Program	(707) 482-1822 ext. 1002 mhanington@yuroktribe.nsn.us	Yurok Tribe Monitoring Team Leader
Grant Johnson Karuk Tribe Water Program	(530) 469-3258 gjohnson@karuk.us	Karuk Tribe Field Manager

Program Team Member	Contact information (Telephone number, email)	Responsibility
Program Management/Administration		
Tim Reed USGS California	(530) 246-5282 treed@usgs.gov	USGS California Field Manager
Marc Stewart USGS Oregon	(541) 776-4258 mastewar@usgs.gov	USGS Oregon Field Manager
Kassandra Grim Yurok Tribe Environmental Program	(707) 482-1822 ext. 1003 kgrimm@yuroktribe.nsn.us	Yurok Tribe Field Manager
Quality Assurance/Quality Control		
Scott Wright USGS	(916) 862-0163 sawright@usgs.gov	QA/QC Manager
Grant Johnson, Karuk Tribe Water Program	(530) 469-3258 gjohnson@karuk.us	Karuk Tribe QA/QC
Alex Etheridge, USGS	(916) 995-0784 aetherid@usgs.gov	USGS QA/QC – Sondes
Denis O'Halloran, USGS	(916) 278-3168 dohall@usgs.gov	USGS QA/QC - Sediment
Matt Hanington, Yurok Tribe Environmental Program	(707) 482-1822 ext. 1002 mhanington@yuroktribe.nsn.us	Yurok Tribe QA/QC
Laboratory Manager		
Stephen Low, USGS Sediment Laboratory	(831) 460-7500 stephlow@usgs.gov	Oversee USL analysis of SCC samples
Data Manager		
Alex Etheridge USGS	(916) 995-0784 aetherid@usgs.gov	Monitoring Data Management and Validation

A.5.4 Organizational Chart and Responsibilities

Figure 1. Organization Chart



A.6 Project Background

Four of the dams in the Klamath River are to be decommissioned beginning in January of 2021, there is a need to evaluate water quality and suspended-sediment transport and water quality before, during and after project implementation. The goal of the program is to gather the necessary scientific information to evaluate the water quality and suspended-sediment transport impacts of implementing the Klamath River Renewal Project (Project) and to comply with federal and state regulatory requirements for water quality monitoring. The Project will remove four dams, including Iron Gate Dam, Copco 1, Copco 2 and J.C. Boyle Dam which impound water on the Klamath River within California and Oregon. The KRRC Technical Team is tasked with establishing and implementing a coordinated monitoring program to accomplish this goal. Information regarding details of dam decommissioning project can be found in The Definite Plan for the Lower Klamath Project (Definite Plan) (KRRC 2018). The Water Quality Monitoring Plan is included in Appendix M of the Definite Plan.

In response to the need for data regarding suspended-sediment transport and water quality, the Monitoring Team will collect data to establish pre-, during and post-dam decommissioning suspended-sediment load and water quality conditions as outlined in Section A.7.1: Work Statement and Produced Products within this QAPP.

As the decommissioning project will result in a discharge to navigable waters of the state of Oregon and California it is subject to Section 401 of the Clean Water Act (CWA) and will be held to conditions set forth in ensuing water quality certifications from both states. For a full description of regulatory criteria and processes ongoing see Section 1.3 of the Definite Plan (KRRC 2018). The scope of the KRRC Technical Team's work will be to evaluate suspended-sediment transport and changes in water quality in accordance with the requirements specified in both the California and Oregon Section 401 Water Quality Certifications (401 WQ Cert). This QAPP reflects conditions stated within the draft California 401 WQ Certification (California State Water Resources Control Board 2018) will be revised once the final California 401 WQ Certification is released and will reflect the final conditions within the certification. The final Oregon 401 WQ Certification has already been released and this QAPP reflects the conditions within the final Oregon 401 WQ Certification (Oregon Department of Environmental Quality 2018).

A.7 Project/Task Description

A.7.1 Work Statement and Produced Products

Six existing USGS stream gage sites along the mainstem of the Klamath River within California and Oregon are being utilized to conduct water quality and suspended-sediment monitoring. Prior to monitoring activities during Water Year 2019, the six existing monitoring sites have been modified, or hardened, during the summer and fall of 2018 to enable water quality data collection during winter and spring high flow periods. Multi-parameter water quality monitoring sondes are operating at all six sites to develop time-series records of water quality data, and water quality sampling for suspended-sediment is being conducted at three of the sites in California (Klamath River near Seiad Valley, Klamath River above Orleans, Klamath River near Klamath). For site descriptions, see Section A.7.4: Geographic Setting. Monitoring activities for all six sites are anticipated to continue during subsequent years, with potential additional sites and analytical constituents.

A.7.2 Constituents to be Monitored and Measurement Techniques

Parameters to be monitored and analyzed with sondes include turbidity, dissolved oxygen (DO), temperature, conductivity, pH, and chlorophyll (summer months in CA only). SSC samples will be collected isokinetically and with automated samplers and delivered to the lab for analysis.

Suspended-sediment transport at individual stream gages will be calculated using techniques described in Rasmussen and others (2009). In summary, continuous (sub-hourly) turbidity data will be used to develop turbidity-SSC regression models to compute continuous SSC at sites where SSC sampling occurs. Those continuous SSC data will then be paired with concurrent streamflow data recorded at the USGS stream gages to calculate continuous suspended-sediment loads (SSL). The SSL data will then be aggregated over desired time frames to produce a total suspended-sediment load for the entire water year, reported in units of tons, kilograms (KG), or metric tons. Computing SSL prior to dam removal provides background data on pre-dam removal sediment transport conditions. Continuing the SSL computations over the course of the drawdowns, dam removals, and post-dam removal time periods will allow for the computation of a sediment budget for the entire Klamath River that will apportion a mass of sediment to the dam removals. The overall sediment budget will help determine how much sediment is transported from behind the dams.

A.7.3 Project Schedule

Table 4 below is the WY 2019 monitoring program schedule for deliverables and activity completions.

Table 4. Project Schedule.

Task/Deliverables	Anticipated date of Completion
Task 1 – Project Administration	
Quarterly Progress Reports	1/15/2019 4/15/2019 7/15/2019 9/15/2019
Draft and Final Meeting Agendas	15 days after meeting
Task 2: Prepare QAPP	
Draft QAPP for Review	12/1/2018
Final QAPP	4/1/2019
Task 3: Install Monitoring Stations	
Equipment list	12/1/2018
Equipment operating instructions	12/1/2018
Equipment Installed and Monitoring Equipment Operational (except for cable way in 2019)	12/1/2018
As-build schematic of all field installations	3/30/2019

Task/Deliverables	Anticipated date of Completion
Task 4: Perform Field Data Collection Activities	
Continuous Time-Series Data Collection	11/1/2018 thru 4/30/2019
Storm Event Sampling	10/1/2018 thru 9/30/2019
Continuous provisional USGS data published in real-time	Ongoing through contract
Final approved USGS records from WY2019	4/1/2020
Task 5: Data Management and Analysis	
Continuous provisional Karuk and Yurok data published in real-time	Ongoing through contract
Final approved USGS records from WY2019	4/1/2020
Laboratory Analysis	2-3 months after sample collection
Task 6: Annual Progress Reporting	
Draft Annual Progress Report	08/01/2019
Final Annual Progress Report	09/30/2019

A.7.4 Geographic Setting

The Klamath River flows 257 miles through Oregon and California to the Pacific Ocean, and is the second largest river in California. It originates in the high desert of south-central Oregon and moves through the Klamath Mountains. Table 5 below provides the six monitoring station locations and descriptions. The six monitoring sites shown below are associated with existing USGS gaging stations. Figure 2. Map of Selected Sites shows the overall geographic location of selected sites. Monitoring site access maps, parking and monitoring equipment locations are included in Appendix A

Table 5. Monitoring Station Location Descriptions

Site Name (USGS Gage No.)	Coordinates*	Operator(s)	Water Data Collected
Klamath River Below Keno (#11509500)	Latitude 42°08'00", Longitude 121°57'40" NAD27	USGS in cooperation with PacificCorp	• Water Temperature • Specific Conductivity • Dissolved Oxygen • pH • Turbidity • Sediment Samples starting WY 2020
Klamath River Below JC Boyle Powerplant (#11510700)	Latitude 42°05'05", Longitude 122°04'20" NAD27	USGS in cooperation with PacificCorp	• Water Temperature • Specific Conductivity • Dissolved Oxygen • pH • Turbidity

Site Name (USGS Gage No.)	Coordinates*	Operator(s)	Water Data Collected
			• Sediment Samples starting WY 2020
Klamath River Below Iron Gate Dam (#11516530)	Latitude 41°55'41", Longitude 122°26'35" NAD27	USGS in cooperation with Karuk Tribe	• Water Temperature • Specific Conductivity • Dissolved Oxygen • pH • Turbidity • Sediment Samples starting WY 2020
Klamath River NR Seiad Valley, CA (#11520500)	Latitude 41°51'14", Longitude 123°13'52" NAD27	USGS in cooperation with Karuk Tribe and USGS – Federal Priority Stream gages (FPS)	• Water Temperature • Specific Conductivity • Dissolved Oxygen • pH • Turbidity • Sediment Samples starting WY 2019
Klamath River Above Orleans (#11523000)	Latitude 41°18'13", Longitude 123°32'00" NAD27	USGS in cooperation with California Department of Water Resources (DWR), Karuk Tribe, and USGS – Cooperative Matching Funds	• Water Temperature • Specific Conductivity • Dissolved Oxygen • pH • Turbidity • Sediment Samples starting WY 2019
Klamath River NR Klamath, CA (#11530500)	Latitude 41°30'40", Longitude 123°58'42" NAD27	USGS in cooperation with Yurok Tribe and USGS – FPS	• Water Temperature • Specific Conductivity • Dissolved Oxygen • pH • Turbidity • Sediment Samples starting WY 2019

*Coordinates taken from USGS National Water Information System (NWIS) website

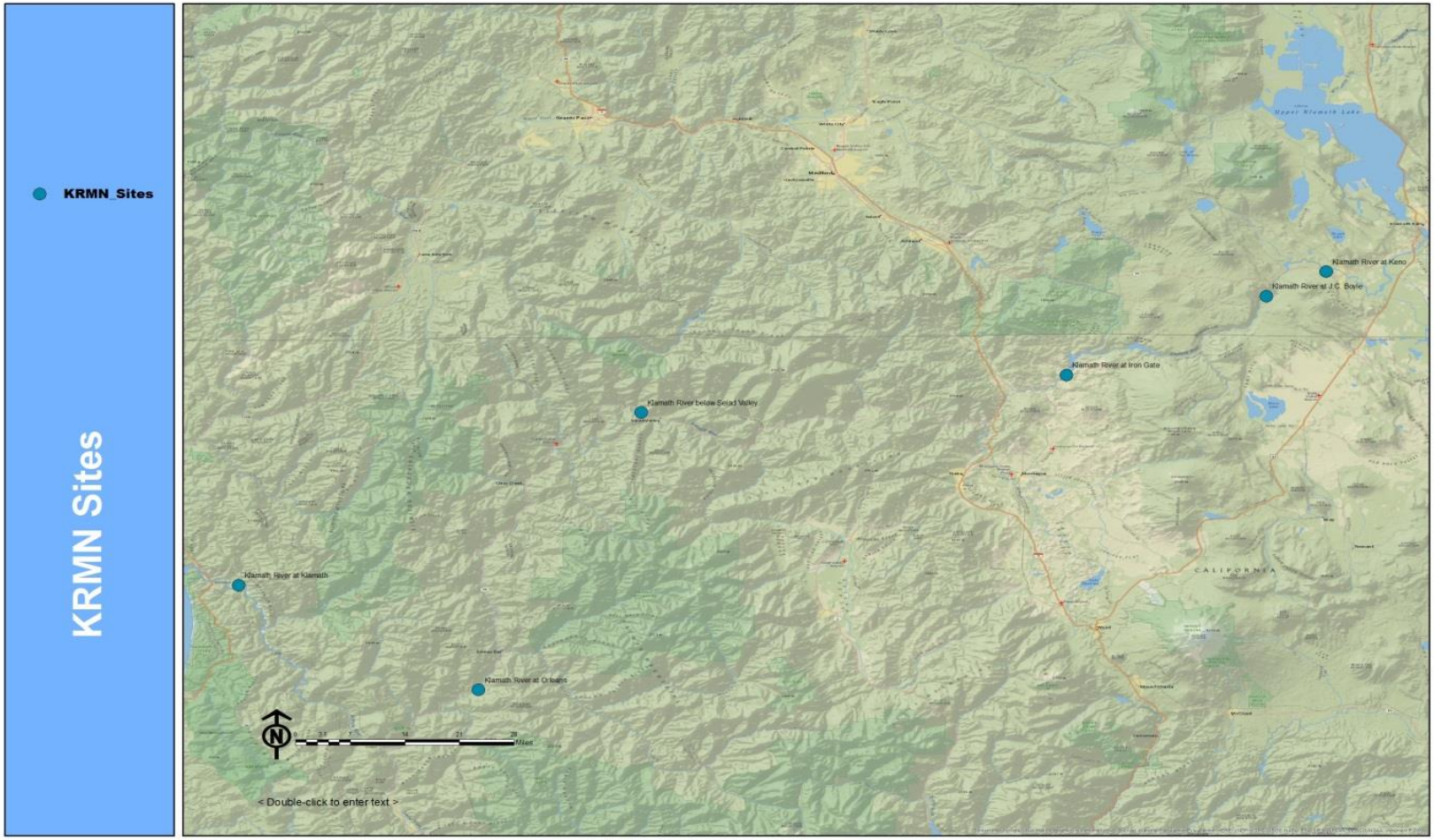


Figure 2. Map of Selected Sites

A.7.5 Constraints

Every effort will be made to collect storm event samples for SSC. Personnel availability may create challenges in collecting samples if multiple sites require sampling at the same time. However, automated pump samplers (ISCO) are deployed to collect samples when the sites cannot be visited. High flow events will be captured to the best of the project teams' ability. Weather conditions will dictate sampling events, and the safety of the crews collecting the samples will be the top priority. If weather conditions create unsafe working environment for sampling crews, the samples will be collected by the automated samplers described above.

A.8 Quality Objectives and Criteria

This section discusses the quality objectives for the project and the performance criteria to achieve those objectives.

For continuous time-series measurements, the data quality criteria to be assessed quantitatively include precision and accuracy alone. These assessments will be different for suspended-sediment samples data. The associated acceptance criteria (types & frequencies of QC checks and acceptance limits) for the project are summarized in Table 6. Measurement Quality Objectives.

A.8.1 Precision

Precision is a measure of agreement among replicate measurements of the same property, under prescribed similar conditions.

Precision will be assessed quantitatively with duplicate samples and expressed as relative percent difference (RPD) by the following equation:

$$RPD(\%) = \frac{\frac{|x1 - x2|}{(x1 + x2)}}{2} X\ 100$$

where,

RPD (%) = relative percent difference

x1 = Original sample concentration

x2 = Duplicate sample concentration

|x1 - x2| = Absolute value of x1 - x2

To assess precision associated with all steps of the project (from sample collection through analysis) field duplicates will be collected and analyzed for SSC samples. Composite (cross-section) samples for SSC will always be collected in duplicate and are referred to as A and B sets in USGS terminology. An A set represents one cross-section sample, and a B set is collected directly after representing a duplicate cross-section sample. To assess laboratory precision alone, the USGS QA Plan for the Analysis of Fluvial Sediment by the USGS California Water Science Center (CAWSC) will be followed (Appendix B)

A.8.2 Accuracy

Accuracy is the degree of agreement of a measurement with the true value. Accuracy includes a combination of random error (precision) and systematic error (bias) that result from sampling and analytical operations. Accuracy of water quality measurements contained in this QAPP are a function of the equipment used during sampling, and of the sampling methods.

For automatic (pump) samples for SSC, single bottle samples collected in conjunction with cross-section samples will be collected at a frequency of 5% (1 duplicate/20 field samples). Collecting a pump sample in conjunction with a cross-section sample allows for accuracy testing of the pump samples, by determining if the pump samples are representative of the cross section as a whole. If the pump samples and cross section samples differ in concentrations, then a box coefficient is applied to the pump samples. The box coefficient is simply a multiplier that is applied to the pump sample to adjust the concentration of that sample to the concentration of the cross-section sample that was collected in conjunction with the pump sample. Applying box coefficients to pump samples is a common practice by USGS, and more documentation can be found in Edwards and Glysson (1999).

Precision of field results will be tested using duplicate samples, with a target of less than 20% RPD, as described previously.

A.8.3 Completeness

Completeness on this project with regards to expected number of collected SSC samples is expected to be approximately 90%. Completeness with regards to continuous water quality data is expected to be as close to a complete record as possible (a complete record is retaining all unit values over a water year), recognizing that data loss can occur for several reasons. These reasons include loss of data during field visits and on-site calibrations, potential issues with data transmission, and other unforeseen circumstances that could result in loss of data.

A.8.4 Representativeness

This is the expression of the degree to which data accurately and precisely represent a characteristic of an environmental condition or a population. Field crews collecting samples will maximize representativeness of samples by selecting sites and employing methodologies to best characterize environmental conditions.

A.8.5 Bias

Bias describes the tendency for under or over prediction of sampled or measured values relative to the true value. Bias is typically assessed using matrix spikes and reference materials. Samples of known sediment concentrations are routinely tested as described in the QA Plan for the Analysis of Fluvial Sediment by the USGS California Water Science Center Sediment Laboratory (Appendix B), and as described in the USGS Office of Surface Water technical memo 98.08, 1998 (https://water.usgs.gov/admin/memo/SW/sw98.05.html). Bias is also assessed in the lab through negative controls (Blanks). Detectable quantities in the blank would indicate positive bias. The CAWSC Santa Cruz Sediment Lab bi-annually participates in the Sediment Lab QA Plan described in (Appendix B).

Table 6. Measurement Quality Objectives

Group	Parameter	Accuracy	Precision	Recovery	Completeness
Conventional Constituents in Fresh Waters	• SSC	Standard Reference Materials (SRM, CRM) within 95% CI stated by provider of material. If not available then with 80% to 120% of true value	Laboratory duplicate, Blind Field duplicate, or MS/MSD 25% RPD Laboratory duplicate minimum.	N/A	Approx. 90%
Continuous Water Quality Data	• dissolved oxygen (DO) • pH • water temperature • specific conductance • turbidity • chlorophyll (CA summer months only)	As described in Wagner and others (2006), Rasmussen and others (2009), and this QAPP	As described in Wagner and others (2006), Rasmussen and others (2009), and this QAPP	N/A	As close to a complete record as possible

A.9 Special Training Needs/Certification

A.9.1 Specialized Training or Certifications

There are no certifications that apply to this work.

A.9.2 Training and Certification Documentation

All relevant training and certification documentation will be stored by respective organization in accordance with their standard operating procedure.

A.9.3 Training Personnel

In July 2018, USGS conducted training for the Karuk and Yurok tribal staff on collection of samples for SSC. Additional SSC sampling training is offered annually through USGS in Castle Rock, WA, which could be attended by new staff within USGS or the Tribes. For operation of continuous monitoring sondes, the USGS California Water Science Center (CAWSC) is planning to offer a water quality data collection training class, which includes turbidity as well as the other water quality parameters, to the relevant Tribal and USGS staff. In November 2018, the Yurok Tribe hosted training on YSI datasonde operation, which was available to all project participants.

The Field Manager for each crew will have the responsibility of overseeing Health and Safety Plan (HSP) compliance by all field staff. Each individual is responsible for their own safety and for following all required HSP policies and procedures. All sampling will be carried out in accordance with USGS job hazard analysis (JHA) documents which will be combined into a packet to serve as a Health and Safety Plan (HSP) for this project and a copy of the HSP will be kept at each monitoring site.

A.10 Documents and Records

All USGS data will be maintained and served publicly through the National Water Information System (NWIS) database. Provisional continuous time series data will be published in real-time on the USGS NWIS website, with final approved records from WY19 available by April 1, 2020. Laboratory results will be provided by the USGS via the NWIS web database. Laboratory results may also be provided electronically for inclusion in a separate project database.

Continuous water quality data collected by the Karuk and Yurok Tribe will be available on the Karuk website and be submitted electronically for inclusion in the project database. The Karuk and Yurok continuous data and associated field data will be stored on their individual servers indefinitely in addition to the project database. Any SSC samples collected by the Karuk and Yurok tribes will be sent to nearest USGS field office under a Chain of Custody (COC) (Appendix C) where a Sediment Laboratory Analysis Request (SLAR) electronic form can be filled out by USGS staff and then sent to USGS Santa Cruz sediment lab, so those records will be available through the USGS NWIS database.

All monitoring entities will provide a summary of data collected each month in quarterly reports to be submitted to CDM Smith for review and then to the KRRC technical team.

Field records will include a written (Appendix C) or electronic record (Aquarius Software) of site visits documenting field observations, site conditions, calibration and maintenance conducted. A field visit summary will be provided in the quarterly reports. Field crews will also collect dated photo documentation of site conditions from each visit showing the condition of equipment and gage and unusual site and river conditions. Additionally, field staff will fill out a Field Inspection Sheet for SSC sampling (Appendix C) including all monitoring sites where SSC samples are collected with information including date, time, number of samples collected, and notes on site conditions.

The Karuk Tribe, Yurok Tribe and USGS will prepare and submit an annual monitoring season summary that covers work completed including: upgrades and development of monitoring locations, samples collected, all other monitoring conducted, photos, and recommendations for program modifications. The annual season summaries will be compiled in an Annual Progress Report that will include site descriptions with photos, mapping, and coordinates, summarize monitoring activities, and provide links to data and results. The report will also present recommendations for program modifications needed to prepare for the required monitoring activities during WY2020 and up to drawdown..

Each sampling entity's QA/QC staff will be tasked with ensuring that all relevant personnel have the most recent version of this QAPP.

Table 7. Document and Record Retention, Archival, and Disposition Information

	Identify Type Needed	Retention	Archival	Disposition
Station Log	Station Description files (record of site visits and conditions – road logs, ownership, equipment, etc.)	Onsite and copy retained in CAWSC and ORWSC (Oregon Water Science Center) Data Program Offices	Archived according to USGS policy SM 502.9 and/or in accordance with this QAPP	Indefinite
Field Visit and Sample Collection Records	Field notes for (1) monitor calibration, (2) SSC Sample collection (3) Autosampler sample collection	Retained in CAWSC and ORWSC Data Program Offices, and Karuk and Yurok Tribal offices.	Archived according to USGS policy and/or in accordance with this QAPP	Indefinite
Analytical Records	Laboratory analyses for SSC and particle sizes	Stored at USL, Santa Cruz, CA	Archived according to USGS policy and in accordance with this QAPP	Indefinite
Data Records	Time Series Data	Retained in CAWSC and ORWSC Data Program Offices, and Karuk and Yurok Tribal offices and project database.	Archived according to USGS policy and in accordance with this QAPP	Indefinite
Assessment Records	Surrogate Model Archives, WQ Station Analyses	Retained in CAWSC and ORWSC Data Program Offices	Archived according to USGS policy	Indefinite

B. Data Acquisition

B.1 Sampling Process Design-Study Design

A total of three sites will be sampled for SSC for this project during WY2019, as summarized in Table 8. Number and Frequency of Suspended-Sediment Samples. Site selection criteria included the use of existing USGS gaging stations, located to enable measurement of changing water quality conditions below project actions. This monitoring project will monitor approximately 240 river miles for continuous water quality data starting at the Klamath River below Keno, and 135 miles for SSC sampling starting at the Klamath River near Seiad in WY 2019. SSC sampling will be conducted at the frequencies shown in Table 8.

B.1.1 Suspended-Sediment Sampling

SSC sampling will occur at each site between November 1, 2018 to September 30, 2019. Sites were selected based on locations of existing USGS gaging stations and to provide a longitudinal profile of SSC and sediment transport from upstream to downstream. Three of the sites (Seiad, Orleans, and Klamath) will each be sampled during four storm events between October 1, 2018 and September 30, 2019. Samples collected will also include 10-12 cross-section composite samples (depth- and width-integrated samples collected from a cableway, bridge, or boat) and 20-30 automated samples (pump samples from an automated sampler. The method chosen to collect individual samples will be determined dependent on weather and hydrologic conditions, and availability of personnel. For events when personnel are not available to collect cross-section composite samples, an automated sampler will be used. Automated (pump) samples will be adjusted to the cross-section samples as described in section A.8.2: Accuracy.

B.1.2 Continuous Monitoring Methods

The KRRC Technical Team will conduct continuous in-situ monitoring as described below. Sites were selected based on locations of existing USGS gaging stations and to provide a longitudinal profile of water quality changes from upstream to downstream. For continuous monitoring, a reading will be taken every 15 minutes by a YSI multi-parameter water quality instrument (sonde). Each reading will include the following parameters: temperature, conductivity (as specific conductance), pH, dissolved oxygen (% saturation and mg/L), turbidity, and chlorophyll. All continuous monitoring will be conducted uniformly and in accordance with the USGS protocols, EPA-approved Karuk and Yurok protocols, and training so data can be validated and analyzed comprehensively (Wagner and others, 2006, Rasumssen and others, 2009, forthcoming USGS techniques and methods on operating fluorescence [e.g. total algae] sensors).

Table 8. Number and Frequency of Suspended-Sediment Samples

Sample Location	Latitude	Longitude	USGS Gage #	Baseline Sampling Nov 2018-Sept 2019	Maximum Number of Storm Sampling Events	Number of Samples per Storm Event	Maximum Number of SSC Samples
Klamath River at Keno	42.133199	-121.962231	11509500	*			
Klamath River at J.C. Boyle	42.084588	-122.073345	11510700	*			
Klamath River at Iron Gate	41.927919	-122.444188	11516530	*			

Sample Location	Latitude	Longitude	USGS Gage #	Baseline Sampling Nov 2018-Sept 2019	Maximum Number of Storm Sampling Events	Number of Samples per Storm Event	Maximum Number of SSC Samples
Klamath River below Seiad Valley	41.853738	-123.232273	11520500	1/month	4	10-12	30
Klamath River at Orleans	41.303460	-123.534504	11523000	1/month	4	10-12	30
Klamath River at Klamath	41.510954	-123.979516	11530500	1/month	4	10-12	30

* These sites will not have sediment sampling in WY19

B.2 Sampling Procedures and Requirements

Suspended-sediment sampling will consist of isokinetic (depth- and width-integrated) sampling, and automated sampling. Appropriately cleaned and weighed sample containers for isokinetic sampling will be obtained from the analyzing laboratory or USGS. Sample bottles and other field equipment will be protected from contaminants.

In the event a sample cannot be collected the project leads will be notified to decide if a backup or alternate option exists.

B.2.1 Suspended-Sediment Sampling

Composite sampling (depth- and width-integrated sampling) requires the manual collection of isokinetic samples by direct bottle filling using USGS techniques described in Edwards and Glysson (1999) and Gray and others (2008). SSC samples may be collected by cableway, from a bridge, or from a boat, depending on the site and streamflow conditions. The complete Suspended Sediment Sampling SOP appears in Appendix D. Suspended sediment. SSC sampling will occur monthly at the three sampling sites as either composite or automated samples from November 1, 2018 to September 30, 2019 as described in the Table 8. Number and Frequency of Suspended-Sediment Samples.

Table 9. Samples Handling

Analyte	Bottle Type/Size	No. Bottles per Sample	Preservative	Minimum Holding Time
Depth-width integrated Suspended-sediment concentration (SSC)	Plastic, either 1-L or 3-L bottles or glass 1-pint bottles	10 each (5 per set)	None	30 days
Autosampler Pumped Suspended-sediment concentration (SSC)	Plastic 1-L bottles	1	None	30 days

B.2.2 Automated Samplers

Automated pump samplers are included to allow for high-frequency sampling and to capture events that might be missed when personnel are not available. Teledyne ISCO 6712 portable samplers or similar automated samplers will be set to trigger at either a specified time or a specified turbidity threshold that will be determined once the project team has evaluated recent turbidity data from the Yurok and Karuk Tribes at the three sampling sites. Once the turbidity threshold is reached, the automated samplers will collect SSC samples at a specified interval based on the site and hydrologic conditions. There will be 20-30 automated samples collected per site from October 1, 2018 thru Sept 30th, 2019.

B.2.3 Continuous Monitoring Methods

Continuous water quality monitoring will be conducted with YSI EXO2 data sondes. Data collection by USGS at the Keno and JC Boyle sites will follow protocols detailed in Wagner and others (2006), and Rasmussen and others (2009). The USGS, Karuk and Yurok Tribe will perform all data collection and equipment maintenance as outlined by manufacturer specifications, this QAPP and in accordance with their respective EPA approved QAPPs, and SOPs (Appendices E, F, and G). The sondes will be housed within a protective PVC perforated pipe, which will secure the sondes in the water column to avoid damage to equipment. Communication cables will be attached to the submerged sondes and routed to the gage house where they will be connected to a datalogger. The datalogger will send USGS data to the database through a GOES satellite window. The Karuk and Yurok Tribes sondes are connected to FTS Axiom data loggers with an SDI-12 cable. Once data is recorded by sonde it is sent to data logger. Both the data logger and sonde retain data. The data logger will transmit data via the GOES satellite network and will be available on EDDN servers. In addition, Karuk and Yurok data will be made available on the Karuk water quality web portal in real time. Sondes will record data at a 15-minute interval.

Procedures The procedures for calibrating sondes are in the protocols, SOPs (Appendices E, F, and G) and the Karuk Tribe and Yurok Tribe QAPPs, summarized in Section B.7: Instrument/Equipment Calibration and Frequency. They are also described in Wagner and others (2006) and Rasmussen and others (2009) for the USGS sites at Keno and JC Boyle.

Field Variances As conditions in the field vary; it may become necessary to implement minor modifications to the sampling procedures and protocols described in this QAPP. Modifications will be documented in the Quarterly Progress Reports.

B.2.4 High Range Turbidity Sensor

USGS will deploy and operate high-range continuous turbidity sensors at the JC Boyle, Iron Gate, Seiad, Orleans, and Klamath sites. The sensors will be ANALITE NEP-5000 180-degree backscatter sensors, and will be calibrated and operated by the published protocols referenced in Section B.2.3: Continuous Monitoring Methods.

B.3 Sample Handling and Custody

SSC samples will be delivered to the USGS lab in Santa Cruz, CA within 30 days of sample collection for analysis. SSC samples do not require storage or transport on ice, and can be stored and transported at room temperature, preferably in a dark location. SSC samples collected by Karuk and Yurok Tribes will be either directly shipped to the lab or physically transferred to USGS personnel under a COC, who will then transport the samples to the lab. Analytical service request forms (ASR) will be filled out by USGS personnel using field forms from USGS, Karuk, and Yurok personnel. The sample bottles will be labeled by Site ID, Date, median sample time (the median time between the start and stop time of the samples), gage height at time of sample, and the sample set (A or B). USGS personnel will fill out necessary information into the electronic forms prior to submitting samples to the lab.

B.4 Equipment, Analytical Methods and Field Measurements

Samples will be collected and analyzed as outlined below.

B.4.1 Field Equipment

Isokinetic Suspend-Sediment Sampling

Composite and individual analyses suspended-sediment sampling will be conducted from bridges, boats, cableways, and by wading the stream cross section following methods described in Edwards and Glysson (1999). For bridge, cableway, and boat samples, a USGS D-49, D-96, D-74, D-95, DH-95 or DH-59 sediment sampler with appropriate glass or plastic bottles or plastic bags for the D-96 bag sampler will be used to collect the samples. These samplers will be lowered and raised through the water column using cable and reel devices. For wading samples, a hand-held DH-81 sediment sampler enclosing a 1-L Nalgene plastic bottle, or a DH-48 sediment sampler enclosing a glass pint bottle will be used. These samplers will be manually lowered and raised through the water column during sample collection. Individual sample bottles will be sent to the Santa Cruz lab for analysis. The measurement principle of these samplers follows isokinetic sampling theory, which states that the water approaching and entering the sampler intake does not change velocity while the sampler is being moved through the water column and collecting the sample. Isokinetic samplers are limited to water velocities greater than 1.5 feet per second and depths less than 15-ft for samplers with rigid bottles (D-74, D-95, DH-95, DH-59). The D-96 bag sampler can be used in velocities from 2.0 to 12.5 ft/s and depths up to 110-ft depending on the nozzle diameter.

Two cross-section composite samples will be collected per sampling event generating 10 1-L sample containers. The first sample (A-set) will generate 5 sample bottles that will be analyzed individually for SSC and percent of sample finer than 63 microns (percent fines). The second sample will composite all of the 5 containers resulting in one SSC and percent fines value, and will be analyzed for full particle size distribution.

Automated Samplers

The Teledyne ISCO automated pump samplers function using a peristaltic pump head that is capable of pumping volumes of water up to 26 vertical feet from the point of pumping to the pump head, and at manufacturer-recommended velocities. The sampler can be configured to hold bottles sized from 1-L to 5.5 gallons if needed. No measurement principle is associated with this equipment. Major attributes include the ability to program the sampler to collect samples at specified temporal frequencies and at specified turbidity thresholds. An SDI-12 interface allows connection with the YSI EXO2 sondes via the data logger to trigger the samples at specified turbidity thresholds without disrupting the transmission of continuous water quality data from the sondes.

Continuous Monitoring Methods

The EXO2 sondes contain sensors that continuously record observations of water temperature, pH, dissolved oxygen, specific conductance, turbidity, and chlorophyll. Water temperature and specific conductance are located on the same probe. The temperature thermistor is a calibrated with a NIST-traceable wet calibration and an accuracy specification of 0.01 degrees Celsius and a resolution of 0.001 degrees Celsius. The specific conductance sensor reports water conductance compensated to 25 degrees Celsius and uses four internal pure-nickel electrodes to measure solution conductance. Conductance resolution is 0.0001 to 0.01 ms/cm. The dissolved oxygen sensor is an optical sensor and operates by shining a blue light of a specified wavelength onto a luminescent dye which is immobilized in a matrix and formed to a disk. Accuracy of the dissolved oxygen sensor is increased by irradiating a red light during the measurement cycle to act as a reference in the determination of the luminescence lifetime. Dissolved oxygen resolution is 0.01 mg/L, or 0.1% air saturation. pH is measured using two electrodes combined into the same probe: one for hydrogen ions and one for a reference. The sensor is a glass bulb filled with a solution of stable pH. pH range is 0 to 14 units with a resolution of 0.01 units. The turbidity sensor employs a near-infrared light source and detects scattering at 90 degrees of the incident light beam, also characterized as a nephelometric near-IR turbidimeter, non-radiometric. As such, units are reported as formazin nephelometric units (FNU). The sensor range is 0-4000 FNU with a resolution of 0.01 FNU for 0-999 FNU, and 0.1 FNU for 1000-4000 FNU. The high-range ANALITE NEP-5000 turbidity sensor is a backscatter sensor that detects scattering at 180 degrees of the incident light beam. The units are reported as nephelometric turbidity units (NTUs). The ANALITE NEP-5000 sensor range is 0-30,000 NTU with a resolution of +/- 1.5 NTU for 0-5,000 NTU, +/- 3.0 NTU for 5,000-10,000 NTU, +/- 9.0 NTU for 10,000-30,000 NTU.

For calibration, maintenance, see manufacturer's instructions (Appendix H), and auditing procedures (Appendices E, F). Raw data from sondes will be collected and stored on dataloggers in the USGS gage houses. This data will also be transmitted via the GOES network and made publicly available.

B.4.2 Analytical Methods

Suspend Sediment Concentration is the only laboratory analysis in this study. All samples will be analyzed by the USGS Sediment Laboratory in Santa Cruz, CA.

Chemistry

SSC will be analyzed using method, ASTM D 3977-97, Standard Test Method for Determining Sediment Concentration in Water Samples (ASTM, 1999). This is the USGS standard for determining concentrations of suspended material in surface water samples. This method is used by all USGS sediment laboratories, and by cooperating laboratories certified to provide suspended-sediment data to the USGS. The laboratory will report both concentration in mg/L and percent of sample less than 63 microns, operationally defined as the break between silt and sand.

Table 10. Analytical Methods

Analyte	Project Quantitation Limit (units, wet or dry weight)	Analytical Method	
		Analytical Method/SOP	Modified for Method yes/no
SSC	mg/L, percent of sample less than 63 microns	ASTM D 3977-97	No

Sample Disposal

This section does not apply to any type of sampling conducted under this QAPP.

Corrective Action

The projects QA/QC Manager will be responsible for documenting sampling failures and instituting corrective measures.

B.5 Quality Control

B.5.1 Blanks

Field Blanks will not be collected for this sampling, which is typical for suspended-sediment sampling.

B.5.2 Spikes and Duplicates

A duplicate sample will be collected with each cross-section composite (isokinetic) SSC sample. The primary and duplicate samples are referred to as "A" and "B" sample sets. Collecting two concurrent or sequential duplicate samples for each cross-section sample allows for comparison of sampling methods and helps to determine if a sampling error occurred. For example, if one of the samples reports a high

concentration relative to the other sample, the hydrographer collecting the sample could determine that the high concentration sample possibly over-sampled the bed-sediment, which is not representative of the suspended sediment. In that scenario, the high-concentration sample would be discarded, and the second sample would be retained.

B.6 Instrument/Equipment Testing, Inspection, And Maintenance

B.6.1 Sampling Equipment

Sampling equipment will be inspected regularly prior to use for safety and operational reasons. Cable reels will also be inspected to ensure crew safety during sample collection. The full lists of all sampling equipment are described in the USGS SOPs Appendices D and E.

B.6.2 Automated Samplers

Automated samplers will be inspected regularly, typically when field crews retrieve samples from the sampling units. The pump heads and battery voltage will be inspected to ensure that sample collection will continue at the scheduled frequency.

B.6.3 Continuous Monitoring Methods

Calibration and maintenance of field equipment/instruments will be performed according to the manufacturer's instructions (Appendix H), and sampling organizations SOPs (Appendices E, F, and G) and recorded in an instrument/equipment logbook.

The project-specific criteria for calibration (frequency, acceptance criteria, and corrective actions associated with exceeding the acceptance criteria) are provided in Table 11. Field Equipment Calibration, Maintenance, Testing, and Inspection.

Table 11. Field Equipment Calibration, Maintenance, Testing, and Inspection

Analytical Parameter	Instrument	Calibration Activity	Maintenance & Testing/ Inspection Activity	Frequency	Acceptance Criteria	Corrective Action
Temperature (Sensor)	EXO2 MPS Multi Probe System: YSI Precision ™ Thermistor		According to Wagner and others (2006) Manufacturer's manual Karuk QAPP[1] Yurok QAPP[2]	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	± 0.15°C of true value at both endpoints or as dictated in Wagner and others (2006)	Remove from use and replace with backup sensor if doesn't pass calibration criteria
pH (electrode)	EXO2 MPS Multi Probe System: YSI Glass Combinatio n electrode	Initial: Two-point calibration bracketing expected field sample range (using 7.0 and 10.0 pH buffer) Post: single-point check with 7.0 pH buffer	According to Wagner and others (2006) and Manufacturer's manual Karuk QAPP Yurok QAPP	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	Initial: Two- point calibration done electronically Post: ±0.1 pH units of true value or as dictated in Wagner and others (2006)	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria and replace with backup sensor.
Dissolved oxygen (sensor)	EXO2 MPS Multi Probe Optical Sensor	Initial: One-point calibration with saturated air (need temp, barometric pressure). Post: single-point check at full saturation	According to Wagner and others (2006) and Manufacturer's manual Karuk QAPP Yurok QAPP	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	Initial: One-point calibration done electronically Post: ±0.5 mg/L of true saturated value or as dictated in Wagner and others (2006)	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria and replace with backup sensor.
Turbidity (sensor)	EXO2 MPS Multi Probe System	Initial: 2 or 3-point calibration using 0, 124, 1010 FNU copolymer beads Post: same calibration as pre-deployment	According to Wagner and others (2006) and Manufacturer's manual Karuk QAPP Yurok QAPP	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	Initial: One-point calibration done electronically Post: ±1 NTU of true value or as dictated in Wagner and others (2006) and Rasmussen and others (2009)	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria and replace with backup sensor.

Analytical Parameter	Instrument	Calibration Activity	Maintenance & Testing/ Inspection Activity	Frequency	Acceptance Criteria	Corrective Action
Conductivity (sensor)	EXO2 MPS Multi Probe System: YSI 4-electrode cell with autoranging	Initial: One- point calibration at high end of expected field sample range (1000 mS/cm standard)	According to Wagner and others (2006) and Manufacturer's manual Karuk QAPP Yurok QAPP	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	Initial: one-point calibration done electronically	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria and replace with backup sensor.
		Post: two-point check with high (1000 mS/cm) and low (0 mS/cm) standards			Post: high standard ±5% of true value and low standard ±10% of true value, or as dictated in Wagner and others (2006)	

[1]Karuk Tribe Water Quality Program 2018; [2]Yurok Tribe Environmental Program 2017

B.6.4 Analytical Instruments

The chemistry analytical laboratory maintains its equipment in accordance with its SOPs, which include those specified by the manufacturer and those specified by the method. Problems with the instrumentation during analysis will require repair, recalibration, and re-analysis of the sample.

Table 12. Testing, Inspection and Maintenance of Analytical Instruments

Equipment / Instrument	Responsible Person	Frequency	SOP Reference
Sartorius Analytical Balance LA230S	Lab Manager	Daily during periods of operation	Knott and others (1992)
Sartorius Macro Balance AZ4101	Lab Manager	Daily during periods of operation	Knott and others (1992)
Fisher Scientific Isotemp Premium Oven 700 Series 13247750F	Lab Manager	Weekly during periods of operation	Knott and others (1992)
Filtration Equipment	Lab Manager	Weekly during periods of operation	Knott and others (1992)

B.7 Instrument/Equipment Calibration and Frequency

B.7.1 Suspend-Sediment Sampling

SSC sampling devices do not require calibration before use, with the exception of the D-96 bag sampler, which requires an intake efficiency tests as described in USGS Office of Surface Water technical memo 2013.03, collected before each set of samples for cross-section composite sampling. Intake efficiency tests for D-96 bag samplers will be performed following the protocols described in USGS Office of Surface Water technical memo 2013.03. Resolution of deficiencies will follow protocols described in USGS office of Surface Water technical memo 2013.03.

B.7.2 Automated Samplers

Maintenance and cleaning of equipment will follow manufacturer's guidelines. Calibration of volume delivered will be done according to manufactures specifications. If automated samplers fail to trigger or deliver proper sample volume. Field technicians will notify QA/QC staff and efforts will be made to resolve the issue.

B.7.3 Continuous Monitoring Methods

For a description of equipment, tools, and instruments and the frequency of calibration see Appendices D, E and F for Karuk and Yurok protocols, Table 11. Field Equipment Calibration, Maintenance, Testing, and Inspection and Table 12. Testing, Inspection and Maintenance of Analytical Instruments. Calibration of EXO2 sondes and documentation of the calibrations will follow procedures outlined in Wagner and others (2006) and Rasmussen and others (2009) for the USGS sites at Keno and JC Boyle. At Iron Gate, Seiad Valley and Orleans calibrations will follow the SOPs outlined in Karuk QAPP (Karuk Tribe Water Quality Program 2018) and at the Klamath site procedures will follow the Yurok QAPP (Yurok Tribe

Environmental Program 2017). Any deficiencies in sampling will be documented in quarterly report and resolved by individual sampling entities.

B.8 Inspection/Acceptance for Supplies and Consumables

USGS hydrographers from the Klamath Falls field office will be responsible for the purchase of consumables necessary for the operation and maintenance of continuous water quality sondes at Keno and JC Boyle. Acceptance criteria are addressed by the internal USGS supply store prior to shipping to field offices. Tracking and storing of the materials is conducted by USGS hydrographers at the field office.

The field measurement supplies the Karuk and Yurok Tribe will use, such as calibration solutions, will be acquired from standard traceable sources, such as the instrument manufacturer or reputable suppliers. The Karuk Tribe will obtain calibration standards from Fondriest Environmental, Inc. The lot number and expiration date on standards and reagents will be checked prior to use. Expired solutions will be discarded and replaced. The source, lot number, and expiration dates of all standards and reagents will be recorded in the field log books.

Table 13. Project Inspection/Acceptance Requirements for Supplies and Consumables

Project	Instrument Name/Model	Date Purchased	Inspection Specifications	Acceptance Criteria	Frequency	Responsible Individual
Water Quality Monitoring at Klamath, Orleans, Seiad Valley, Iron Gate	YSI Multiprobe EXO2	10/2018	Karuk, Yurok QAPP	Manufacture specifications (Table 8)	Every 2 weeks	Field Officers

B.9 Data Management

Management of data collected by USGS will follow established protocols, and will be stored in the NWIS database, which is publicly accessible. USGS databases retain all original raw data, and records processing and management follows guidelines detailed in Wagner and others (2006) and Rasmussen and others (2009).

The Karuk Tribe will ensure that all field collected audit and calibration data will be recorded on paper and digitally. All raw continuous monitoring data collected by the Karuk and Yurok Tribe will be stored on their individual servers or the Karuk server and made available to KRRC. Filling of project related documents will follow the guidelines in the Karuk and Yurok Tribes QAPPs (Karuk 2018, Yurok 2017). Raw continuous time series data will be entered into Aquatic Informatics, Inc. Time Series software to be evaluated and corrected based upon procedures outlined in the Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and Data Reporting (Wagner and others, 2006, and Rasmussen and others, 2009) by the USGS. Both real time and corrected data will be made available on the Karuk Tribes Water Quality Web Portal and submitted to the project database.

C. Assessments and Response Actions

During the course of the project, it is important to assess the projects' activities to ensure that the QAPP is being implemented as planned. This helps to ensure that everything is on track and serves to minimize learning about critical deviations toward the end of the project when it may be too late to remedy the situation. For the current project, the ongoing assessments will include:

- Field Oversight,
- Readiness review of the field team prior to starting field efforts,
- Field activity audits,
- Review of field sampling and measurement activities methodologies and documentation at the end of each event, and
- Laboratory Oversight - evaluation of laboratory data generated for each quarterly sampling event.

C.1 Reports to Management

Quarterly progress reports will be prepared and submitted to KRRC. The Yurok Tribe will provide a summary of data collected to the Karuk Tribe for inclusion in the quarterly progress reports. Quarterly progress reports will include respective invoices.

An annual progress report will also be prepared and submitted to KRRC by September 30, 2019. The annual progress report will describe equipment installation and site reinforcement with photos, mapping and site coordinates, all monitoring activities, links to USGS, Karuk and Yurok data results or an established repository with all the results, and recommended QAPP revisions and site modifications for WY2020, as necessary. Note that a detailed report of data trends and analysis will not be included in this report.

D. Data Review, Verification, and Validation

Prior to utilizing data to make project decisions, the quality of the data needs to be reviewed and evaluated to determine whether the data satisfy the projects' objectives. This process involves technical evaluation of the off-site laboratory data, as well as, review of the data in conjunction with the information collected during the field sampling and field measurement activities. This latter, more qualitative review provides for a clearer understanding of the overall usability of the projects' data and potential limitations on their use. Section A.8: Quality Objectives and Criteria outline various criteria that will be used to evaluate project data.

D.1 Verification and Validation Methods

The setting of data review, verification, and validation requirements helps to ensure that project data are evaluated in an objective and consistent manner. For the current project, such requirements have been defined for information gathered and documented as part of field sampling and field measurement activities, as well as for data generated by the off-site laboratory.

Individual monitoring agencies will be responsible for validating various components of project information in accordance with their respective QAPPs (Karuk 2018, Yurok 2017).

D.2 Reconciliation with User Requirements Checklists

The Karuk and Yurok tribes will flag data that does not meet the acceptance criteria outlined in Section A.8: Quality Objectives and Criteria.

Uncertainty for data collected by USGS is reported and quantified as part of the records processing that is required for all USGS data sets. Data limitations are reported by flagging of data and qualitative rating of water quality records. These flags and ratings are retained with the data when retrieved from the USGS database.

Once all the data from the field and laboratory have been evaluated, the QA Officers will make an overall assessment concerning the final usability of the data (and any limitations on its use) in meeting the projects' needs. The initial steps of this assessment will include, but are not necessarily limited to:

- Discussions with the Field Technicians,
- Review of deviations from the QAPP or associated SOPs to determine whether these deviations may have impacted data quality (and determining whether any impacts are widespread or single incidents, related to a few random samples or a batch of samples, and/or affecting a single or multiple analyses),
- Evaluation of the field and laboratory results and QC information,
- Review of any other external information which might influence the results, such as activities up stream, meteorological conditions, wildfires, and data from other sources,
- Evaluation of whether the completeness goals defined in this QA Project Plan have been met,
- Examination of any assumptions made when the study was planned, if those assumptions were met and, if not, how the project's conclusions are affected.

In addition, the Monitoring Management Team will assess the effectiveness of the monitoring program and data collection at the end of each calendar year. Sampling locations, frequency, list of analytical parameters, field measurement protocols, choice of the analytical laboratory, etc. will be modified as needed to reflect the changing needs and objectives of the KRRP. This QAPP will be revised and/or amended accordingly.

E. References

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APPENDIX B

Karuk Tribe QAPP 2018

KARUK TRIBE

DEPARTMENT OF NATURAL RESOURCES

P.O. Box 282 * Orleans, California 95556

2018

Quality Assurance Project Plan

For Water Quality Sampling and Analysis

CWA 106 grant identification # BG-97991217

Prepared by

Karuk Tribe Water Quality Program

Karuk Tribe Water Quality Program
Quality Assurance Project Plan

For Water Quality Sampling and Analysis

Water Quality Program
Karuk Tribe Department of Natural Resources
PO Box 282
Orleans, CA 95556

This QAPP has been approved by:

Karuk Water Quality Project Manager _____

Karuk Water Quality QA Officer _____

_____

For EPA use:

Approved by EPA Project Manager: Date:

_____ _____

Expedited Review? ☒ Yes ☐ No

Received by QA Office: Date:

_____ _____

Reviewed by: Date:

_____ _____

Approved: Date:

_____ _____

Region 9 Quality Assurance Manager

Table of Contents

1.0 PROJECT MANAGEMENT

This Quality Assurance (QA) Project Plan has been prepared for the monitoring of surface water by the Karuk Tribe located in Humboldt and Siskiyou County, California. The surface water monitoring program is part of the Tribe's water quality management program developed under Section 319 of the Clean Water Act. This section of the QA Project Plan describes how the project will be managed, organized and implemented.

1.1 Title and Approval Page - See Pages 1-2.

1.2 Table of Contents - See Pages 3 - 8.

1.3 Distribution List

The following is a list of individuals who will receive copies of the approved QAPP and any subsequent revisions or changes.

Susan Fricke Karuk Tribe Water Resources Director Karuk Tribe: Department of Natural Resources P.O. Box 282 Orleans, California 95556 Ph: 530-598-3414 sfricke@karuk.us	**Tim Wilhite** GAP Project Officer USEPA c/o Klamath Nat'l Forest 1312 Fairlane Road Yreka, CA 96097-9549 Ph: 530-841-4577 Fax: 530-841-4571 Wilhite.Timothy@epamail.epa.gov
Karuk Tribal Council PO Box 1016 – 64236 Second Avenue Happy Camp, Ca 96039 Toll Free: (800) 505-2785 (530) 493-1600 – Fax: (530) 493-5322	**Aquatic Research Inc.** 3927 Aurora Ave. N Seattle, WA 98103 Ph: 206-632-2715 info@aquaticresearchinc.com
Jim Sweet Aquatic Analysts 43 Telegraph Ln Friday Harbor, WA 98250 Ph: 503-869-5032 jwsweet@aol.com	**Chesapeake Biological Laboratory** 1 Williams Street Solomons, MD 20688 Ph: 410-326-4281
GreenWater Laboratories 205 Zeagler Drive, Suite 302 Palatka, FL 32177 Ph: 386-328-0882 info@greenwaterlab.com	**Bartholomew Laboratory** Oregon State University 226 Nash Hall Corvallis, OR 97331 Ph: 541-737-1834

Loretta Vanegas CWA 106 Project Officer USEPA REGION 9 75 Hawthorne Street *Mail Code:* WTR-10 San Francisco, CA 94105	**Eugenia McNaughton,** Manager Region 9 Quality Assurance Section U.S. EPA Region 9 75 Hawthorne Street *Mail Code:* MTS-3 San Francisco, CA 94105
Ph: 415-972-3433 Vanegas.Loretta@epa.gov	(415) 972-3411 McNaughton.Eugenia@epa.gov

1.4 Project Organization

Table 1 lists key players and contractors, including those collecting samples, contractors that will process samples and Karuk Tribe Water Quality Program (KTWQP) staff that will oversee quality control (QC) procedures. Laboratories that will process samples are 1) Aquatic Research Inc. in Seattle, Washington, 2) Aquatic Analysts Inc. in Friday Harbor, Washington, 3) the U.S. Environmental Protection Agency Region IX Laboratory in Richmond, California, 4) Chesapeake Biological Laboratory in Solomons, Maryland, 5) GreenWater Laboratories in Palatka, Florida, and 6) Bartholomew Laboratory in Corvallis, Oregon.

The KTWQP is completing this QAPP to define how QC procedures are implemented and to define how the KTWQP and its staff will work together on quality assurance (QA) to insure that data are properly collected and analyzed, managed and stored for on-going use, and results published in a timely fashion. Because of the systematic planning process documented in this QAPP, the KTWQP will supply quality assured data for management decisions related to the aquatic environment within Karuk Ancestral Territory (KAT) and surrounding areas.

The KTWQP is organized as shown in Figure 1. The KTWQP Project Manager has ultimate control over and responsibility for the WQ program. The KTWQP Project Manager is responsible for program coordination, budget management, technical oversight and overall program quality.

The QA Officer will have responsibility and authority for:

- Ongoing review of monitoring methods and equipment calibration,
- Report Preparation,
- Auditing field notebooks, databases, chain of custody forms, and
- Insuring adherence to field and laboratory QA/QC programs.

In short, the QA Officer will insure that QC procedures developed in this QAPP are carried out. The Data Manager and Water Quality Technicians will work under the supervision of the QA Officer and follow procedures as defined in this QAPP.

The Data Manager will:

- Transfer results from the field or laboratory into databases,
- Properly store data and archive to insure against loss,
- Run preliminary analysis of data, and provide charts for reports, and
- Assist with report preparation.

The WQ Technicians will:

- Collect field samples,
- Fill out forms to record results and field conditions,
- Care for and calibrate equipment, and
- Properly fix and ship samples needing laboratory analysis.

Any time there are problems perceived by the Data Manager or the WQ Technician with any part of the WQ Monitoring Program, they are to notify the KTWQP Project Manager so they can work collaboratively on resolving issues. The QA Officer will also periodically conduct audits to detect QA/QC problems or deficiencies.

If any tests of surface water exceed tribally adopted water quality standards, then the KTWQP Project Manager will be notified so that they can inform the Karuk Tribal Council. Following notification of the Tribal Council, the KTWQP would then inform the North Coast Regional Water Quality Control Board staff and work cooperatively with that agency for abatement of problems.

The KTWQP will send water quality samples needing laboratory analysis to Aquatic Research Inc., and to Chesapeake Biological Lab. Phytoplankton and algae samples will be sent to Jim Sweet of Aquatic Analysts to be processed and analyzed. Samples to be tested for microcystin toxins will be sent to the US EPA Region 9 Lab and GreenWater Lab. Samples to be analyzed for ceratonova shasta (c.shasta) will be sent to Bartholomew Lab.

1.5 Background and Problem Definition

This section states background information to provide a historical, scientific, and regulatory perspective for the project, and articulates specific problems to be solved.

1.5.1 Background

The Karuk Tribe is the second largest Tribe in California, with over 3,700 Tribal members currently enrolled. The Karuk Tribe is located along the middle Klamath River in northern California. Karuk Ancestral Territory covers over 90 miles of the mainstem Klamath River and numerous tributaries (Figure 2, Table 2). The Klamath River system is central to the culture of the Karuk People, as it is a vital component of our religion, traditional ceremonies, and subsistence activities. Degraded water quality and quantity has resulted in massive fish kills, increased occurrences of toxic algae, and outbreaks of fish diseases. Impaired water quality conditions also apply extreme limitations and burdens to our cultural activities.

1.5.1.1 Decline of the fishery

What was once a historically productive fishery has now declined to numbers precluding tribal members from utilizing their fishing rights on ancestral waters and limiting their take for sustenance throughout the Klamath River watershed. The Indian people of the Karuk Tribe traditionally depended on the land and waters to provide for their physical and cultural needs. The state of the watershed today prevents this dependency.

Historically, spring-run Chinook salmon were abundant in the rivers of the Klamath Basin, considerably outnumbering the fall Chinook run (Hume in Snyder 1931). "Salmon ascend the river in large numbers, before the waters subside in the spring", remarked Gibbs in 1851 (SRWC SAP 2005). Fall Chinook, winter and summer steelhead were also widespread in the Klamath Basin. (Maria, personal communication in SRWC SAP 2005). Today, the spring Chinook and summer steelhead run is virtually nonexistent in the Klamath River (KRBFTF, 1991. p. 2-87, 2-99, and 4-15; USFS, 2000b, p.3-9; USFS, 2000a).

Coho salmon would have flourished in the numerous ponds created by beavers in Mid-Klamath tributaries and the mainstem Klamath (SRWC SAP 2005 & Belchik, personal communication). Brown et al. (1994) state that California coho populations are probably less than 6% of what they were in the 1940s, and there has been at least a 70% decline since the 1960s. Coho salmon occupy only 61% of the SONCC Coho ESU streams that were previously identified as historical coho salmon streams (CDFG,
2002, p.2)

1.5.1.2 Land Use Factors

Consideration of factors limiting salmon and steelhead production, water quality and attainment of other beneficial uses in Mid-Klamath region must be tiered. Flow depletion in tributaries and water diversions cause secondary water quality problems as transit time increases and stagnation of water occurs. This alteration of timing and flow volume subsequently affects sediment dynamics and the hydro-morphology of these water ways. Limiting factors are most often linked to the land use activities of logging, agriculture, and historical mining.

Historical Mining: Historically, gold was mined in the Mid-Klamath region. The type of mining performed in Northern California during the late 1800s was hydraulic mining, not chemical (like cyanide-leach mining), so less chemical contamination is associated with it. Surface and groundwater in the MidKlamath could potentially be contaminated with heavy metals, such as arsenic, that naturally occur in association with gold but are discarded in mine tailings. The use of mercury to separate gold from concentrates was

common place. Dredge tailings from hydraulic mining can also serve as a source of sediment pollution. Current mining practices are being evaluated by CDFG at present.

Agriculture: Beginning around 1850, ranching became a prevalent use of land on the Klamath River and its tributaries. Grazing of cattle is still performed by landowners adjacent to the Klamath River and its tributaries. This could contribute to erosion of streams and bacterial contamination of surface waters where cattle are permitted access to streams. Agricultural practice near waterways may contribute contaminants such as pesticides, nitrates, and phosphates to the surface water.

In the Shasta River and the Scott River, two major Klamath River tributaries, the flow depletion due to water extraction for agriculture causes warming as the water volume is reduced. Decreasing flows also causes the formation of isolated pools, which can and do strand juvenile fish. Warming water temperatures and nutrient rich agricultural return water increases the amount of periphyton growth on stream substrate, which has been demonstrated in the Shasta River. High rates of photosynthesis by algae in low flow conditions can cause large nocturnal and diurnal fluctuations in pH and dissolved oxygen. The secondary effects related to high photosynthetic activity in stagnant, de-watered reaches are not targeted because loss of flow is an over-riding impact.

Logging: Much of the land in Siskiyou County was logged, beginning in the latter half of the 19th century. Historic timber practices could result in herbicide and pesticide contamination of surface and ground water. Erosion due to clear-cutting and logging roads (whether still used and maintained, or abandoned) contributes significant amounts of sediment to the Klamath River system and has altered the natural hydrograph.

Upland areas of the Klamath River which have been extensively logged have high road densities prompting multiple Regional Water Board TMDLs across the Klamath basin. Compaction of soils and changes in routing of storm water on logged areas and logging roads are known to:

- Increase peak discharge (Montgomery and Buffington, 1993; Jones and Grant, 1996),
- Increase sediment yield (Hagans et al., 1986, de la Fuente and Elder, 1998), and
- Decrease large wood available for recruitment to streams (Reeves et al., 1993; Schuett-Hames et al., 1999).

The potential changes in aquatic conditions related to upland disturbance are described below.

Increased Peak Discharge: Elevated peak discharge can increase median particle size distribution to those greater than optimal for salmonid use, wash out large wood, and trigger bank failures and channel scour. Channel changes can include decreased pool frequency and depth (Buffington and Montgomery, 1993). Wider and shallower channels are also more subject to warming. Although less well-studied, hydrologic changes associated with compaction of a watershed can also lead to decreased summer base flows.

Increased Sediment Yield: Sediment yield is a noted problem in tributaries to the Klamath River mainstem (NCRWQCB, 2003; 2005). Fine sediment comes primarily from surface or gully erosion. Sommarstrom et al. (1990) identified road cuts and road fills on decomposed granitic soils as a major source of fines within the Scott River watershed, a major tributary to the Klamath River.

Fine Sediment: High levels of sand and fine sediment can fill interstitial spaces in stream gravels, decrease salmonid egg and alevin survival and reduce aquatic insect habitat. Decreased aquatic invertebrate production can diminish food resources for juvenile salmonids. Smaller sediment particles are highly mobile and may cause diminished pool frequency and depth, thus reducing salmonid juvenile carrying capacity and adult salmonid holding habitat.

Mass Wasting: The coarse and fine sediment yielded by mass wasting can cause channel aggradation, loss of pool habitat, changes in median particle size, decreased spawning gravel quality and channel adjustments that facilitate stream warming.

Large Wood Depletion: Changes in riparian conditions can increase ambient air temperature over streams and reduce relative humidity, thus leading to stream warming (Bartholow, 1989; Pool and Berman, 2001). Cold air moving down slope from Marble Mountain peaks in winter may also cause elevated risk for the formation of anchor ice along streams where canopy is lacking. Pools formed by large wood are extremely important as nursery areas for coho salmon juveniles (Reeves et al., 1988) that must spend one year in freshwater before migrating to the ocean. Large wood depletion can therefore cause diminished aquatic habitat complexity, reduced pool frequency and lower carrying capacity for juvenile coho. Large coniferous trees in riparian zones may take decades or centuries to grow to sufficient size to be useful in buffering air temperatures and providing wood of sufficient size to provide lasting habitat value (Shuett-Hames et al., 1999).

1.5.1.3 Purpose of Water Quality Investigations

It is the mission of the Karuk Tribe to protect, promote, and preserve the cultural resources, natural resources, and ecological processes upon which the Karuk People depend. This mission requires the

protection and improvement of the quality and quantity of water flowing through Karuk Ancestral Territory and Tribal trust lands. The Karuk Tribe's Department of Natural Resources has been monitoring daily water quality conditions in the Klamath River since January of 2000 and tributaries to the Klamath River since 1998. The Karuk Tribe has been collaboratively involved in maintaining water quality stations along the Klamath River and its tributaries with the United States Environmental Protection Agency (USEPA), the United States Geological Survey (USGS), the Bureau of Reclamation (BOR), the Yurok Tribe, Quartz Valley Indian Reservation, Hoopa Tribe, and Resighini Rancheria, Oregon State University and PacifiCorp.

The data produced is indispensable in monitoring water quality conditions within the Klamath River System. We are building a long-term monitoring data set that allows us to track these conditions and monitor them for improvement. This data is important to state and federal processes currently underway and provides information for Tribal Council and resource managers to make informed decisions. The water quality data the Karuk Tribe collects is essential to providing quality data regarding processes that involve and affect the Karuk Tribe.

The goal of the KTWQP is to provide the Karuk Tribe with a quantitative assessment of water quality effecting KAT, and to further expand the Tribe's scientific knowledge for tribal members, fisheries, future planning, and watershed activities. Additionally, these analyses will help identify any surface water contamination problems that could affect fish habitat, since wild salmon are an important resource to the Karuk Tribe and a vital piece of the Tribe's cultural heritage.

The data was collected in accordance with this QAPP will be used to develop baseline information in order to document water quality changes over time, screen for potential water quality problems, and to provide a scientific foundation in order to actively participate in the management of the Mid-Klamath watershed.

1.5.2 Problem Definition

1.5.2.1 Nutrient and Toxic Algae Pollution

The Klamath River in California is listed as an impaired water body under the Clean Water Act (CWA) Section 303(d) list for temperature, nutrients, dissolved oxygen (DO), sediment, and microcystin (NCRWQCB, 2009). The mid-Klamath River can have elevated water temperatures, low dissolved oxygen levels, elevated sediment loads, loading from organic matter, and high levels of the cyanotoxin microcystin. These detrimental conditions are caused by a variety of factors including hydrological modification, agricultural use, timber harvesting, mining activities, and fire suppression (NCRWQCB, 2009). Some of the beneficial uses that are important to the Karuk Tribe and impacted by poor water

quality conditions are, cultural use, subsistence fishing, cold freshwater habitat, recreation, commercial and sport fishing, shellfish harvesting, rare, threatened, or endangered species, migration of aquatic organisms, spawning, reproduction, and/or early development, and wildlife habitat (NCRWQCB, 2007).

The presence of Microcystis aeruginosa (MSAE) contributes to not only fish health problems, but also to human health problems. As MSAE cells die and decay the hepatoxin microcystin is released, which can cause a range of reactions in humans and/or animals: rash, irritation, conjunctivitis, nausea, vomiting, diarrhea, liver damage, tingling, numbness, paralysis, and death (Chorus and Bartram 1999; Chorus 2001). Once ingested, microcystin is not excreted and instead it bioaccumulates and can cause liver damage, decreased liver function, and eventually mortality (WHO, 1998). Mortality in fish, domestic animals, and humans has been recorded following from both single-dose events and long-term exposure to microcystin (Carmichael 1994).

Nutrient and toxic algae pollution in the Klamath River is causing stressful conditions for Pacific salmonid species and their juveniles and providing an environment that fosters an increase in disease organisms (YTEP, 2006). The reduced salmon production and loss of access to salmon as a food resource has had major health consequences for Native Peoples in the Klamath River basin (Norgaard, 2005).

1.5.2.2 Ceratonova Shasta

Stable river channel conditions, abundant algae beds and deposits of benthic organic matter in the Klamath River just below Iron Gate Dam provide ideal habitat for a polychaete worm that plays host to one of the Klamath River's most deadly fish diseases, *Ceratonova shasta* (Stocking and Bartholomew, 2004; Stocking, 2006). This myxozoan parasite infects the intestine of salmonid fishes, which can lead to enteronecrosis and mortality. *Ceratonova shasta* cycles between two hosts and two spore stages: waterborne actinospores released from freshwater polychaete worms infect salmonids and develop into myxospores, which are then infectious to polychaetes (Bartholomew, 2016). The combination of direct stress to fish from water pollution in combination with increased abundance of pathogens has led to more than 40% of downstream migrant juvenile Chinook salmon dying before they reach the ocean in some years (Foot et al., 2003; Nichols and Foot, 2005). The Bartholomew Lab at Oregon State University has been monitoring the spatial and temporal abundance of the parasite in the Klamath River basin since 2006 using sentinel fish exposures, river water sampling, and polychaete sampling. The KTWQP assists with water sample collection and filtration.

1.5.3 Principal data users/decision makers who will use the data to make decisions

The first step to fulfill the goal of this QAPP is the collection of baseline data for water bodies in the Mid-Klamath watershed. Quality assured water quality data collected by the KTWQP will be used in management decisions regarding the watershed. Data will be shared with the U.S. EPA

and NCRWQCB staff through timely reports on findings, including for use in TMDL updates. Other agencies and entities cooperating in Klamath watershed management, including the U.S. National Forest (Klamath and Six Rivers), may also receive KTWQP data after it has undergone QA/QC and analysis. The KTWQP will also share data with tribal members through annual reports and with the public upon request.

1.5.4 Brief Summary of Existing Information

Klamath River nutrient pollution has been widely recognized since the 1950's (Phinney and Peak, 1962; CH2M Hill, 1985; Kier Associates, 1991). The adult salmon kill in September 2002 (CDFG, 2003; Guillen, 2003), chronic high mortality of juvenile salmon (Nichols and Foot, 2005) and discovery of problems with toxic algae in KHP (Klamath Hydroelectric Project) reservoirs (Kann and Corum, 2006) all point to a water quality crisis. As noted above, sources of pollution include upstream agricultural operations and nitrogen fixing algae in Upper Klamath Lake, Lost River, Lower Klamath Lake and KHP reservoirs.

In 1989 the Karuk Tribe formed the Department of Natural Resources which primarily focused on fisheries work. About ten years later, the KTWQP was started. Water quality data was collected in coordination with USGS and USFWS and generally focused on the KAT but also occurred upstream of the KAT. In 1995, USFWS monitored Klamath River water quality as linkages between water pollution and fish health became more apparent. Data have included grab samples for nutrients and those derived from continuous recording data probes that capture parameters such as pH, D.O., temperature and conductivity.

The Klamath River Water Quality Monitoring Coordination Workgroup that includes Tribes and State and federal agencies was formed after the September 2002 adult salmon kill and coordinated increased water quality sampling. Asarian and Kann (2006) used existing nutrient data to construct a nutrient budget by reach for the Klamath River and their study lists all nutrient related water quality samples collected between 1996 and 2004. They pointed out data gaps for nutrient sampling using adequate laboratory detection limits and the need for more periphyton samples. The Hoopa Tribal Environmental Protection Agency (TEPA, 2008) used existing data to characterize Klamath River nutrient pollution and to set limits on their Reservation waters just upstream of Weitchpec where they have been granted Treatment in the Same Manner as a State (TAS) and set water quality standards.

In 2004, the Yurok Tribe, NCRWQCB, and PacifiCorp conducted a Klamath River periphyton study that included sites above and within the KAT, with results summarized by Eilers (2005) and Hoopa TEPA (2008).

The Karuk Tribe began cooperative water quality sampling, including nutrients, with USFWS in 2001.

The KTWQP has operated continuous water quality datasondes at several locations above and within KAT since that time for temperature, D.O., pH, and conductivity. Monitoring for toxic algae species began in 2005 and is ongoing. Periphyton sampling occurred in 2008 and 2011-2014. The KTWQP has been responsible for all of its sample collection, transportation to applicable laboratories, data storage, and data analysis related to nutrients since 2007. The KTWQP has been assisted by Aquatic Ecosystems for analysis of phytoplankton and toxic algae data. Nutrient data collected from 2001-2006 by KTWQP

underwent extensive QA/QC examination. Starting in 2016 all nutrient data has been submitted to the California Environmental Data Exchange (CEDEN) and then cross walked to EPA's STORET. Data will also be added to the comprehensive TMDL database, which is shared and augmented by the Klamath River Water Quality Monitoring Coordination Workgroup and used by the U.S. EPA and NCRWQCB for the Klamath River TMDL.

1.6 Project/Task Description

This section provides a summary of all work to be performed, products to be produced, and the schedule for implementation. This is most easily discussed in sections: Nutrient Sampling, Public Health Sampling, Continuous Monitoring, and C. Shasta sampling.

1.6.1 Nutrient Sampling

A total of eight sites will be sampled for a complete nutrient suite. Table 3 lists the KTWQP sampling sites for nutrients. The sampling area includes 147 river miles of the mainstem Klamath River upstream and within KAT and the Salmon, Scott, and Shasta Rivers above their confluence with the Klamath River. The Salmon River is within KAT, whereas the Scott and Shasta Rivers are upstream of KAT. Scott and Shasta provide excellent spawning habitat for salmonids that are harvested on the KAT, thereby serving as important tributaries to the tribe's fishery. Although the Klamath River is bordered mostly by forests and wildlands, nutrient pollution and now toxic algae are creating water quality problems in KAT. A map of specific locations of the sampling sites is shown in Figure 3.

The KTWQP will collect biweekly samples (every other week) between May and October and monthly samples between November and April, excluding the months of January and February. This schedule was selected because May-October is when nutrients impair water quality in the mainstem Klamath River. Late spring through fall are important times for juvenile salmonid (Chinook, Coho, steelhead) migration, adult spring and fall Chinook migration into the Klamath basin, and migration and rearing of lamprey and green sturgeon, which are all of great importance to the Karuk People. Water quality conditions may impact these species of importance and may also impact the use of the river for subsistence fishing, ceremonial use, other cultural use, and recreation. Although year-round biweekly sampling is preferred to understand the nutrient dynamics of the Klamath River (Asarian and Kann, 2006; Kann and Asarian, 2007), funding availability limits sampling in certain months.

At the locations previously selected, water samples will be collected with a churn splitter to ensure that the sample is homogeneously mixed before the sample bottles are filled. Depending on location, two collection methods may be used. For all sites except for WA, the churn is fully submerged into the stream

and filled to the lid with flowing water, not stagnant water. For WA, a site sampled from a bridge, a Van Dorn sampler is used to collect 3 samples from across the channel. The samples are poured into the churn and treated the same as all other sites.

Sample bottles and chemical preservatives used will be provided by Aquatic Research Inc. and Aquatic Analysts, and are considered sterile prior to field usage. Sample bottles without chemical preservatives will be rinsed with stream water from the churn three times before filling with sample water. In the case of bottles that contain chemical preservatives, bottles are not rinsed before sample collection and care is taken to avoid over-spillage that would result in chemical preservative loss. Sample bottles used for Chesapeake Biological Laboratory will be cleaned prior to the sampling event using the procedures listed in Appendix E-7. Collected samples are placed in coolers on ice for transport to contracted laboratories for analysis or to KTWQP office for filtering.

Samples being sent to Chesapeake Biological Laboratory will first be filtered at the KTWQP office according to procedures listed in section 11.1.1 of Appendix E-7.

Samples sent to Aquatic Research Inc. will be analyzed for the following parameters: Total Phosphorus, Ortho-Phosphorus, Total Nitrogen, Nitrate+Nitrite, Ammonia, Chlorophyll *a*/Phaeophytin *a*, Dissolved Organic Carbon, Total Suspended Solids, Volatile Suspended Solids, Turbidity, and Alkalinity. Samples sent to Aquatic Analysts will be analyzed for Phytoplankton. Samples sent to Chesapeake Biological Laboratory will be analyzed for Particulate Organic Carbon, Particulate Organic Nitrogen, Particulate Inorganic Phosphorus, and Particulate Organic Phosphorus.

General water quality parameters (temperature, dissolved oxygen, conductivity, and pH) will also be simultaneously measured at each site with a YSI datasonde and the data will be recorded onto the grab sample datasheet. The YSI datasonde will have been calibrated using the procedures in Appendix E-4.

1.6.2 Public Health Sampling

A total of five sites will be sampled for microcystin and one site will be sampled for anatoxin-a. Table 3 lists the KTWQP sampling sites for public health. To best monitor public health risks, water samples are collected at locations used for public access and recreation.

Public health sampling occurs biweekly (every other week) starting in June. Once high levels of microcystin are detected, sampling increases to a weekly interval. MSAE blooms and those of other toxic algae species

occur in late summer and early fall, when fishing for subsistence and ceremonial use is at its peak. Public health sampling is continued through October, or until microcystin is no longer detected.

Samples will be collected as grab samples using the same sampling protocol at all locations. At each sampling location, samplers should conduct an initial visual survey of the public access area to identify where surface grab samples would be collected to represent a reasonable maximum exposure at that public access location. Because cyanobacteria can accumulate and dissipate rapidly, depending on sun and wind conditions, a location having a greater presence of cyanobacteria should be identified within each designated public access area, where the public is likely to come into contact with cyanotoxins. This requires subjective selection by the sampler, but should be limited to locations within the public access area (e.g., roughly 50 meters). When possible, sampling crew field trainings should be conducted before the sampling season begins, and involve comparing where different samplers subjectively select to sample in an effort to normalize the selection process.

Grab samples will be performed using a clean wide-mouth jar (about 8 cm diameter and 10 cm depth) that is turned on its side and then submerged into the upper 10 cm of the water. KTWQP will follow Environmental Sampling of Cyanobacteria for Cell Enumeration, Identification and Toxin Analysis Standard Operating Procedures (Appendix E-2) to complete this sampling.

Sample bottles will be 4 oz. pre-cleaned glass thick-walled jars and are considered sterile prior to field usage. Collected samples will be labeled and promptly placed in a cooler with ice to both protect from sunlight and chill until shipped. Double-bagged wet ice or blue ice is acceptable as long as the maximum threshold temperature (6°C) for samples is not exceeded. Block ice is discouraged to protect sample bottles from breaking during shipping. The ice supply will be replenished as often as needed to maintain samples at or below 6°C, and prior to preparing coolers for shipping to the appropriate laboratories. For shipping, glass samples bottles will be protected from breakage using bubble wrap.

Samples sent to the U.S. EPA Region IX Laboratory will be analyzed for microcystin toxin using the enzyme linked immunosorbent assay (ELISA) method. Samples sent to GreenWater Laboratories will be analyzed for microcystin variants and anatoxin-a using liquid chromatography/mass spectrometry (LCMS/MS).

General water quality parameters (temperature, dissolved oxygen, conductivity, and pH) will also be simultaneously measured at each site with a YSI datasonde and the data will be recorded onto the grab sample datasheet. The YSI datasonde will have been calibrated using the procedures in Appendix E-4.

The Karuk Tribe standard for public health protection and limit of microcystin pollution level is <0.8 µg/L and anatoxin-a pollution level is <90 µg/L. KTWQP will issue warnings and communicate with all appropriate agencies should Klamath River samples exceed these thresholds.

1.6.3 Continuous Monitoring

A total of six sites will be continuously monitored using YSI datasondes. Table 3 lists the KTWQP sonde monitoring sites. Three of these stations are located at fixed points along the mainstem Klamath River (Orleans, Seiad Valley, and Iron Gate) and the other three stations are located at fixed points in tributaries (Shasta River, Scott River, and Salmon River). Figure 3 shows the locations of the sampling stations. These stations create a longitudinal profile of water entering and exiting the Mid-Klamath region. The tributary sites are located near their mouths to highlight their influence on the mainstem Klamath River. These tributaries also support abundant runs of spring and fall chinook, coho, steelhead, lamprey, and sturgeon (Salmon River only).

Water quality parameters to be sampled for each site are Temperature, Specific Conductivity, pH, and Dissolved Oxygen. In addition to these parameters, the mainstem stations will monitor Turbidity and Blue Green Algae (using a phycocyanin probe). Two of the tributary stations, Scott River and Salmon River, will also monitor Turbidity.

All of the stations will continuously monitor using a YSI datasonde. The sondes will be fixed to a cable and protected by a metal pipe which will suspend the probes to avoid damage to equipment. The stations at Orleans, Salmon River, Scott River, and Shasta River will deploy a YSI 6600 V2 datasonde. The stations at Seiad Valley and Iron Gate will deploy a YSI EXO2 datasonde.

This sampling focuses around the summer base flow (the growing season), which is generally from MayOctober. All six sites will be deployed during these months. A reading will be taken every 30 minutes and the data will be available real-time on the KTWQP website. The Iron Gate site and the Salmon River site will be deployed year-round with plans to implement year round monitoring at all Klamath River mainstem site Fall of 2018.

Datasondes will be calibrated at a biweekly (every other week) interval following YSI instructions and other standard procedures for calibration (U.S. EPA, 2001) that are attached as Appendices E-4 and E-5. Every winter the YSI datasondes will be sent back to the factory for preventative maintenance and any defective sensors will be replaced.

This monitoring will help discover whether there are water quality problems with waters within or adjacent to the KAT and the KTWQP will report any findings of action levels of contaminants and work to abate any identified problems.

1.6.4 Ceratonova Shasta

The Karuk Tribe collects c.shasta water samples at five monitoring stations. These sites are termed Orleans (KOR), Seiad Valley (KSV), Kinsman Fish Trap (KMN), Beaver Creek (KBC), and I-5 Bridge (KI5) and their locations are shown in Figure 4. Water collection will occur at the following sites according to the following schedule:

(1) Weekly all year at Beaver Creek and Seiad Valley (to encompass previous and current spring parasite 'hot spots')

(2) Weekly from March through October at I-5 Bridge and Orleans

(3) March through mid-June at Kinsman Fish Trap

Water samples will be collected using an ISCO automatic sampler. The ISCO will be programmed to begin sampling at 8 am and collect 1 L of water from the river every 2 hours for 24 hours. After the completion of the program, the total sample will be mixed manually and 4 x 1 L samples will be poured into clean 1 L sample bottles. All samples will be transported back to the KTWQP office in a cooler with ice. KTWQP will filter the samples within 24 hours of collection according to protocols found in Appendix E-8.

Samples will be sent overnight to Bartholomew Lab at Oregon State University for molecular analysis.

1.7 Quality Objectives and Criteria for Measurement Data

This section discusses the quality objectives for the project and the performance criteria to achieve those objectives.

1.7.1 Project Objectives

The primary goal of this *QAPP* is to ensure that high quality data be generated by the KTWQP that this data can be used to answer questions about the quality of waters within KAT and to foster their protection or improvement over time. Specific questions to be answered through these studies include:

1) What are current in-river conditions?

2) What are current nutrient levels?
3) Are there nutrient levels indicative of pollution in the Klamath River, including reaches within the KAT?
4) What are the levels of MSAE and microcystin toxin in the Klamath River, including reaches within the KAT?
5) Are there other potentially toxic blue-green species present in the Klamath River and algal toxins other than the most common microcystin variant?
6) What is the Ceratonova Shasta parasite density during salmonid spring out-migration and fall inmigration?

KTWQP investigations occur within and above KAT. YTEP and Hoopa will provide data to answer the same questions for downstream reaches. In the longer term, these samples will show pollution variation between water years and provide a basis to judge effectiveness of short-term and long-term management and regulatory actions taken to abate pollution throughout the Klamath River Basin. This will also allow participation of Tribes as resource co-managers and as full partners in adaptive management. Within the KAT specifically, the data may be used as justification for improvement of standards needed to protect Tribal members, the public and other beneficial uses.

Evidence gathered will help regulating agencies make informed decisions off of the 401 certification of the KHP and Klamath TMDL and prompt further action on non-point source pollution from agriculture through mechanisms such as the Klamath River and Lost River TMDL implementation. In the short term, action will be taken immediately to inform appropriate agencies and the public when dangerous levels of blue-green algae cell counts or toxins are discovered.

The Tribe's primary concern with surface water is to minimize the effects of human activity in the watershed, to bolster the health of the ecosystem, to preserve cultural resources, and to return fish populations to a sustainable level enabling tribal members to utilize their fishing rights. Current numbers of returning salmonids will not support a fishery on KAT as it once did.

1.7.2 Decisions to be made using the data

The surface water monitoring program is designed to characterize the surface water resources of MidKlamath. The baseline data generated from 2005-present provides valuable information about the current condition of the Klamath River Basin's water resources. On-going monitoring allows the Tribe to begin to track changes in water quality over time and to assess current and potential future environmental impacts to Klamath River water quality.

Decisions to be made with the data include:

- If data for any analyte or field parameter (from an individual location or single quarterly sampling event) are found to exceed the project action limits, then the Tribal Council will be notified.
- If data are found to exceed the project action limits and appear to be increasing with time, then the Tribal Council will be notified and a plan for future investigations of potential sources will be discussed.
- If waters flowing onto KAT are impaired (i.e., exceed project action limits or the national water quality standards), then the issue will be brought to the attention of the Tribal Council for possible discussion with the US EPA Project Officer.

The Karuk Tribe will determine if any action is needed to reduce surface water pollution from tribal lands. Some examples of actions that could result from findings of poor water quality on KAT are:

- Remediation activities for point sources to stop contamination if a single point source is suspected.
- Stream and watershed restoration activities (e.g. planting native flora for erosion control).
- Pollution prevention planning and establishment of educational programs on KAT to reduce anthropogenic sources of pollution.

The Karuk Tribe will also use this information to act as co-managers in the Klamath River Watershed with federal, state, and local agencies. The information will be shared with these agencies in order to track changes over time and to ultimately improve the quality and quantity of fish populations in the watershed.

1.7.3 Action Limits/Levels

Specific water quality limits and levels are found in tables 5-8.

1.7.4 Measurement Performance Criteria/Acceptance Criteria

Data quality indicators (DQI) include accuracy, precision, comparability, completeness, representativeness, and sensitivity. The quality control criteria established by KTWQP for data gathering, sampling, and analysis activities assures that important data gaps regarding Klamath River nutrient and toxic algae pollution can be filled with scientifically accurate data.

The general approach to assessing each DQI is described below. Some DQIs will be assessed quantitatively, while others will be assessed qualitatively. For quantitative assessments, example calculations have been provided and the QC samples (to assess each DQI) have been identified.

The frequency of the QC samples and the measurement performance criteria for each QC sample for each type of analysis are provided in Table 12. For quantitative assessment of laboratory methodology, the laboratory's QA Manual and analytical SOPs have been reviewed by the Karuk Tribe's project team, and the associated laboratory QC (types & frequencies of QC samples and QC acceptance limits) have been determined to be adequate in meeting the data quality needs of the project. As such, the laboratory QC has been accepted as the project's measurement performance criteria for the analytical component, while project-specific criteria have been defined to assess the field sampling component.

For field measurements, the DQIs to be assessed quantitatively include precision and accuracy alone. The associated acceptance criteria (types & frequencies of QC checks and acceptance limits) for the project are summarized in Table 12 and 13.
Data quality will be assured by:

- Proper study design,
- Following standard methods,
- Using well calibrated equipment,
- Taking and maintaining good field records,
- Following chain of custody procedures for laboratory analysis,
- Prompt data entry in standard programs and formats, Data archiving with back-ups to insure against loss, and Proper oversight of QA/QC procedures.

The primary DQI specific to this project is whether uncertainty associated with each measurement is low enough to provide sufficient resolution to determine values relative to the above references.

Accuracy: *Accuracy* is the degree of agreement of a measurement with the true value. Accuracy includes a combination of random error (precision) and systematic error (bias) that result from sampling and analytical operations. Accuracy of water quality and quantity measurements contained in this QAPP is a function of the equipment used during sampling.

Accuracy/bias will be assessed as related to recovery, as well as in regards to potential contamination sources. Both of these terms will be evaluated quantitatively.

Accuracy/bias related to recovery is an assessment of the laboratory analytical methods alone. For Laboratory Control Samples (LCS), it will be expressed as % Recovery by the following equation:

$$\% \text{ Recovery} = \frac{X}{} \times 100$$

T

where,

X = Measured concentration

T = True spiked concentration

or, for Matrix Spike (MS) samples, by the following equation:

$$\% \text{ Recovery: } \frac{Xms - Xfs}{Xa} \times 100$$

where,

Xms = the amount of target analyte measured in the matrix spike sample

Xfs = the amount of target analyte measured in the corresponding field sample

Xa = the amount of target analyte spiked (into the matrix spike sample)

The frequency of the LCS and/or MS samples associated with the analytical parameters will be one for every 20 samples or 5%. No LCS or MS samples will be analyzed as part of the field measurements.

Accuracy/bias as related to contamination involves both a field sampling and laboratory component. To assess all steps of the project (from sample collection through analysis), field blanks will be collected and analyzed. Field blanks are planned to be collected at a frequency of 5% (or 1 blank/20 field samples) for off-site analysis of metals and anions. To assess potential laboratory contaminant sources alone, laboratory blanks will be prepared and analyzed at a one per batch or 5% frequency. No blanks will be analyzed as part of the field measurements.

Precision of field results will be tested using duplicate samples, taken as field splits, with a target of less than 20% relative percent difference (RPD).

Precision: *Precision* is a measure of agreement among replicate measurements of the same property, under prescribed similar conditions.

Precision will be assessed quantitatively with duplicate samples and expressed as relative percent difference (RPD) by the following equation:

$$RPD\ (\%) = \frac{|X_1 - X_2|}{} \times 100$$

$(X_1 + X_2)/2$

where,

RPD (%) = relative percent difference

X_1 = Original sample concentration

X_2 = Duplicate sample concentration

$|X_1 - X_2|$ = Absolute value of $X_1 - X_2$

To assess precision associated with all steps of the project (from sample collection through analysis) field duplicates will be collected and analyzed. Field duplicates will be collected at a frequency of 10% (1 duplicate/10 field samples) for each analytical parameter and 5% (1 duplicate each of 2 days/10 field samples) for each field measurement parameter. To assess laboratory precision alone, laboratory duplicates will be prepared and analyzed at a 5% frequency.

Comparability: Samples will be taken with comparable methods across the universe of samples on the Klamath River and its tributaries so the results will be comparable within each year. Methods are also consistent with previous samples that make up baseline and trend data for nutrients, phytoplankton, periphyton and algal toxins.

Completeness: Given the high quality of past samples taken by KTWQP, completeness on this project is expected to be over 90%, which is highly desirable because samples will only be taken bi-weekly.

Representativeness: This is the expression of the degree to which data accurately and precisely represent a characteristic of an environmental condition or a population. Field crews collecting samples will ensure representativeness of samples by selecting free-flowing water from established sampling locations and using a churn splitter to mix sample water once collected (Lurry and Kolbe, 2000) and by following protocols for public health sampling and c. Shasta sampling.

See Table 10 for comparability measures and detection limits for nutrient samples, including U.S. EPA or American Public Health Association (APHA) (Eaton et al., 1995) approved sampling methods.

Sensitivity: The ability of a method to detect and quantify an analytical parameter of concern at the concentration level of interest will be assessed semi-quantitatively. No actual QC samples are involved. Instead, the laboratory to perform the analyses has provided their QLs and DLs and demonstrated that these are lower than the project action limits (as shown in Tables 5, 6, 7 and 8) for the majority of the analytical parameters. For field measurements, the sensitivity is defined by the instrument manufacturer (Table 9).

1.8 Special Training Requirements/Certificates

No special training of field personnel is required for this project. The WQPM is an experienced scientist who has been leading and training employees in conducting water quality investigations since 2004. She has been trained by and/or worked with the US Forest Service, the Pacific Southwest Field Station, US Geological Survey, the North Coast Regional Water Quality Control Board, the Klamath Basin Monitoring Program, the Klamath Blue Green Algae Work Group, and the California Harmful Algae Bloom to standardize water quality monitoring protocols. Equipment used includes HOBO temp loggers, flow meters, and hydolabs / data sondes and sampling includes nutrient and phytoplankton grabs, public health monitoring for harmful algae blooms, and periphyton surveys. The KTWQP Project Manager will oversee initial sampling events to ensure that field staff is following the guidelines of this QAPP.

The WQ Technician will keep clear records about how instructions from the Program Manager were followed and make notes about any conditions that might cause anomalies in data. The KTWQP QA Officer will inspect the field and sampling equipment and periodically audit the WQ Technician to make sure that proper maintenance is taking place and is being documented.

The collection of all surface water samples using hand held equipment will use standard field methods as described in this QAPP, which are derived from recognized U.S. EPA (1983; 2004) and U.S. Geologic Survey (USGS, 1998) protocols.

1.9 Documents and Records

This section describes the process and responsibilities for ensuring the appropriate project personnel have the most current approved version of the QA Project Plan, including version control, updates, distribution, and disposition.

1.9.1 QA Project Plan Distribution

It is the responsibility of the KTWQP Program Manager/QA Officer to prepare and maintain amended versions of the QA Project Plan and to distribute the amended QA Project Plan to the individuals listed in Section 1.3. This QAPP, once approved, will be kept in printed form for ease of reference of the WQ Technician, QA Officer and KTWQP Program Manager. When updated plans are approved, one copy of an older version will be retained in the KTWQP library, but clearly stamped to indicate that it is no longer current. In addition, each page of the QAPP will be clearly labeled as to the version and date of revision.

1.9.2 Field Documentation and Records

In the field, records will be documented in several ways, including field logbooks, photographs, preprinted forms (such as labels and chain-of-custody forms), corrective action reports, and field audit checklists and reports. Field activities must be conducted according to this QAPP. All documentation generated by the sampling program will be kept on file in the office of the Karuk Tribe Water Quality Program.

1.9.2.1 Field Notebooks

Bound field logbooks will be used to record field observations, sampling site conditions, and on-site field measurements. These books will be kept in a permanent file in the KTWQP office. At a minimum, information to be recorded in the field logbooks at each sample collection/measurement location includes:

- Sample location and description,
- Sampler's names,
- Date and time of sample collection,
- Designation of sample as composite or grab,
- Type (media or matrix) of sample (for this project, all are surface water samples),
- Type of sampling equipment used,
- Type of field measurement instruments used, along with equipment model and serial number,
- Field measurement instrument readings,
- Field observations and details related to analysis or integrity of samples (e.g., weather conditions, noticeable odors, color),
- Preliminary sample descriptions (e.g., clear water with strong ammonia-like odor),
- Sample preservation,
- Lot numbers of the sample containers, sample identification numbers and any explanatory codes,
- Shipping arrangements (overnight air bill number), and Name(s) of recipient laboratory(ies).

In addition to the sampling information, the following specific information will also be recorded in the field logbook for each day of sampling:

- Team members and their responsibilities,
- Time of arrival/entry on site and time of site departure,

- Other personnel on site,
- Deviations from the QAPP or SOPs required in the field, and
- Summary of any meetings or discussions with tribal, contractor, or federal agency personnel.

Separate instrument/equipment notebooks or logbooks will be maintained for each piece of equipment or instrument. These logbooks will be used to record field instrument calibration and maintenance information. Each logbook will include the name, manufacturer, and serial number of the instrument/equipment, as well as dates and details of all maintenance and calibration activities.

1.9.2.2 Photographs

Digital photographs will be taken at each sampling location and at other areas of interest near the sampling area for every sampling event. The photographs will serve to verify information entered into the field logbook. Photographs will include a date and time stamp on each picture. Digital photographs will be archived in a permanent digital file to be kept in the KTWQP office.

For each photograph taken, the following information will be written in the field logbook or recorded in a separate field photography logbook:

- Time, date, location, and weather conditions
- Description of the subject photographed
- Direction in which the picture was taken
- Name and affiliation of the photographer

1.9.2.3 Labels

All samples collected will be labeled in a clear and precise way for proper identification in the field and for tracking in the laboratory. The Laboratory will provide sample labels (see Appendix A1) for this project. The samples will have pre-assigned, identifiable, and unique numbers. At a minimum, the sample labels will contain the following information:

- Sampling location or name,
- Unique sample number,
- Sample description (e.g., grab, composite),
- Date and time of collection,

- Initials/signature of sampler,
- Analytical parameter(s), and Method of preservation.

Each sample for a given parameter will have a unique identifier. The sample identification numbering scheme is site, date, and method of collection (e.g. open water composite or surface grab).

Example sample label *SA032211-OC*

SA = site identification

032211 = date

OC = Open Channel

1.9.2.4 Field Quality Control Sample Records

Field QC samples (duplicates and blanks) will be labeled as such in the field logbooks. They will be given unique (fictitious) sample identification numbers and will be submitted "blind" to the laboratory (i.e., only the field logbook entry will document their identification and the laboratory will not know these are QC samples). The frequency of QC sample collection will also be recorded in the field logbook.

1.9.2.5 Chain-of-Custody Forms and Custody Seals

Chain-of-custody forms and custody seals (see Appendix A-2) will be provided by the laboratory. The forms will be used to document collection and shipment of samples for off-site laboratory analysis, while the seals will serve to ensure the integrity of (i.e., there has been no tampering with) the individual samples.

All sample shipments will be accompanied by a chain-of-custody form. The forms will be completed and sent with each shipment of samples to the laboratory. If multiple coolers are sent to a laboratory on a single day, forms will be completed and sent with the samples for each cooler. The original form will be included with the samples and sent to the laboratory. Copies will be sent to the KTWQP Program Manager/QA Officer.

The chain-of-custody form will identify the contents of each shipment and maintain the custodial integrity of the samples. Generally, a sample is considered to be in someone's custody if it is either in someone's physical possession, in someone's view, locked up, or kept in a secured area that is restricted to authorized personnel. Until the samples are shipped, the custody of the samples will be the responsibility of the field

personnel, who will sign the chain-of-custody form in the "relinquished by" box and note the date, time, and air bill number.

The shipping containers in which samples are stored will also be sealed with self-adhesive custody seals any time they are not in someone's possession or view before shipping, as well as during shipping. All custody seals will be signed and dated.

1.9.3 Laboratory Documentation and Records

The analytical laboratory will keep a sample receiving log and all completed chain-of-custody forms submitted with the samples collected for this project. The analytical laboratory will also keep records of all analyses performed, as well as associated QC information, including: laboratory blanks, matrix spikes, laboratory control samples, and laboratory duplicates. Hard copy data of the analytical results will be maintained for six years by the laboratory.

The data generated by the laboratory for each sampling event will be compiled into individual data packages/reports. The data packages will include the following information:

- Project narrative including a discussion of problems or unusual events (including but not limited to the topics such as: receipt of samples in incorrect, broken, or leaking containers, with improperly or incompletely filled out chain-of-custody forms, with broken chain-of-custody seals, etc.; receipt and/or analysis of samples after the holding times have expired; summary of QC results exceeding acceptance criteria; etc.),

- Sample results and associated QLs,

- Copies of completed sample receiving logs and chain-of-custody forms, and

- QC check sample records and acceptance criteria (to be included for all QC samples listed in Table 12, including the temperature blank check).

All data packages will be reviewed by the Laboratory QA Officer to ensure the accurate documentation of any deviations from sample preparation, analysis, and/or QA/QC procedures; highlights of any excursions from the QC acceptance limits; and pertinent sample data. Once finalized, the Laboratory QA Officer will

provide the data packages/reports to the Laboratory Project Manager who will sign them and submit them to the KTWQP Program Manager/QA Officer. Laboratories will provide the following QC data for each parameter analyzed; laboratory duplicate results and associated RPD, spike results and associated % recovery, blank results, and QC check information. Any problems identified by the Laboratory QA Officer will be documented in the narrative part of the tribe's report.

Information about the documentation to be provided by the analytical laboratory is also contained in each laboratory's QA Manual (Appendix A-3).

1.9.4 Technical Reviews and Evaluations

As part of the QA efforts for the project, on-going technical reviews will be conducted and documented. These reviews are associated with both field activities and the data generated by the off-site laboratory.

1.9.4.1 Field Audit Reports

The KTWQP Program Manager/QA Officer will observe selected sampling events to ensure that sample collection and field measurements are going according to plan. The results of the observations will be documented in a designated QA Audit Logbook. Once back in the office, the KTWQP QA Officer will formalize the audit in a Field Audit Report to be forwarded to the KTWQP Program Manager and the KTWQP Water Quality Technician/Field Sampler.

1.9.4.2 Corrective Action Reports (following Field Audits)

Corrective action reports will be prepared by the KTWQP Water Quality Technician/Field Sampler in response to findings identified by the KTWQP Program Manager/QA Officer during field visits and audits. The reports will focus on plans to resolve any identified deficiencies and non-compliance issues that relate to on-going activities and problems of a systematic nature, rather than on one-time mistakes. Corrective Action reports do not have a specific format, but will be handled as an internal memorandum.

1.9.4.3 Field Activities Review Checklist

At the end of each sampling event, a technical review will be conducted of field sampling and field measurement documentation to ensure that all information is complete and any deviations from planned methodologies are documented. This review is described in Section 3.1.1.3. The review, as well

as comments associated with potential impacts on field samples and field measurement integrity, will be documented on a Field Activities Review Checklist (as provided in Appendix B-1).

1.9.4.4 Laboratory Review Checklist

Following receipt of the off-site laboratory's data package for each sampling event, The KTWQP QA Officer/Data Manager will conduct a technical review of the data to ensure all information is complete, as well as to determine if all planned methodologies were followed and QA/QC objectives were met. The results of this review, as well as comments associated with potential impacts on data integrity to support project decisions, will be documented on a Laboratory Data Review Checklist (as provided in Appendix B-2).

1.9.5 Project Document Backup and Retention

Hardcopies of field notebooks, checklists, laboratory results and other paperwork will be maintained in the KTWQP office water quality file for six years. After six years, project files will be placed in long term storage. The Tribe's policy is to maintain records indefinitely.

Electronic data will be backed up on two separate external hard-drives. One external hard-drive will be stored in the Karuk Tribe Department of Natural Resources office and the second external hard-drive will be stored in a fireproof safe in the KTWQ office.

1.9.6 Annual Reports

The KTWQP Program Manager/QA Officer is responsible for the preparation of annual reports (summarizing the year's activities) to be submitted to the US EPA Grants Project Officer.

The annual reports should include, at a minimum:

- Description of the project,
- Table summarizing the results (of all project data collected to date, including both laboratory data and field measurements),
- Final laboratory data package (including QC sample results),
- Discussion of the field and laboratory activities, as well as any deviations or modifications to the plans,
- Trends observed as a result of the year's monitoring efforts,
- Copies of Field Audit Reports and any associated Corrective Action Reports,
- Copies of Field Activities Review Checklists and Data Review Checklists,

- Evaluation of the data in meeting the project objectives, including data exceeding Action Levels,
- Recommendations to the Tribal Council regarding exceedance which are occurring on an ongoing basis, and
- Recommendations/changes for future project activities (e.g., adding/deleting sampling locations and/or analyses, modifications to SOPs, amendments to the QA Project Plans, etc.).

2.0 DATA GENERATION AND ACQUISITION

This section of the QA Project Plan describes how the samples will be collected, shipped, and analyzed.

2.1 Sampling Design

2.1.1 Nutrient Sampling Design

A total of eight locations will be sampled for the surface water monitoring program. These locations will be along the Klamath River and at the mouths of major tributaries. Sample sites are in locations that provide a longitudinal profile of the Klamath River from Iron Gate Reservoir to Orleans. Also included are inputs from the Shasta, Scott and Salmon Rivers. Sampling locations are depicted in Figure 3. The sample parameters to be collected at each site are summarized in Table 4. The sample locations, names, and rationale for selecting each site are summarized in greater detail as follows:

- OR (Klamath River at Orleans) – Located just upstream of the USGS gauge. Conditions are indicative of the Klamath River at the downriver end of the KAT.
- SA (Salmon River near mouth) – Conditions of the Salmon River, an important tributary that enters the Klamath River near the center of the world for the Karuk Tribe. Site of a USGS gauge. Major tributary that provides habitat for all Tribal Trust fish species.
- HC (Klamath River below Happy Camp) – About a ¼ mile upstream of Oak Flat Creek.
- SV (Klamath River below Seiad Valley) – This site is just downstream of Seiad Valley but upstream of the USGS gauge. This is near the upstream end of the KAT thereby indicative of water quality conditions entering the KAT.
- SC (Scott River at Johnson's Bar) – This site is about one mile up from the confluence of the Scott and Klamath Rivers. It represents water quality conditions coming out of the lower canyon reach of the Scott River.
- WA (Klamath River at Walker Bridge) – This site is located between two major tributaries, the Scott and Shasta Rivers and is downriver of the town of Klamath River. This site

provides water quality information after the effects of the KHP have been reduced but before entering the KAT where more minor tributaries enter the River.

- SH (Shasta River at USGS Gauge) – This site is located at the USGS gauge and is upstream of the confluence about 300 meters.
- IG formerly KRBI (Klamath River below Iron Gate) – This site is located immediately downstream of Iron Gate dam and upstream of the USGS gauge. It is the start of the free-flowing River below the KHP.

The baseline monitoring program will include monthly to bimonthly analyses throughout the year at 8 locations identified shown in Figure 3. Analyses will include alkalinity, total phosphorus (TP), orthophosphate (SRP), ammonia, nitrate and nitrite, total nitrogen (TN), chlorophyll a, pheophytin, total organic carbon (TOC), dissolved organic carbon (DOC), total dissolved solids (TDS), and volatile suspended solids (VSS). Sample locations will also be field tested for temperature, pH, dissolved oxygen, conductivity (as specific conductance), turbidity in the winter, and BGA in the summer. Additionally, photo documentation will occur at each sampling location during every sampling event.
Site specific analyses are found in Table 4.

Samples will be collected throughout each calendar year. In addition, a parameter may be removed from the monitoring program if the sampling results indicate it is not of concern or added if new land uses develop after the monitoring program begins or the monitoring data indicates other potential parameters to include. If the sample collection changes, this will be noted in the quarterly reports to the US EPA Grants Project Manager and documented in an amendment to the QA Project Plan.

2.1.2 Public Health Sampling Design

A total of five sites will be sampled for microcystin and one site will be sampled for anatoxin-a. Table 3 lists the KTWQP sampling sites for public health and Figure 3 identifies the specific locations. The site specific analyses are listed in Table 4. To best monitor public health risks, water samples are collected at locations used for public access and recreation. The sample locations, names, and rationale for selecting each site are summarized in greater detail as follows:

- OR (Klamath River at Orleans) – Located just upstream of the USGS gauge. Conditions are indicative of the Klamath River at the downriver end of the KAT.
- HC (Klamath River below Happy Camp) – About a ¼ mile upstream of Oak Flat Creek.
- SV (Klamath River below Seiad Valley) – This site is just downstream of Seiad Valley but upstream of the USGS gauge. This is near the upstream end of the KAT thereby indicative of water quality conditions entering the KAT.
- BB (Brown Bear River Access) – Labeled USFS river access sign in the town of Klamath River.

- IB-This site is located at the Colliers rest stop by the I-5 bridge.

Public health sampling occurs biweekly (every other week) starting in June. Once high levels of microcystin are detected, sampling increases to a weekly interval. MSAE blooms and those of other toxic algae species occur in late summer and early fall, when fishing for subsistence and ceremonial use is at its peak. Public health sampling is continued through October, or until microcystin is no longer detected.

2.1.3 Continuous Monitoring Sampling Design

The KTWQP will conduct year round continuous monitoring at three maintstem Klamath River sites (OR, SV, IG) and Salmon River (SA) and six sites during the spring, summer and fall months (OR, SA, SV, SC, SH, and IG). Monitoring locations are summarized in Figure 3. The sample locations, names, and rationale for selecting each site are summarized in greater detail as follows:

- OR (Klamath River at Orleans) – Located at the USGS gauge. Conditions are indicative of the Klamath River at the downriver end of the KAT.
- SA (Salmon River near mouth) – This site is located at a USGS gauge. Conditions of the Salmon River, an important tributary that enters the Klamath River near the center of the world for the Karuk Tribe. Major tributary that provides habitat for all Tribal Trust fish species.
- SV (Klamath River below Seiad Valley) – This site is located at the USGS gauge and is downstream of Seiad Valley. This is near the upstream end of the KAT and is thereby indicative of water quality conditions entering the KAT.
- SC (Scott River at Roxbury Bridge) – This site is about 1/2 mile up from the confluence of the Scott and Klamath Rivers. It represents water quality conditions coming out of the lower canyon reach of the Scott River.
- SH (Shasta River at USGS Gauge) – This site is located at the USGS gauge and is upstream of the confluence about 300 meters.
- IG (Klamath River below Iron Gate) – This site is located at the USGS gauge and is immediately downstream of Iron Gate. It is the start of the free-flowing River below the KHP.

For the continuous monitoring project, a reading will be taken every 30 minutes by a YSI datasonde. Each reading will include the parameters: temperature, conductivity (as specific conductance), pH, dissolved oxygen (% saturation and mg/L), turbidity (at all sites except SH), and BGA (at OR, SV, IG).

2.1.4 Ceratonova Shasta Sampling Design

The KTWQP will conduct C.Shasta monitoring at five sites along the Klamath River. The sites are determined by Bartholomew Laboratory at Oregon State University. These sites are Orleans (KOR), Seiad Valley (KSV), Kinsman Fish Trap (KMN), Beaver Creek (KBC), and I-5 Bridge (KI5) and their locations are shown in Figure 4. Water collection will occur at the following sites according to the following schedule:

(1) Weekly all year at Beaver Creek and Seiad Valley (to encompass previous and current spring parasite 'hot spots')

(2) Weekly from March through October at I-5 Bridge and Orleans

(3) Weekly from March through mid-June at Kinsman Fish Trap

Water samples will be collected using an ISCO automatic sampler. The ISCO will be programmed to begin sampling at 8 am and collect 1 L of water from the river every 2 hours for 24 hours. After the completion of the program, the total sample will be mixed manually and 4 x 1 L samples will be poured into clean 1 L sample bottles. All samples will be transported back to the KTWQP office in a cooler with ice. KTWQP will filter the samples within 24 hours of collection according to protocols found in Appendix E-8. Additionally, temperature loggers (Hobos) attached to each ISCO will record river temperature every 15 minutes.

2.2 Sampling Methods

2.2.1 Nutrient Sampling Methods

KTWQP follows standard water quality grab sample procedures for nutrients sampling using a churn to mix samples and following an appropriate regimen of blanks, duplicates and other steps to assure quality.

Equipment/Materials Field equipment for nutrient samples include a churn splitter, van dorn sampler, bottles provided by laboratories, and a YSI datasonde.
The following are the items on the KTWQP nutrient sampling check list that staff refer to before going into the field to collect nutrient or phytoplankton data:

1. Portable Water Quality instrument = YSI datasonde,
2. Ice (in bottles or packs),
3. Sample Bottles,
4. Camera,
5. Extra labels for sample bottles,
6. Coolers,
7. Churn splitter,
8. Van Dorn sampler,
9. Clip board,
    a. Data sheet
    b. Pencils
    c. Permanent markers
    d. Field notebook
    e. Chain of Custody forms
    f. Protocol Instructions
    g. Shipping forms
10. Watch,
11. Waders and boots,
12. Distilled Water- 5+ gallons, and
13. Shipping boxes, packing material, packing tape.

Decontamination For all samples collected to be sent to Aquatic Research Inc., samples will be collected directly into sample bottles/containers provided from the laboratory. As such, no field decontamination of these bottles (used as the sampling equipment) is necessary. The bottles will be provided and certified clean by the laboratory according to procedures described in the laboratory's QA Manual provided in Appendix A-3.

For all samples collected to be sent to Aquatic Analysts, samples will be collected directly into sample bottles provided from the laboratory. Sample bottles contain a chemical preservative (Lugols Iodine) and are considered sterile prior to field usage.

For all samples collected to be sent to Chesapeake Biological Laboratory, samples will be collected directly into sample bottles which have previously been cleaned in the KTWQP office. As such, no field decontamination of these bottles is necessary. The bottles will be cleaned using the following procedure:

- Non-phosphate detergent and tap water wash (using a brush, if necessary),
- Tap-water rinse,
- 10 % HCl rinse (twice), and
- Deionized/distilled water rinse (three times).

Decontamination of the field equipment, churn splitter and van dorn sampler, will be completed in the KTWQP office prior to the sample event. They will be cleaned according to US EPA Region 9 recommended procedures using the following washing fluids in sequence:

- Non-phosphate detergent and tap water wash (using a brush, if necessary),
- Tap-water rinse, and
- Deionized/distilled water rinse (twice).

The churn splitter requires cleaning with distilled water in the field after use at each sampling location (see Churn Cleaning SOP, Appendix E-3).

In the case that there is a need to collect surface water samples by an alternative method, decontamination of reusable sampling equipment coming in direct contact with the samples will be necessary. Decontamination will occur prior to each use of a piece of equipment and after use at each sampling location. Disposable equipment (intended for one-time use) will not be decontaminated but will be packaged for appropriate disposal. All reusable/non-disposable sampling devices will be decontaminated according to US EPA Region 9 recommended procedures using the following washing fluids in sequence:

- Non-phosphate detergent and tap water wash (using a brush, if necessary),
- Tap-water rinse, and
- Deionized/distilled water rinse (twice).

Equipment will be decontaminated in a predesignated area on plastic sheeting. Cleaned small equipment will be stored in plastic bags. Materials to be stored more than a few hours will also be covered.

Procedures

1. Upon arriving at a sampling location, a field measurement will be taken using a YSI datasonde and recorded on the data sheet. The parameters recorded will be temperature, conductivity, pH, dissolved oxygen, and turbidity or BGA.

2. Photos will be taken looking upriver and downriver of the sampling location.

3. Water samples will be collected with a churn splitter to ensure that the sample is homogeneously mixed before the sample bottles are filled. Depending on location, two collection methods may be used. For all sites except for WA, the churn is fully submerged into the stream and filled to the lid with flowing water, not stagnant water. For WA, a site sampled from a bridge, a Van Dorn sampler is used to collect 3 samples from across the channel. The samples are poured into the churn and treated the same as all other sites. Prior to filling the churn for nutrient sampling, the churn will be rinsed three times with distilled water. The goal of rinsing is to remove substances adhering to equipment from previous exposure to environmental and other media (Lurry and Kolb, 2000). After rinsing with distilled water, the churn is rinsed three times with stream water. Samples are collected from uniformly mixed water by wading out into the water channel from the bank and the churn is fully submerged into the stream and filled to the lid with sample water. Completely filling the churn allows for all sample bottles to be filled from one churn; thereby minimizing differences in water properties and quality between samples.

   Proper use of the churn guarantees that the water is well mixed before the sample is collected. The churn should be stirred at a uniform rate by raising and lowering the splitter at approximately 9 inches per second while bottles are being filled (Bel-Art Products, 1993). If filling is stopped for some reason, the stiffing rate must be resumed before the next sample is drawn from the churn. As the volume of water in the churn decreases, the round trip frequency increases as the velocity of the churn splitter remains the same. Care must be taken to avoid breaking the surface of the water as the splitter rises toward the top of the water in the churn.

   Sample bottles without chemical preservatives will be rinsed with stream water from the churn three times before filling with sample water. In the case of bottles that contain chemical preservatives, bottles are not rinsed before sample collection and care is taken to avoid overspillage that would result in chemical preservative loss.

4. Clearly label each sample container so that each sample is uniquely identified and includes the following information: the water body name, station location, date and time collected, sampler's name, type of sample (e.g. open churn), sample depth, and type of analysis.

5. Collected samples are placed in coolers on ice for transport to contracted laboratories for analysis or to KTWQ office for filtering.

Field Variances As conditions in the field vary; it may become necessary to implement minor modifications to the sampling procedures and protocols described in this QA Project Plan. If/when this is necessary; the KTWQP Technician will notify the KTWQP Project Manager/QA Officer of the situation to obtain a verbal approval prior to implementing any changes. The approval will be recorded in the field logbook. Modifications will be documented in the Annual Report to the US EPA Grants Project Officer.

2.2.2 Public Health Sampling Methods

For public health sampling, KTWQP follows the Cyanobacteria Sampling SOP prepared by the Blue Green Algae Working Group (Appendix E-2).

Equipment/Materials The following are the items on the KTWQP public health sampling check list that staff refer to before going into the field to collect algal toxin data:

1. Portable Water Quality instrument = YSI datasonde,
2. Ice (in bottles or packs),
3. Sample Bottles,
4. Camera,
5. Extra labels for sample bottles,
6. Coolers,
7. Wide-mouth sampling jar (about 8 cm diameter and 10 cm depth),
8. Clip board,
    a. Data sheet
    b. Pencils
    c. Permanent markers
    d. Field notebook
    e. Chain of Custody forms
    f. Protocol Instructions
    g. Shipping forms
9. Watch,
10. Waders and boots,
11. Distilled Water- 1 gallon, and
12. Shipping boxes, packing material, packing tape.

Decontamination For all samples collected for public health sampling, sample bottles will be 4 oz. precleaned thick-walled glass jars and are considered sterile prior to field usage. As such, no field decontamination of these bottles is necessary.

Decontamination of the wide-mouth sampling jar will be completed in the KTWQP office prior to the sample event. It will be cleaned according to recommended procedures using the following washing fluids in sequence:

- Non-phosphate detergent and tap water wash (using a brush, if necessary),
- Tap-water rinse, and
- Deionized/distilled water rinse (twice).

The wide-mouth sampling jar requires cleaning with distilled water in the field after use at each sampling location.

Procedures

1. Upon arriving at a sampling location, an initial visual survey of the public access area is conducted. The exact collection location is then identified to best represent the maximum toxic algae exposure.

2. A field measurement will be taken using a YSI datasonde and recorded on the data sheet. The parameters recorded will be temperature, conductivity, pH, dissolved oxygen, and turbidity or BGA.

3. Photos will be taken looking upriver and downriver of the sampling location.

4. Open clean wide-mouth sampling jar. Tip opening of jar towards the water (at approximately a 45 angle) and slowly break water surface and begin to dip jar into the water. Turn the sampling container so that bottom side of jar is 8 cm below and horizontal to the surface. In other words, the jar will fully enter the water, but the top rim and side will not go below the surface. If in flowing water, when turning the bottle upright, turn it so that the opening faces upstream. The sampling bottle should not be moved along the surface to fill. Because of the wide mouth and shallow depth, it will be immediately filled.

5. Tilt the full jar upright as it is slowly removed.

6. Carefully raise the full jar from the water.

7. Cap the container, tightening securely. Invert the jar gently three times, uncap the jar and pour to aliquot a portion into the first sample bottle, re-cap the jar and again gently invert the jar three times. Now uncap the jar and pour to aliquot a portion into the second sample bottle. The second sample bottle may be a replicate for the same lab, a different lab, or a non-replicate for different analyses at the same or a different lab. Any additional sub-dividing of the sample in the jar must be done by recapping and gently reinverting the collection jar three times.

8. Clearly label the sample container, so that each sample is uniquely identified and includes the following information: the water body name, station location, date and time collected, sampler's name, type of sample (e.g. public health shoreline grab), sample depth (for example, 0 to 10 cm), and type of analysis (for example, cyanotoxin by ELISA).

9. Promptly place the labeled sample container in a cooler with ice to both protect from sunlight, and chill, until shipped. Double-bagged wet ice or blue ice is acceptable as long as the maximum threshold temperature (6°C) for samples is not exceeded. Block ice is discouraged to protect sample bottles from breaking during shipping.

10. Replenish ice supply as often as needed to maintain samples at or below 6°C, and prior to preparing coolers for shipping to the appropriate laboratories.

Field Variances As conditions in the field vary; it may become necessary to implement minor modifications to the sampling procedures and protocols described in this QA Project Plan. If/when this is necessary; the KTWQP Technician will notify the KTWQP Project Manager/QA Officer of the situation to obtain a verbal approval prior to implementing any changes. The approval will be recorded in the field logbook. Modifications will be documented in the Annual Report to the US EPA Grants Project Officer.

2.2.3 Continous Monitoring Methods

The continuous monitoring will be done using a YSI datasonde. The sondes will be fixed to a cable and protected by a metal pipe which will suspend the probes to avoid damage to equipment. The stations at Orleans, Salmon River, Scott River, and Shasta River will deploy a YSI 6600 V2 datasonde. The stations at Seiad Valley and Iron Gate will deploy a YSI EXO2 datasonde.

Each field datasonde will be calibrated every two weeks according to the procedures in Appendix E-4 and Appendix E-5. The calibration standards will be supplied by Aurical Company and Fondriest Environmental for turbidity standards.

Equipment/Materials The following are the items on the KTWQP datasonde calibration check list that staff refers to before going into the field to calibrate:

1. 1L 1,000 uS/cm Conductivity Standard,
2. 1L pH 7 Standard,
3. 1L pH 10 Standard,
4. 1L 12.4 FNU Turbidity Standard (April – October),
5. 1L 124 FNU Turbidity Standard,
6. 1L 1000 FNU Turbidity Standard (Nov – March),
7. Clipboard,
    a. Data sheet
    b. Pencils
8. Towel for DO calibration,
9. Reference Sonde,
10. Handheld,
11. 1 Gallon Distilled Water,
12. Sonde Tool Kit, 13. 5 Gallon Bucket, and
14. Crate.

Procedures The procedures for calibrating are in the SOPs in Appendix E-4 for the YSI 6600 V2 datasondes and Appendix E-5 for YSI EXO2 datasondes.

Field Variances As conditions in the field vary; it may become necessary to implement minor modifications to the sampling procedures and protocols described in this QA Project Plan. If/when this is necessary; the KTWQP Technician will notify the KTWQP Project Manager/QA Officer of the situation to obtain a verbal approval prior to implementing any changes. The approval will be recorded in the field logbook. Modifications will be documented in the Annual Report to the US EPA Grants Project Officer.

2.2.4 Ceratonova Shasta Sampling Methods

For C. Shasta sampling, KTWQP follows the C. Shasta SOP (Appendix E-8). All samples are collected using an ISCO automatic sampler.

Equipment/Materials The following are the items on the KTWQP C. Shasta sampling check list that staff refer to before going into the field to collect C. Shasta water samples:

1. 4 clean 1L bottles per site, and
2. Clipboard.

a. Data sheet
b. Pencils

Decontamination Decontamination of the 1L sample bottles will be completed in the KTWQP office prior to the sample event. They will be cleaned according to recommended procedures by rinsing three times with tap water and using a brush if necessary.

Decontamination of the ISCO collection bottle will be completed in the field by rinsing three times with tap water.

Procedures

1. Upon arriving at a sampling location, remove the top of the ISCO and verify that the screen reads Sample Complete. If so, continue to step 2. If not, scroll through the menu to determine why the previous sampling event did not occur correctly. Record on datasheet.

2. Reprogram the ISCO to start the next program at 8 am for the following week.

3. Secure the top of the ISCO taking care not to press any more buttons.

4. Open the middle part of the ISCO to reveal the large collection bottle.

5. Remove the lids of the 4 clean 1L sample bottles.

6. Manually mix the water in the large collection bottle and carefully pour into the 4 1L sample bottles, mixing between each pour. Tighten the lids on each of the 4 1L sample bottles.

7. Dump out the remaining water from the large collection bottle.

8. Rinse the large collection bottle three times with tap water.
9. Return the large collection bottle to the ISCO and secure the sampler by restacking the ISCO and hooking all three latches.

In the event that the previous sampling event did not occur correctly, a surface grab must be taken. This is recorded on the datasheet. The following steps are for collecting a surface grab:

1. Remove the lid of the clean 1L sample bottle.

2. Fill from the surface of the water by tilting the bottle.

3. Tighten the lid on the 1L sample bottle and repeat the process for the remaining 3 clean 1L sample bottles. All four samples should be taken from the same location.

Field Variances As conditions in the field vary; it may become necessary to implement minor modifications to the sampling procedures and protocols described in this QA Project Plan. If/when this is necessary; the KTWQP Technician will notify the KTWQP Project Manager/QA Officer of the situation to obtain a verbal approval prior to implementing any changes. Modifications will be documented and approved by the Bartholomew Laboratory at Oregon State University.

2.3 Field Health and Safety Procedures

A brief tail-gate safety meeting will be held the first day of each sampling event to discuss emergency procedures (e.g., location of the nearest hospital or medical treatment facility), local contact information (e.g., names and telephone numbers of local personnel, fire department, police department), as well as to review the tribe's contingency plan.

When wading, care will be taken to avoid slipping on rocks and algae. Also, due to weather conditions during the sampling events and the possibility of health concerns (e.g., heat stress) from working in high temperatures, field personnel will be advised to drink plenty of water and wear clothing (e.g., hat, longsleeved shirt) that will cover and shade the body.

Potential routes of exposure related to field sampling and measurement activities are through the skin (e.g., from direct contact from the surface water) and/or by ingestion (e.g., from not washing up prior to eating).

2.4 Disposal of Residual Materials

This section does not apply to any type of sampling conducted under this QAPP.

2.5 Quality Assurance for Sampling

Detailed instructions for collection of all field QC samples are discussed in Section 2.8 and listed in Table 12.

Additional deviations from the QA Project Plan may be implemented as field variances or modifications. These deviations will be communicated to the KTWQP Program Manager/QA Officer by the KTWQP Technician/Field Sampler for approval. Documentation any deviations is the responsibility of the KTWQP

QA Officer. Deviations noted during the field audit will be documented in the QA Audit Logbook, recorded in the Field Audit Reports, and discussed in the annual reports.

2.6 Sample Handling and Custody

This section describes the sample handling and custody procedures from sample collection through transport and laboratory analysis. It also includes procedures for the ultimate disposal of the samples. All samples will be fully documented and complete notes will accompany every sampling event, including photo monitoring.

2.6.1 Field Notes and Logbooks

Sampling from each day of data collection will be recorded in the field notebook, which includes:

1. Survey crew identification,
2. Date and time,
3. Station ID,
4. Sample ID,
5. Ambient water quality measurements (temperature, pH, D.O., conductivity)
6. Number of bottles collected of each sample type (nutrients, phytoplankton, and toxins),
7. Sample collection device,
8. Details of undocumented sample locations, and
9. Note fields for recording site conditions.

All ambient water quality information is recorded with a YSI datasonde that is calibrated prior to going in the field. Since this is the only source of field-recorded water quality data, YSI instrument calibration is not noted on sampling data sheets.

2.6.2 Photographs

Photographs will be taken at each sampling location during each sampling event. They will serve to verify information entered in the field logbook. For each photograph taken, the following information will be written in the logbook:

- Time, date, location, and weather conditions, • Description of the subject photographed, and

- Name of person taking the photograph.

2.6.3 Labeling

All samples collected will be labeled in a clear and precise way for proper identification in the field and for tracking in the laboratory. At a minimum, the sample labels will contain the following information: station location, date of collection, analytical parameter(s), and method of preservation. Every sample, including samples collected from a single location but going to separate laboratories, will be assigned a unique sample number

2.6.4 Chain of Custody

All sample shipments for analyses will be accompanied by a KTWQP Nutrient, Phytoplankton, or Algal Toxin Chain of Custody Form (Appendix A2). These forms will be completed and sent with each sample for each laboratory and each shipment (i.e., each day). If multiple coolers are sent to a single laboratory on a single day, duplicate forms will be completed and sent in each cooler.

Until the samples are shipped, the custody of the samples will be the responsibility of KTWQP staff assigned to collection and shipment of samples and the Project Manager. The chain of custody form includes date and time of transfer to carrier and carrier shipping number. Each laboratory listed above will be responsible for chain of custody once they have received the cooler from the shipping company.

2.6.5 Sample Packaging and Shipment

Sturdy coolers suitable for secure sample transit are provided by the laboratories and KTWQP staff makes sure that packing materials and ice are supplemented to protect samples in transit. The KTWQP Algal Toxin Chain of Custody Form supplies U.S. EPA staff at the Region 9 Richmond Laboratory with a Regional Analytical Program (RAP) number. Shipment of samples will not include a copy of the KTWQP field notebook, so that labs cannot introduce bias because locations are unknown to them.

1. All samples are removed from coolers
2. Place bubble wrap around the inside edge of the cooler to prevent breakage during shipment, and/or wrap bottles individually.
3. Prepare bags of ice to be used to keep the samples cool during transport when wet ice is used.

Pack the ice in doubled, zip-locked plastic bags.

4. Check the sample bottle screw caps for tightness.
5. Ensure sample labels are affixed to each sample container and protected by a cover of clear tape.
6. Wrap all glass sample containers in bubble wrap to prevent breakage.
7. Samples are placed in cooler and entered on COC
8. Place the bagged ice or blue ice on top and around the samples to chill them to the correct temperature.
9. Fill the empty space in the cooler with bubble wrap, Styrofoam peanuts, or any other available inert material to prevent movement and breakage during shipment.
10. Enclose the appropriate chain-of-custody(s) in a zip-lock plastic bag 1. Close the lid of the cooler. Tape the cooler shut

Daily, the KTWQP Field Samplers will notify the Laboratory Project Manager of the sample shipment schedule. The laboratory will be provided with the following information:

- Sampler's name,
- Name and location of the site or sampling area,
- Names of the tribe and project,
- Total number(s) and matrix of samples shipped to the laboratory,
- Carrier, air bill number(s), method of shipment (e.g., priority next day),
- Shipment date and when it should be received by the laboratory,
- Irregularities or anticipated problems associated with the samples, and
- Whether additional samples will be shipped or if this is the last shipment.

2.6.6 Sample Custody

The field sampler is responsible for custody of the samples until they are delivered to the laboratory or picked up for shipping. (Note: As few people as possible will handle the samples to ensure sample custody.) Chain-of-custody forms must be completed in the field. Each time one person relinquishes control of the samples to another person, both individuals must complete the appropriate portions of the chain-of-custody form (see Appendix A2) by filling in their signature as well as the appropriate date and time of the custody transfer.

During transport by a commercial carrier, the air bill will serve as the associated chain-of-custody. Once at the laboratory, the sample receipt coordinator will open the coolers and sign and date the chain-ofcustody form. The laboratory personnel are then responsible for the care and custody of samples. The analytical laboratory will track sample custody through their facility using a separate sample tracking form, as discussed in the laboratory QA Manual included in Appendix A3.

A sample is considered to be in one's custody if:

- The sample is in the sampler's physical possession,
- The sample has been in the sampler's physical possession and is within sight of the sampler,
- The sample is in a designated, secure area, and/or
- The sample has been in the sampler's physical possession and is locked up.

2.6.7 Sample Disposal

Following sample analysis, each laboratory will store the unused portions for an established length of time (see lab QA/QC Manual's in Appendix A-3). At that time, the laboratory will properly dispose of all the samples (if applicable). Sample disposal procedures at the laboratory are discussed in the laboratory's QA Manual included in Appendix A-3.

2.7 Analytical Methods

The field measurement and off-site laboratory analytical methods are listed in Tables 9, 10, and 11 and discussed below.

2.7.1 Field Measurement Methods See Section 2.2

2.7.2 Laboratory Analysis Methods

Surface water samples will be analyzed at Aquatic Research Inc., Chesapeake Bay Laboratory, EPA Region 9 Lab, Aquatic Analysts, GreenWater Laboratories, and Bartholomew Laboratory. Analyses will be performed following either EPA-approved methods or methods from *Standard Methods for the*

Examination of Water and Wastewater, 20 Edition, as summarized in Tables 10 and 11. SOPs for the analytical methods are included in Appendix A-3. The Laboratory QA/QC Officer must notify the Laboratory Project Manager if there is any knowledge of the SOPs not being followed.

Both the laboratory and consultant will summarize the data and associated QC results in a data report, and provide this report to the KTWQP Program Manager. The KTWQP Program Manager/QA Officer will review the data reports and associated QC results to make decisions on data quality and usability in addressing the project objectives.

2.8 Quality Control Requirements

This section identifies the QC checks that are in place for the sample collection, field measurement, and laboratory analysis activities that will be used to access the quality of the data generated from this project.

2.8.1 Field Sampling Quality Control

Field sampling QC consists of collecting field QC samples to help evaluate conditions resulting from field activities. Field QC is intended to support a number of data quality goals:

- Combined contamination from field sampling through sample receipt at the laboratory (to assess potential contamination from field sampling equipment, ambient conditions, sample containers, sample transport, and laboratory analysis) - assessed using field blanks;
- Sample shipment temperature (to ensure sample integrity and representativeness that the sample arriving at the laboratory has not degraded during transport) - assessed using temperature blanks; and
- Combined sampling and analysis technique variability, as well as sample heterogeneity - assessed using field duplicates.

For the current projects, the types and frequencies of field QC samples to be collected for each field measurement and off-site laboratory analysis are listed in tables 12. These include field blanks, temperature blanks (as included in a footnote to the table), and field duplicates.

Field Blanks

Field blanks will be collected to evaluate whether contaminants have been introduced into the samples during the sample collection due to exposure from ambient conditions or from the sample containers themselves. Field blank samples will be obtained by pouring deionized water into a sample container at the sampling location. Field blanks will not be collected if equipment blanks have been collected during the sampling event. If no equipment blanks are collected (and none are planned because samples will be collected directly into sample containers), one field blank will be collected for every 10 samples or a frequency of 10%. Field blank frequency is outlined in Table 12.

Field blanks will be preserved, packaged, and sealed in the same manner described for the surface water samples. A separate sample number and station number will be assigned to each blank. Field blanks will be submitted blind to the laboratory for invalidation of results, greater attention to detail during the next sampling event, or analysis of metals, hardness, and anions. No field blanks are planned for phytoplankton identification/enumeration. Field duplicates will be used to assess laboratory results.

If target analytes are found in field blanks, sampling and handling procedures will be reevaluated and corrective actions will be taken. These may consist of, but are not limited to, obtaining sampling containers from new sources, training of personnel, discussions with the laboratory, or other procedures deemed appropriate.

Field Duplicate Samples

Field duplicate samples will be collected to evaluate the precision of sample collection through analysis. Field duplicates will be collected at designated sample locations by alternately filling two distinct sample containers for each analysis. Field duplicate samples will be preserved, packaged, and sealed in the same manner described for the surface water samples. A separate sample number and station number will be assigned to each duplicate. The samples will be submitted as “blind” (i.e., not identified as field duplicates) samples to the laboratory for analysis.

For the current projects, field duplicates will be collected for each analytical parameter, and field measurement parameter, at the frequencies shown in Table 12. The duplicate samples will be collected at random locations for each sampling event. Criteria for field duplicates for the analytical and field measurement parameters are provided in Table 12. If criteria are exceeded, field sampling and handling

procedures will be evaluated, and problems will be corrected through greater attention to detail, additional training, revised sampling techniques, or whatever appears to be appropriate to correct the problems.

2.8.2 Field Measurement Quality Control

Quality control requirements for field measurements are provided in Table 12.

2.8.3 Laboratory Analyses Quality Control (off-site)

Laboratory QC is the responsibility of the personnel and QA/QC department of the contracted analytical laboratories. Each laboratory's Quality Assurance Manuals detail the QA/QC procedures it follows. The following elements are part of standard laboratory quality control practices:

- Analysis of method blanks,
- Analysis of laboratory control samples,
- Instrument calibration (including initial calibration, calibration blanks, and calibration verification),
- Analysis of matrix spikes, and
- Analysis of duplicates.

The data quality objectives for Aquatic Analysts, Aquatic Research Inc, EPA Region 9 Lab, GreenWater Laboratories, and Chesapeake Bay Laboratory (including frequency, QC acceptance limits, and corrective actions if the acceptance limits are exceeded) are detailed in the QA Manuals and SOPs (as in Appendix A-3). Any excursions from these objectives must be documented by the laboratory and reported to the Project Manager/QA Officer.

The Karuk Tribe has reviewed each laboratory's control limits and corrective action procedures and feels that these will satisfactorily meet tribal project data quality needs. A summary of this information is included below. These include laboratory (or method) blanks, laboratory control samples, matrix spikes, and laboratory duplicates.

Method Blanks

A method blank is an analyte-free matrix, analyzed as a normal sample by the laboratory using normal sample preparation and analytical procedures. A method blank is used for monitoring and documenting

background contamination in the analytical environment. Method blanks will be analyzed at a frequency of one per sample batch (or group of up to 20 samples analyzed in sequence using the same method).

Corrective actions associated with exceeding acceptable method blank concentrations include isolating the source of contamination and re-digesting and/or re-analyzing the associated samples. Sample results will not be corrected for blank contamination, as this is not required by the specific analytical methods. Corrective actions will be documented in the laboratory report's narrative statement.

Laboratory Control Samples

Laboratory control samples (LCS) are laboratory-generated samples analyzed as a normal sample and by the laboratory using normal sample preparation and analytical procedures. An LCS is used to monitor the day-to-day performance (accuracy) of routine analytical methods. An LCS is an aliquot of clean water spiked with the analytes of known concentrations corresponding to the analytical method. LCS are used to verify that the laboratory can perform the analysis on a clean matrix within QC acceptance limits. Results are expressed as percent recovery of the known amount of the spiked analytical parameter.

One LCS is analyzed per sample batch. Acceptance criteria (control limits) for the LCS are defined by the laboratory and summarized in their associated QA Manuals (Appendix A-3). In general, the LCS acceptance criteria recovery range is 70 to 130 percent of the known amount of the spiked analytical parameter. Corrective action, consisting of a rerunning of all samples in the affected batch, will be performed if LCS recoveries fall outside of control limits. Such problems will be documented in the laboratory report's narrative statement.

Matrix Spikes

Matrix spikes (MS) are prepared by adding a known amount of the analyte of interest to a sample. MS are used as a similar function as the LCS, except that the sample matrix is a real-time sample rather than a clean matrix. Results are expressed as percent recovery of the known amount of the spiked analytical parameter. Matrix spikes are used to verify that the laboratory can determine if the matrix is causing either a positive or negative influence on sample results.

One MS is analyzed per sample batch. Acceptance criteria of the MS are defined by the laboratory and summarized in each QA Manual (Appendix A-3). In general, the MS acceptance criteria recovery range is

of 70 to 130 percent of the known amount of the spiked analytical parameter. Generally, no corrective action is taken for matrix spike results exceeding the control limits, as long as the LCS recoveries are acceptable. However, the matrix effect will be noted in the laboratory report's narrative statement and documented in the Karuk Tribe's reports for each sampling event.

Laboratory Duplicates

A laboratory duplicate is a laboratory-generated split sample used to document the precision of the analytical method. Results are expressed as relative percent difference between the laboratory duplicate pair.

One laboratory duplicate will be run for each laboratory batch or every 10 samples, whichever is more frequent. Acceptance criteria (control limits) for laboratory duplicates are specified in the laboratory QA Manual and SOPs, Appendix A-3. If laboratory duplicates exceed criteria, the corrective action will be to repeat the analyses. If results remain unacceptable, the batch will be rerun. The discrepancy will be noted in the laboratory report's narrative statement and documented in the Tribe's reports for each sampling event.

2.9 Instrument/Equipment Testing, Inspection, and Maintenance

2.9.1 Field Measurement Instruments/Equipment

Sampling equipment under the care of the KTWQP will be maintained according to the manufacturer's instructions. Maintenance logs will be kept in the office of the KTWQP Program Manager/QA Officer. Each piece of equipment will have its own maintenance log. The log will document any maintenance and service of the equipment. A log entry will include the following information:

- Name of person maintaining the instrument/equipment,
- Date and description of the maintenance procedure,
- Date and description of any instrument/equipment problem(s),
- Date and description of action to correct problem(s),
- List of follow-up activities after maintenance (i.e., system checks), and
- Date the next maintenance will be needed

2.9.2 Laboratory Analysis Instruments/Equipment

Inspection and maintenance of laboratory equipment is the responsibility of the Aquatic Analysts, Aquatic Research Inc, U.S. EPA Region 9 Lab, Chesapeake Bay Laboratory, and GreenWater Laboratories and is described in each laboratory's QA Manual included as Appendix A-3.

2.10 Instrument/Equipment Calibration and Frequency

2.10.1 Field Measurement Instruments/Equipment

Calibration and maintenance of field equipment/instruments will be performed according to the manufacturer's instructions (see Appendices E-4 and E-5) and recorded in an instrument/equipment logbook. Each piece of equipment/instrument will have its own logbook.

The project-specific criteria for calibration (frequency, acceptance criteria, and corrective actions associated with exceeding the acceptance criteria) are provided in Table 13.

2.10.2 Laboratory Analysis Instruments/Equipment

Laboratory instruments will be calibrated according to the appropriate analytical methods. Acceptance criteria for calibrations are found in each of their QA Manuals included as Appendix A-3.

2.11 Inspection and Acceptance of Supplies and Consumables

2.11.1 Field Sampling Supplies and Consumables

Sample containers and preservatives will be provided by the analytical laboratories and the Karuk Tribe. Containers will be inspected for breakage and proper sealing of caps. Other equipment such as sample coolers and safety equipment will be acquired by the Karuk Tribe. For reusable sampling equipment, materials/supplies necessary for equipment decontamination will be purchased by the Karuk Tribe. Any equipment deemed to be in unacceptable condition will be replaced.

2.11.2 Field Measurement Supplies and Consumables

Field measurement supplies, such as calibration solutions, will be acquired from standard sources, such as the instrument manufacturer or reputable suppliers. Chemical supplies will be American Chemical Society reagent grade or higher. The lot number and expiration date on standards and reagents will be checked prior to use. Expired solutions will be discarded and replaced. The source, lot number, and expiration dates of all standards and reagents will be recorded in the field log books.

2.11.3 Laboratory Analysis (off-site) Supplies and Consumables

Each of the laboratory's requirements for supplies and consumables are described in its QA Manual which is provided in Appendix A-3.

2.12 Data Acquisition Requirements (Non-Direct Measurements)

To supplement field measurements and laboratory analytical activities conducted under these projects, other potential "external" data sources will be researched. These sources include, but are not limited to, the U.S. Geological Survey, the North Coast Regional Water Quality Control Board, the California Department of Water Resources, the U.S. Environmental Protection Agency, the United States Forest Service, the Hoopa Tribe, and the Yurok Tribe. The primary use of this external data will be to help focus the Karuk Tribe's data collection efforts (for example, the information may be used to identify new sites in the Klamath River watershed for future sampling).

If it appears that the "external" data might facilitate water body evaluation, the data will first be reviewed to verify that they are of sufficient quality to meet the needs of the project by examining:

1. the sample collection and location information;
2. the data to see whether they are consistent with known tribally-collected data from the same general vicinity; and
3. the QA/QC information associated with the data.

If the data are of insufficient or unknown quality, limitations will be placed on its use in supporting project decisions. In general, it is anticipated that decisions for the current project will be based on data collected by the Karuk Tribe following this current QA Project Plan.

3.0 ASSESSMENT AND OVERSIGHT

This section describes how activities will be checked to ensure that they are completed correctly and according to procedures outlined in this QA Project Plan.

3.1 Assessment/Oversight and Response Actions

During the course of the project, it is important to assess the projects' activities to ensure that the QA Project Plan is being implemented as planned. This helps to ensure that everything is on track and serves to minimize learning about critical deviations toward the end of the project when it may be too late to remedy the situation. For the current project, the ongoing assessments will include:

- Field Oversight,
- Readiness review of the field team prior to starting field efforts,
- Field activity audits,
- Review of field sampling and measurement activities methodologies and documentation at the end of each event, and
- Laboratory Oversight - evaluation of laboratory data generated for each quarterly sampling event.

Details regarding these assessments are included below.

2.13 Data Management

All data collected by the KTWQP will be maintained in appropriate bound notebooks and electronic databases. Data from the laboratory will be requested in both hard copy and electronic form. The electronic and hard copy results will be compared to ensure that no errors occurred in either format. If discrepancies are noted, the laboratory will be contacted to resolve the issues.

3.1.1 Field Oversight

3.1.1.1 Readiness Reviews

Sampling personnel will be properly trained by qualified personnel before any sampling begins and will be given a brief review of sampling procedures and equipment operation by the KTWQP Program Manager/QA Officer before each sampling event. Equipment maintenance records will be checked to

ensure all field instruments are in proper working order. Adequate supplies of all preservatives and bottles will be obtained and stored appropriately before heading to the field. Sampling devices will be checked to ensure that they have been properly cleaned (for devices which might be reused) or are available in sufficient quantity (for devices which are disposable). Proper paperwork, logbooks, chain of custody forms, etc. will be assembled by the sampling technician. The KTWQP Project Manager/QA Officer will review all field equipment, instruments, containers, and paperwork to ensure that all is in readiness prior to the first day of each sampling event. Any problems that are noted will be corrected before the sampling team is permitted to depart the Karuk Tribe's facilities.

3.1.1.2 Field Activity Audits

Once a month, the KTWQP Project Manager/QA Officer will assess the sample collection methodologies, field measurement procedures, and record keeping of the field team to ensure activities are being conducted as planned (and as documented in this QA Project Plan). Any deviations that are noted will be corrected immediately to ensure all subsequent samples and field measurements collected are valid. (Note: If the deviations are associated with technical changes and/or improvements made to the procedures, the KTWQP QA Officer will verify that the changes have been documented by the KTWQP Technicians in the Field Log Book and addressed in an amendment to this QA Project Plan.) The KTWQP QA Officer may stop any sampling activity that could potentially compromise data quality.

The KTWQP QA Officer will document any noted issues or concerns in a QA Audit Logbook and discuss these items informally and openly with the KTWQP Water Quality Technicians while on site. Once back in the office, they will formalize the audit findings (for each event) in a Field Audit Report which will be submitted to the KTWQP Program Manager and the KTWQP Technicians.

The KTWQP Technician will prepare a Corrective Action Report to address any audit findings discussed in the Field Audit Report. The Corrective Action Report will be issued as an internal memorandum the KTWQP Program Manager/QA Officer in response to problems noted during on-site audits and will document steps taken to reduce future problems prior to the next sampling event.

3.1.1.3 Post Sampling Event Review

Following each sampling event, the KTWQP Data Manager will complete the Field Activities Review Checklist (Appendix B-1). This review of field sampling and field measurement documentation will help ensure that all information is complete and any deviations from planned methodologies are documented. This review will be conducted in the office, not in the field. The results of this review, as well as comments associated with potential impacts on field samples and field measurement integrity will be forwarded to the KTWQP Program Manager to be used in preparing the reports for each event and also to be used as a guide to identify areas requiring improvement prior to the next sampling event.

3.1.2 Laboratory Oversight

Following receipt of the off-site laboratory's data package for each sampling event, the KTWQP QA Officer will review the data package for completeness, as well as to ensure that all planned methodologies were followed and that QA/QC objectives were met. The results of the review will be documented on the Laboratory Data Review Checklist (Appendix B-2). (Note: The KTWQP Program Manager/QA Officer has the authority to request re-testing or other corrective measures if the laboratory has not met the project's QA/QC objectives and/or has not provided a complete data package.)

Due to the scope and objectives of the current projects, the Karuk Tribe is not planning any laboratory audits at this time. However, the Karuk Tribe will check periodically with the state of California certification agency to make sure that the laboratory remains in good standing for those methods that the Karuk Tribe is requesting.

The laboratories' QA Manuals describe the policies and procedures for assessment and response in the laboratory.

3.2 Reports to Management

Annually, the KTWQP Program Manager will prepare and submit a report on that year's sampling activities. Contents of this report have been described previously in Section 1.9.6. The prepared report will show any data trends that have occurred. The report will also discuss how any actions taken during the year may have affected the trends. This report will be submitted to the Tribal Council for approval. After approval, the report will be submitted to the US EPA Grants Project Officer.

4.0 DATA REVIEW AND USABILITY

Prior to utilizing data to make project decisions, the quality of the data needs to be reviewed and evaluated to determine whether the data satisfy the projects' objectives. This process involves technical evaluation of the off-site laboratory data, as well as review of the data in conjunction with the information collected during the field sampling and field measurement activities. This latter, more qualitative review provides for a clearer understanding of the overall usability of the projects' data and potential limitations on their use. This section describes the criteria and procedures for conducting these reviews and interpreting the projects' data.

4.1 Data Review, Verification, and Validation Requirements

The setting of data review, verification, and validation requirements helps to ensure that project data are evaluated in an objective and consistent manner. For the current project, such requirements have been defined for information gathered and documented as part of field sampling and field measurement activities, as well as for data generated by the off-site laboratory.

4.1.1 Field Sampling and Measurement Data

Any information collected during sample collection and field measurements is considered field "data." This includes field sampling and measurement information documented in field logbooks (as listed in Section 1.9.2.1), photographs, and chain of custody forms.

Once the KTWQP Technician returns to the office following a sampling event, they turn in the field data to the KTWQP Data Manager who is responsible for conducting a technical review of the field data to ensure that all information is complete and any deviations from the planned methodologies are documented. For the purpose of this project, the review will be documented using the Field Activities Review Checklist provided in Appendix B-1. This checklist comprehensively covers the items to be reviewed and leaves room to capture any comments associated with potential impacts on field samples and field measurement integrity based on the items listed.

4.1.2 Laboratory Data

For the data generated by an off-site laboratory, the laboratory is responsible for its own internal data review and verification prior to submitting the associated data results package to the KTWQP QA Officer. The details of the review (including checking calculations, reviewing for transcription errors, ensuring the

data package is complete, etc.) are discussed in the laboratory's QA Manual included as Appendix A3. Details of the information that will be included in each data package are listed in Section 1.9.3 of this QA Project Plan.

Once the laboratory data are received by the Karuk Tribe, the KTWQP QA Officer is responsible for further review and validation of each data package. For the purpose of this project, data review and validation will be conducted using the Data Review Checklist provided in Appendix B-2 in conjunction with the QC criteria (i.e., frequency, acceptance limits, and corrective actions) defined in Tables 10, 11 and 12. This review will include evaluation of the field and laboratory duplicate results, field and laboratory blank data, matrix spike recovery data, and laboratory control sample data pertinent to each analysis. The review will also include ensuring data are reported in compliance with the project action limits and quantification limits defined in Tables 5-8; the sample preparation/analytical procedures were performed by the methods listed in Table 10; sample container, preservation, and holding times met the requirements listed in Table 11; the integrity of the sample (ensuring proper chain of custody and correct sample storage temperatures) is documented from sample collection through shipment and ultimate analysis, and the data packages. The Data Review Checklist comprehensively covers the review of all these items.

The KTWQP QA Officer will further evaluate each data package's narrative report and summary tables to see whether the laboratory "flagged" any sample results based on poor or questionable data quality and to ensure that any exceedances of the laboratory's QC criteria (as listed in Table 12) are documented. If a problem was noted by the laboratory, the KTWQP QA Officer will evaluate whether the appropriate prescribed corrective action was taken by the laboratory, the action successfully resolved the problem, and the process and its resolution were accurately documented.

An effort will be made to identify whether any data quality problem is the result of laboratory issues and/or if it may be traced to some field sampling activity. If the laboratory is determined to be responsible, the KTWQP QA Officer will request information from the laboratory documenting that the problem has been resolved prior to submitting future samples. If some aspect of the field operation (e.g., sample collection, sample containers and/or preservation, chain-of-custody, sample shipment, paperwork, etc.) is identified as the possible problem, efforts will be made to retrain the KTWQP's field staff to minimize the potential of the problem recurring. If the problem is believed to be due to the sample matrix, the KTWQP Program Manager/QA Officer will discuss the use of alternative analytical methods with the

laboratory; and, if an alternative method is available that might minimize the problem, the QA Project Plan will be modified and/or amended accordingly.

If any of the QC criteria and/or the project requirements (as discussed above) is exceeded, the associated data will be qualified as estimated and flagged with a "J". If grossly exceeded, the associated data will be rejected and the need for re-sampling will be considered. However, since the data are being generated for a baseline assessment, it is generally felt that paying special attention to some troublesome sample collection or analytical concern during the next sampling event will be sufficient and re-sampling will not be necessary.

4.2 Verification and Validation Methods

Defining the data verification and validation methods help to ensure that project data are evaluated in an objective and consistent manner. For the current projects, such methods have been described for information gathered and documented as part of the field sampling and field measurement activities, as well as the data generated by the off-site laboratories.

4.2.1 Field Sampling and Measurement Data

The methods associated with verification and validation of the field sampling and measurement data are included within the discussion provided in Section 4.1.1.

4.2.2 Laboratory Data

The methods associated with verification and validation of the laboratory data are included within the discussion provided in Section 4.1.2.

4.3 Reconciliation with User Requirements

The purpose of the continued monitoring of the KAT is to assess the surface water resources and determine whether analytes of concern exceed national and tribal water quality standards. This also provides the Karuk Tribe with the opportunity to begin efforts of co-management in the Mid-Klamath watershed. Data must fulfill the requirements of this QA Project Plan to be useful for the overall project. Information needed to support decision making under the surface water monitoring program is contained in this QA Project Plan, field documentation, the laboratory "data package" report, the Field Activities Review Checklist, the Laboratory Data Review Checklist, and the Field Audit Report and associated

Corrective Action Report. This section describes the steps to be taken to ensure data usability (after all the data have been assembled, reviewed, verified, and validated) prior to summarizing the information in the Annual Report.

Once all the data from the field and laboratory have been evaluated (as described in Sections 4.1 and 4.2), the KTWQP Program Manager/QA Officer will make an overall assessment concerning the final usability of the data (and any limitations on its use) in meeting the projects' needs. The initial steps of this assessment will include, but are not necessarily limited to:

- Discussions with the KTWQP Water Quality Technician,
- Review of deviations from the QA Project Plan or associated SOPs to determine whether these deviations may have impacted data quality (and determining whether any impacts are widespread or single incidents, related to a few random samples or a batch of samples, and/or affecting a single or multiple analyses),
- Evaluation of the field and laboratory results and QC information,
- Review of any other external information which might influence the results, such as activities up stream, meteorological conditions (such as storm events proceeding sampling that might contribute to high turbidity readings), and data from other sources,
- Evaluation of whether the completeness goals defined in this QA Project Plan have been met,
- Examination of any assumptions made when the study was planned, if those assumptions were met and, if not, how the project's conclusions are affected.

After all this information has been reviewed, the KTWQP Program Manager/QA Officer will incorporate their perspective on the critical nature of any problems noted and, ultimately, identify data usability and/or limitations in supporting project objectives and decision making. All usable data will then be compared to the Project Action Limits (as listed in Table 5 and Table 6) to identify whether these limits have been exceeded. Decisions made regarding exceeding the Project Action Limits will follow the "...if...then..." statements included in Section 1.7.2.

In addition, the KTWQP Program Manager/QA Officer will assess the effectiveness of the monitoring program and data collection at the end of each calendar year. Sampling locations, frequency, list of analytical parameters, field measurement protocols, choice of the analytical laboratory, etc. will be

modified as needed to reflect the changing needs and project objectives of the Karuk Tribe. This QA Project Plan will be revised and/or amended accordingly.

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FIGURES

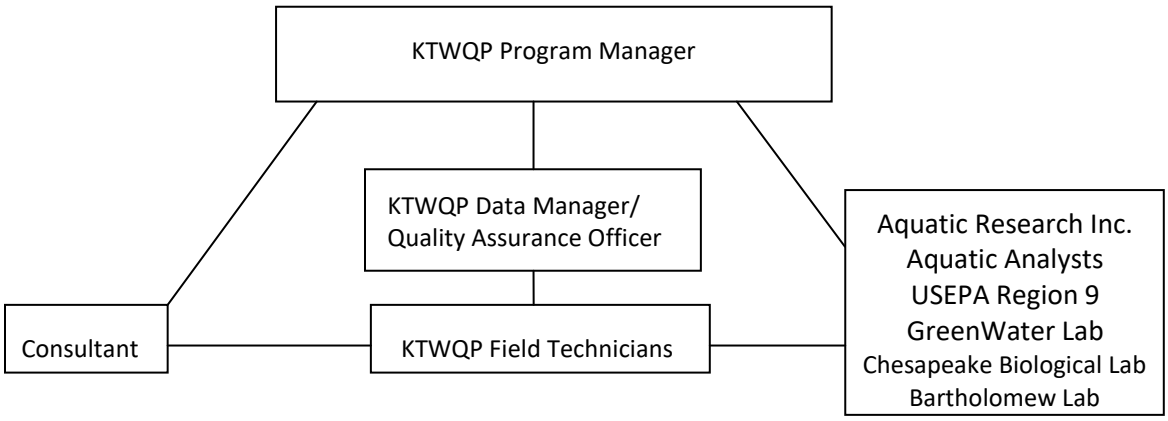


Figure 1. Program Organization.

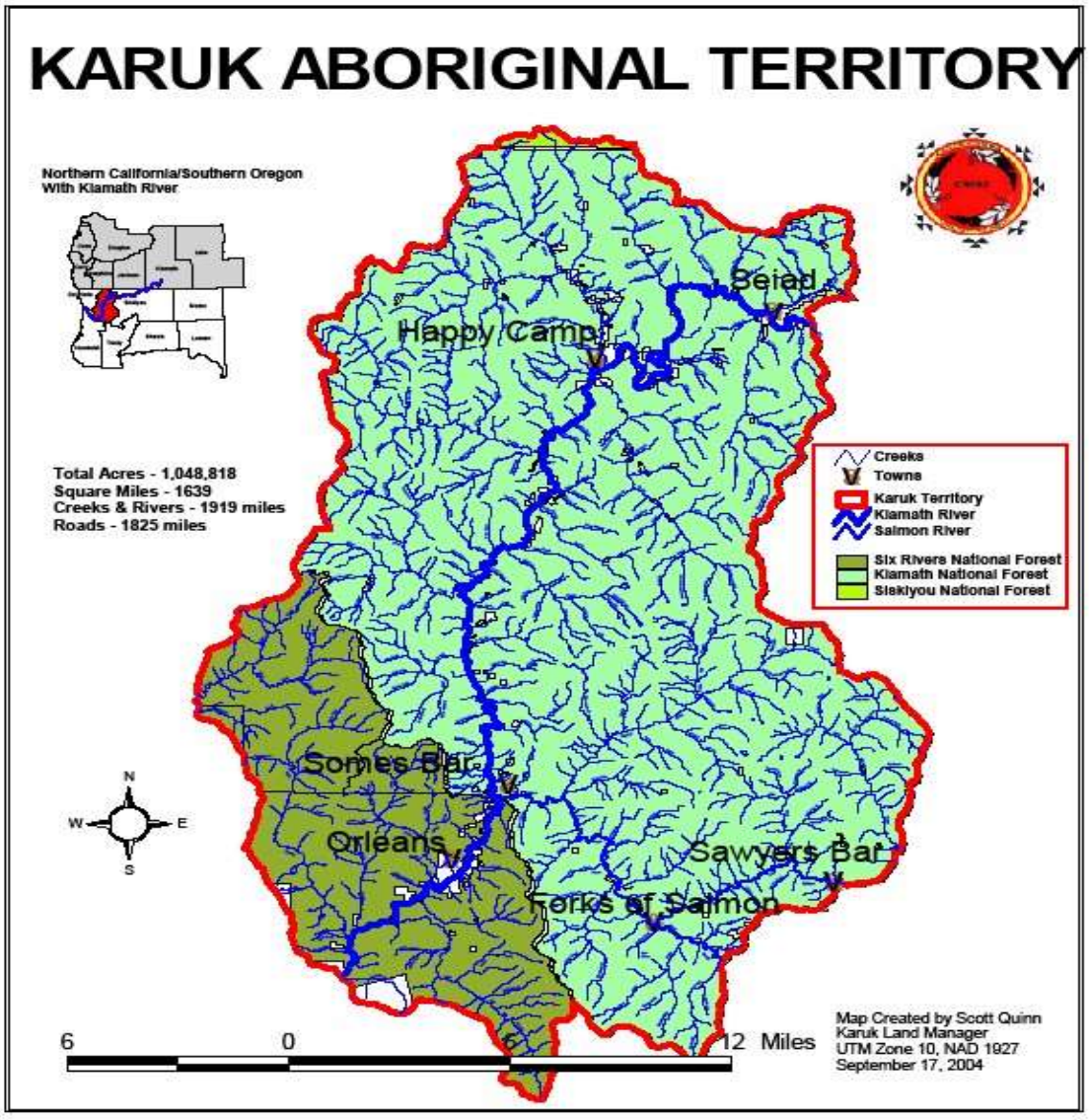


Figure 2. Map of Karuk Aboriginal Territory including towns, counties and where it is relative to the State of California and Oregon. Map from Karuk Tribe.

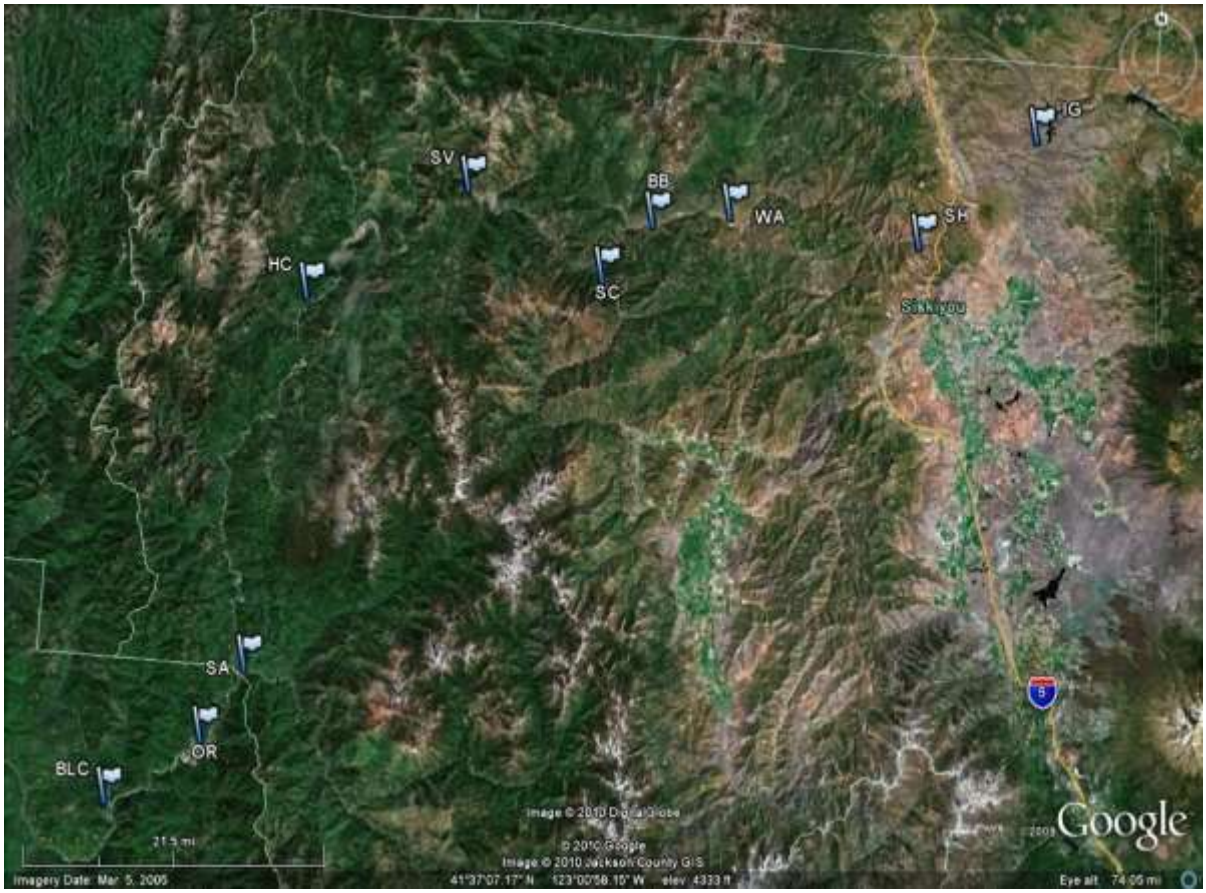


Figure 3. Overview of sampling sites for nutrient sampling, public health sampling, and continuous monitoring.

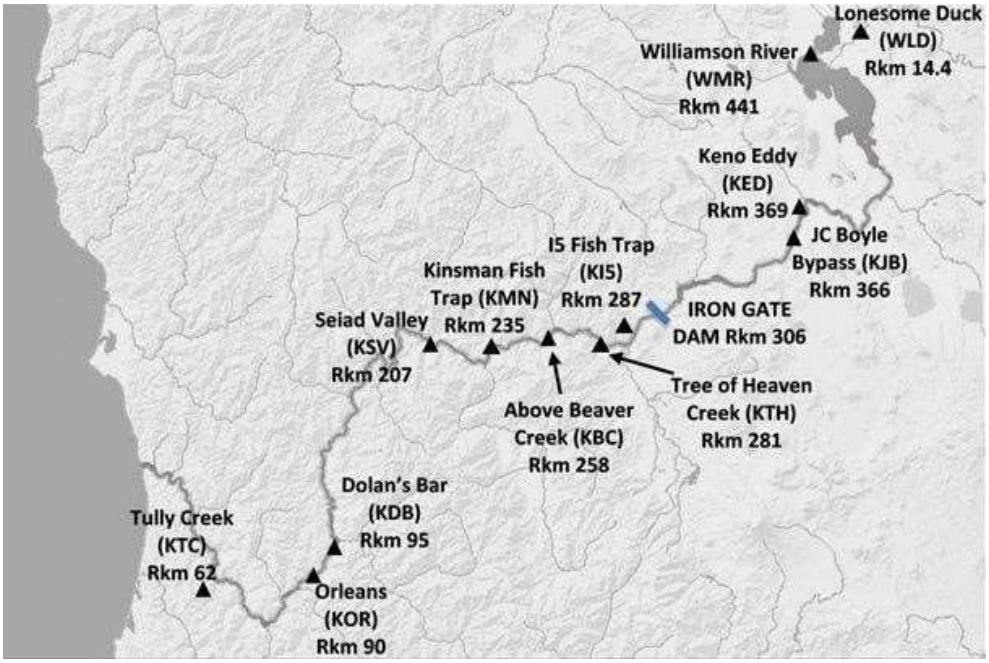


Figure 4. Klamath River Index Sites with site abbreviations and river kilometers (Rkm). Map from Oregon State University Department of Microbiology.

TABLES

Table 1. All parties participating in collection, shipping and handling, analysis of Klamath River nutrient, toxic algae, and c.shasta data by the KTWQP and those responsible for implementation of QA/QC procedures.

Title/Responsibility	Staff/Contractor	Phone Number
EPA Project Manager	Loretta Vanegas	(415) 972-3433
Program Manager	Susan Fricke	(530) 598-3414
Data Quality Manager	Grant Johnson	(530) 469-3258
Field Manager	Grant Johnson	(530) 469-3258
KTWQP Technician	Larry Alameda	(530) 469-3258
Quality Assurance Officer	Grant Johnson	(530) 469-3258
Consultant, Aquatic Ecosystems	Jacob Kann	(541) 482-1575
Consultant, Riverbend Sciences	Eli Asarian	(707) 832-4206
Contractor, Aquatic Research Inc.	Damien Gadomski	(206) 632-2715
Contractor, Aquatic Analysts	Jim Sweet	(503) 869-5032
Contractor, USEPA Region 9 Lab	Andy Lincoff	(510) 412-2389
Contractor, GreenWater Laboratories	Mark Aubel	(386) 328-0882
Contractor, Chesapeake Biological Laboratory	Jerry Frank	(410) 326-4281
Contractee, Bartholomew Laboratory	Sascha Hallet	(541) 737-4721

Table 2. Atlas of Tribal Waters within Ancestral Territory.

Atlas of Tribal Waters Within Ancestral Territory

Total number of Klamath River miles	90
Total number of perennial stream miles	1,900
Total number of lake acres	442
Total number of wetland acres	UNKNOWN

Table 3. Site codes and locations of Karuk sampling stations for nutrients, algal toxins, and Sondes. Nutrient Suite indicates collecting nutrients, algal toxins and phytoplankton. Sonde indicates real time continuous monitoring, and public health designates surface grab sampling for phytoplankton and algal toxins.

Locations and Parameters to be Monitored							
Site ID	Latitude	Longitude	Nutrient Suite	Sonde	Public Health	Winter Turbidity	Location
OR	N 41 18.336	W 123 31.895	X	X	X		Klamath River at Orleans
SA	N 41 22.617	W 123 28.633	X	X		X	Salmon River at USGS Gage
HC	N 41 43.780	W 123 25.775	X		X		Klamath River downstream of Happy Camp
SV	N 41 50.561	W 123 13.132	X	X	X		Klamath River downstream of Seiad Valley
SC	N 41 46.100	W 123 01.567	X	X			Scott River at Johnson's Bar
BB	N 41 49.395	W 122 57.718			X		Brown Bear River Access on Klamath River
WA	N 41 50.242	W 122 51.895	X				Klamath River at Walker Bridge
SH	N 41 49.390	W 122 35.700	X	X			Shasta River at USGS Gage

IG	N 41 55.865	W 122 26.532	X	X		X	Klamath River below Iron Gate Hatchery Bridge

Table 4. Sample locations and parameters for nutrient sampling and public health sampling.

ID	OR	SA	HC	SV	SC	BB	WA	SH	IB	IG
Monitoring Locations	Klamath River near Orleans	Salmon River near mouth	Klamath River near Happy Camp	Klamath River near Seiad Valley	Scott River near mouth	Klamath River at Brown Bear River Access	Klamath River at Walker Bridge	Shasta River near mouth	Klamath River at I-5 bridge	Klamath River below Iron Gate
Photo Points	X	X	X	X	X	X	X	X	X	X
Temp.	X	X	X	X	X	X	X	X	X	X
pH	X	X	X	X	X	X	X	X	X	X
Conductivity	X	X	X	X	X	X	X	X	X	X
Turbidity		X			X					
DO	X	X	X	X	X	X	X	X	X	X
Total Phosphorus	X	X	X	X	X		X	X		X
Dissolved Phosphorus	X	X	X	X	X		X	X		X
Total Nitrogen	X	X	X	X	X		X	X		X
Ammonium Nitrogen	X	X	X	X	X		X	X		X
Nitrate + Nitrite	X	X	X	X	X		X	X		X
Phytoplankton	X	X	X	X	X		X	X		X
Chlorophyll	X	X	X	X	X		X	X		X
Total Organic Carbon	X	X	X	X	X		X	X		X

Dissolved Organic Carbon	X	X	X	X	X		X	X		X
Pheophytin	X	X	X	X	X		X	X		X
Alkalinity	X	X	X	X	X		X	X		X
Volatile Suspended Solids	X	X	X	X	X		X	X		X
Total Suspended Solids	X	X	X	X	X		X	X		X
Orthophosphate	X	X	X	X	X		X	X		X
Microcystin	X	X	X	X	X	X	X	X		X
Anatoxin-A									X	X

Table 5. Specific water quality objectives for Tribal waterbodies.

		Specific Conductance (micromhos) @ 25		Dissolved Oxygen (mg/L)[4]		Hydrogen Ion (pH units)[5]		Hardness (mg/L as CaCO3)	Boron (mg/L as B)	
Hydrologic Area	Waterbody	90% Upper Limit[1]	50% Upper Limit[2]	Min	50% Lower Limit2	Max	Min	50% Upper Limit[2]	90% Upper Limit[1]	50% Upper Limit[2]
Shasta Valley	All Streams	700	400	7	9	8.5	7	200	0.5	0.1
	Groundwaters[3]	800	500	-	-	8.5	7	180	1	0.3
Scott Valley	All Streams	400	275	7	9	8.5	7	120	0.2	0.1
	Groundwaters[3]	500	250	-	-	8	7	120	0.1	0.1
Salmon River	All Streams	150	125	9	10	8.5	7	60	0.1	0
Middle Klamath River	Klamath R (near Doggett Creek to Orleans)	350	275	*[4]	*[4]	8.5	7	80	0.5	0.2
	Other Streams	300	150	7	9	8.5	7	60	0.1	0
	Groundwaters[3]	750	600	-	-	8.5	7.5	200	0.3	0.1

1 90% upper and lower limits represent the 90 percentile values for a calendar year. 90% or more of the values must be less than or equal to an upper limit and greater than or equal to a lower limit.

2 50% upper and lower limits represent the 50 percentile values of the monthly means for a calendar year. 50% or more of the monthly means must be less than or equal to an upper limit and greater than or equal to a lower limit.

3 Value may vary depending on the aquifer being sampled. This value is the result of sampling over time, and as pumped, from more than one aquifer.

4 The Site Specific Objectives (SSOs) for dissolved oxygen (DO) for the mainstem Klamath River are presented separately in Table 6.

Table 6. Dissolved oxygen objectives for the mainstem Klamath River.

Location	Percent DO Saturation Based On Natural Receiving Water Temperatures[1]	Time Period
Klamath River from near Doggett Creek to the Scott River	90%	October 1 through March 31
	85%	April 1 through September 30
Klamath River from Scott River to Orleans	90%	Year round

1 Corresponding DO concentrations are calculated as daily minima, based on site-specific barometric pressure, site-specific salinity, and natural receiving water temperatures as estimated by the T1BSR run of the Klamath TMDL model and described in Tetra Tech, December 23, 2009, Modeling Scenarios: Klamath River Model for TMDL Development. The estimates of natural receiving water temperatures used in these calculations may be updated as new data or method(s) become available.

A		B Freshwater Aquatic Life		C Human Health (10-6 risk for carcinogens) For consumption of:	
# Compound	CAS Number	Criterion Maximum Conc. (c) (ug/L) B1	Criterion Continuous Conc. (c) (ug/L) B2	Water & Organisms (ug/L) D1	Organisms Only (ug/L) D2
1. Antimony	7440360			5.6 a	640 a
2. Arsenic	7440382	340 h,l,r	150 h,l,r		

3. Beryllium	7440417				
4. Cadmium	7440439	4.3 d,h,l,r	2.2 d,h,l,r		
5a. Chromium (III)	16065831	570 d,h,l,r	74 d,h,l,r		
5b. Chromium (VI)	18540299	16 h,l,r	11 h,l,r		
6. Copper	7440508	13 d,h,l,r	9.0 d,h,l,r	1,300 k	
7. Lead	7439921	65 d,h,l	2.5 d,h,l		
8a. Mercury	7439976	1.4 h,l,r	0.77 h,l,r		

Table 7. Water quality objectives for aquatic life & organism consumption.

A		B Freshwater Aquatic Life		C Human Health (10-6 risk for carcinogens) For consumption of:	
8b. Methylmercury	22967926				0.3 mg/kg i
9. Nickel	7440020	470 d,h,l,r	52 d,h,l,r	610	4,600
10. Selenium	7782492	o,p	5.0	170 a	4,200 a
11. Silver	7440224	3.4 d,f,h,l			
12. Thallium	7440280			0.24 a	0.47 a
13. Zinc	7440666	120 d,h,l	120 d,h,l,r	7,400 a	25,000 a
14. Cyanide	57125	22 r,s	5.2 r,s	140 a	16,000 a,j
15. Asbestos	1332214			7 million fibers/L k	
16. 2,3,7,8-TCDD (Dioxin)	1746016			5.0 E-9 b	5.1 E-9 b
17. Acrolein	107028			190	290
18. Acrylonitrile	107131			0.051 a,b	0.25 a,b

19. Benzene	71432			0.61 - 2.2 a,b	14 - 51 a,b
20. Bromoform	75252			4.3 a,b	130 a,b
21. Carbon Tetrachloride	56235			0.23 a,b	1.6 a,b
22. Chlorobenzene	108907			130 a	1,600 a,j
23. Chlorodibromomethane	124481			0.40 a,b	13 a,b
24. Chloroethane	75003				
25. 2-Chloroethylvinyl Ether	110758				
26. Chloroform	67663				
27. Dichlorobromomethane	75274			0.55 a,b	17 a,b
28. 1,1-Dichloroethane	75343				
29. 1,2-Dichloroethane	107062			0.38 a,b	37 a,b
30. 1,1-Dichloroethylene	75354			0.056 a,b	1.2 a,b
31. 1,2-Dichloropropane	78875			0.50 b	15 b
32. 1,3-Dichloropropene	542756			0.34 a,b	21 a,b
33. Ethylbenzene	100414			530 a	2,100 a
34. Methyl Bromide	74839			47 a	1,500 a
35. Methyl Chloride	74873				

A		B Freshwater Aquatic Life		C Human Health (10-6 risk for carcinogens) For consumption of:	
36. Methylene Chloride	75092			4.6 a,b	590 a,b

37. 1,1,2,2-Tetrachloroethane	79345			0.17 a,b	4.0 a,b
38. Tetrachloroethylene	127184			0.69 b	3.3 b
39. Toluene	108883			1,300 a	15,000 a
40. 1,2-Trans-Dichloroethylene	156605			140 a	10,000 a
41. 1,1,1-Trichloroethane	71556				
42. 1,1,2-Trichloroethane	79005			0.59 a,b	16 a,b
43. Trichloroethylene	79016			2.5 b	30 b
44. Vinyl Chloride	75014			0.025 a,b	2.4 a,b
45. 2-Chlorophenol	95578			80 a	150 a
46. 2,4-Dichlorophenol	120832			77 a	290 a
47. 2,4-Dimethylphenol	105679			380 a	850 a
48. 2-Methyl-4,6-Dinitrophenol	534521			13	280
49. 2,4-Dinitrophenol	51285			69 a	5,300 a
50. 2-Nitrophenol	88755				
51. 4-Nitrophenol	100027				
52. 3-Methyl-4-Chlorophenol	59507				
53. Pentachlorophenol	87865	19 e,r	15 e,r	0.27 a,b	3.0 a,b,j
54. Phenol	108952			21,000 a	1,700,000 a,j
55. 2,4,6-Trichlorophenol	88062			1.4 a,b	2.4 a,b
56. Acenaphthene	83329			670 a	990 a
57. Acenaphthylene	208968				
58. Anthracene	120127			8,300 a	40,000 a

59. Benzidine	92875			0.000086 a,b	0.00020 a,b
60. Benzo(a)Anthracene	56553			0.0038 a,b	0.018 a,b
61. Benzo(a)Pyrene	50328			0.0038 a,b	0.018 a,b
62. Benzo(b)Fluoranthene	205992			0.0038 a,b	0.018 a,b
63. Benzo(ghi)Perylene	191242				

A		B Freshwater Aquatic Life		C Human Health (10-6 risk for carcinogens) For consumption of:	
64. Benzo(k)Fluoranthene	207089			0.0038 a,b	0.018 a,b
65. Bis(2-Chloroethoxy)Methane	111911				
66. Bis(2-Chloroethyl)Ether	111444			0.030 a,b	0.53 a,b
67. Bis(2-Chloroisopropyl)Ether	108601			1,400 a	65,000 a
68. Bis(2-Ethylhexyl)Phthalate (x)	117817			1.2 a,b	2.2 a,b
69. 4-Bromophenyl Phenyl Ether	101553				
70. Butylbenzyl Phthalate (w)	85687			1,500 a	1,900 a
71. 2-Chloronaphthalene	91587			1,000 a	1,600 a
72. 4-Chlorophenyl Phenyl Ether	7005723				
73. Chrysene	218019			0.0038 a,b	0.018 a,b
74. Dibenzo(a,h)Anthracene	53703			0.0038 a,b	0.018 a,b
75. 1,2-Dichlorobenzene	95501			420 a	1,300 a
76. 1,3-Dichlorobenzene	541731			320	960

77. 1,4-Dichlorobenzene	106467			63	190
78. 3,3'-Dichlorobenzidine	91941			0.021 a,b	0.028 a,b
79. Diethyl Phthalate	84662			17,000 a	44,000 a
80. Dimethyl Phthalate	131113			270,000	1,100,000
81. Di-n-Butyl Phthalate	84742			2,000 a	4,500 a
82. 2,4-Dinitrotoluene	121142			0.11 b	3.4 b
83. 2,6-Dinitrotoluene	606202				
84. Di-n-Octyl Phthalate	117840				
85. 1,2-Diphenylhydrazine	122667			0.036 a,b	0.20 a,b
86. Fluoranthene	206440			130 a	140 a
87. Fluorene	86737			1,100 a	5,300 a
88. Hexachlorobenzene	118741			0.00028 a,b	0.00029 a,b
89. Hexachlorobutadiene	87683			0.44 a,b	18 a,b
90. Hexachlorocyclopentadiene	77474			47 a	1,300 a,j
91. Hexachloroethane	67721			1.4 a,b	3.3 a,b

A		B Freshwater Aquatic Life		C Human Health (10-6 risk for carcinogens) For consumption of:	
92. Ideno(1,2,3-cd)Pyrene	193395			0.0038 a,b	0.018 a,b
93. Isophorone	78591			35 a,b	960 a,b
94. Naphthalene	91203				
95. Nitrobenzene	98953			17 a	690 a,j

96. N-Nitrosodimethylamine	62759			0.00069 a,b	3.0 a,b
97. N-Nitrosodi-n-Propylamine	621647			0.0050 a,b	0.50 a,b
98. N-Nitrosodiphenylamine	86306			3.3 a,b	6.0 a,b
99. Phenanthrene	85018				
100. Pyrene	129000			830 a	4,000 a
101. 1,2,4-Trichlorobenzene	120821			35 a	70 a
102. Aldrin	309002	3.0 f		0.000049 a,b	0.000050 a,b
103. alpha-BHC	319846			0.0026 a,b	0.0049 a,b
104. beta-BHC	319857			0.0091 a,b	0.017 a,b
105. gamma-BHC (Lindane)	58899	0.95 r		0.012 b	0.023 b
106. delta-BHC	319868				
107. Chlordane	57749	2.4 f	0.0043 f	0.00080 a,b	0.00081 a,b
108. 4,4'-DDT	50293	1.1 f	0.001 f	0.00022 a,b	0.00022 a,b
109. 4,4'-DDE	72559			0.00022 a,b	0.00022 a,b
110. 4,4'-DDD	72548			0.00031 a,b	0.00031 a,b
111. Dieldrin	60571	0.24 r	0.056 r	0.000052 a,b	0.000053 a,b
112. alpha-Endosulfan	959988	0.22 f	0.056 f	62 a	89 a
113. beta-Endosulfan	33213659	0.22 f	0.056 f	62 a	89 a
114. Endosulfan Sulfate	1031078			62 a	89 a
115. Endrin	72208	0.086 r	0.036 r	0.059 a	0.060 a,j
116. Endrin Aldehyde	7421934			0.29 a	0.30 a,j

117. Heptachlor	76448	0.52 f	0.0038 f	0.000078 a,b	0.000079 a,b
118. Heptachlor Epoxide	1024573	0.52 f	0.0038 f	0.000039 a,b	0.000039 a,b
A		B Freshwater Aquatic Life		C Human Health (10-6 risk for carcinogens) For consumption of:	
119. Polychlorinated Biphenyls (PCBs)			0.014 q	0.000064 a,b,q	0.000064 a,b,q
120. Toxaphene	8001352	0.73	0.0002	0.00027 a,b	0.00028 a,b
Total Number of Criteria (g)		23	21	96	95

a. This criterion reflects the Environmental Protection Agency's q1* or RfD, as contained in the Integrated Risk Information System (IRIS) as of August 28, 2000. The fish tissue bioconcentration factor (BCF) from the 1980 Ambient Water Quality Criteria document was retained in each case (unless otherwise noted).

b. This criterion is based on carcinogenicity of 10-6 risk.

c. Criterion Maximum Concentration (CMC) equals the highest concentration of a pollutant to which aquatic life can be exposed for a short period of time without deleterious effects. Criterion Continuous Concentration (CCC) equals the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4 days) without deleterious effects. The term

"ug/L" means micrograms per liter.

d. Freshwater aquatic life criteria for metals are expressed as a function of total hardness (mg/L) in the waterbody. The equations are provided at paragraph (i) through (iv) of section 2. Values displayed in the table correspond to a total hardness of 100 mg/L.

e. Freshwater aquatic life criteria for pentachlorophenol are expressed as a function of pH, and are calculated as follows: Values displayed in the table correspond to a pH of 7.8. CMC = exp(1.005(pH) - 4.869). CCC = exp(1.005(pH) - 5.134).

f. This Criterion is based on 304(a) aquatic life criterion issued in 1980, and was issued in one of the following documents: Aldrin/Dieldrin (EPA 440/5-80-019), Chlordane (EPA 440/5-80-027), DDT (EPA 440/5-80-038), Endosulfan (EPA 440/5-80-046), Endrin (EPA 440/5-80-047),

Heptachlor (EPA 440/5-80-052), Hexachlorocyclohexane (EPA 440/5-80-054), Silver (EPA 440/5-80-071). The Minimum data requirements and derivation procedures used to derive the 1980 criteria were different from those in the 1985 Guidelines. For example, a "CMC" derived using the 1980 Guidelines was derived to be used as an instantaneous maximum. If assessment is to be done using an averaging period, the values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.

g. These totals simply sum the number of criteria in each column. For aquatic life, there are 24 priority toxic pollutants with some type of freshwater or saltwater, acute or chronic criteria. For human health, there are 99 priority toxic pollutants with either "water + organism" or "organism only" criteria. Note that these totals count chromium as one pollutant even though EPA has developed criteria based on two valence states. In the matrix, EPA has assigned numbers 5a and 5b to the criteria for chromium to reflect the fact that the list of 126 priority pollutants includes only a single listing for chromium.

h. Criteria for these metals are expressed as a function of the water-effect ratio, WER, as defined in paragraphs (vii) through (ix) of section 2. CMC = (column B1 or C1 value) x WER; CCC = (column B2 or C2 value) x WER.

i. This criterion is a fish tissue residue criterion based on a total fish consumption weighted rate of 0.0175 kg/day. See EPA-823-R-01-001

j. No criterion for protection of human health from consumption of aquatic organisms (excluding water) was presented in the 1980 criteria document or in the 1986 Quality Criteria for Water. Nevertheless, sufficient information was presented in the 1980 document to allow a calculation of a criterion, even though the results of such a calculation were not shown in the document.

k. The CWA 304(a) criterion for this compound is the MCL or drinking water action level.

l. These freshwater criteria for metals are expressed in terms of the dissolved fraction of the metal in the water column. Criterion values were calculated by using EPA's Clean Water Act 304(a) guidance values (described in the total recoverable fraction) and then applying the conversion factors in (v) and (vi) of section 2.

o. The CMC = 1/[(f1/CMC1) + (f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and CMC1 and CMC2 are 185.9 µg/l and 12.82 µg/l, respectively.

p. This water quality criterion is expressed in terms of total recoverable metal in the water column. It is scientifically acceptable to use the conversion factor (0.996 for the CMC, or 0.922 for the CCC) to convert this criterion to a value that is expressed in terms of dissolved metal. (See 40 CFR part 132.)

q. This criterion applies to total PCBs (that is, the sum of all homolog, all isomer, all congener, or all Aroclor analyses).

r. This criterion has been recalculated pursuant to the 1995 Updates: Water Quality Criteria Document for the Protection of Aquatic Life in Ambient Water, Office of Water, EPA-820-B-96- 001, September 1996. See also Great Lakes Water Quality Initiative Criteria Document for the Protection of Aquatic Life in Ambient Water, EPA-80-B-95-004, March 1995.

s. This water quality criterion is expressed as µg free cyanide (as CN)/L.

Table 8. Limits of pollution for various nutrient parameters, MSAE, and microcystin toxins.

Water Quality Parameter	**Recognized Pollution Level**
Total Nitrogen (TN) (mg/L)	0.2 mg/l
Total Phosphorus (TP) (mg/L)	0.035 mg/l
Periphyton Chlorophyll *a* (mg/m^2)	150 mg/m^2
Microcystis aeruginosa cell count	<1,000 cells/ml
Microcystin Toxin	0.8 □g/l

Table 9. Precision of sampling equipment used by KTWQP.

Matrix	**Parameter**	**Measurement Method**	**Precision**	**Accuracy**	**Measurement Range**
Water	Temperature	Onset HOBO Water Temp Pro Loggers	±0.2°C at 0° to 50°C (±0.36°F at 32° to 120°	±0.2°C at 0° to 50°C (±0.36°F at 32° to 120°	0° to 50°C (32° to 122°F) in water (non-freezing)
Water	Temperature	YSI 6600 MPS Multi Probe System: YSI Precision ™ Thermistor	0.1°C	± 0.15°C	-5 to 60°C

Water	Temperature	YSI EXO2 MPS Multi Probe System: YSI Precision ™ Thermistor	0.001°C	±0.01°C at 5° to 35°C and ±0.05°C at 35° to 50°C	-5 to 50°C
Water	pH	YSI 6600 MPS Multi Probe System: YSI Glass Combination electrode	0.01 units	±0.2 units	0 to 14 units

Matrix	**Parameter**	**Measurement Method**	**Precision**	**Accuracy**	**Measurement Range**
Water	pH	YSI EXO2 MPS Multi Probe System: YSI Glass Combination electrode	0.01 units	±0.1 pH units within ±10˚C of calibration temp	0 to 14 units
Water	Dissolved Oxygen	YSI 6600 MPS Multi Probe System Steady state polarographic	0.01 mg/L	±2% @ 0 to 20 mg/L ±6% @ 20 to 50 mg/L	0 to 50 mg/L
Water	Dissolved Oxygen	YSI EXO2 MPS Multi Probe System Steady state polarographic	0.01 mg/L	±1% @ 0 to 20 mg/L ±5% @ 20 to 50 mg/L	0 to 50 mg/L

Water	Conductivity	YSI 6600 MPS Multi Probe System: YSI 4electrode cell with autoranging	0.001 mS/cm to 0.1 mS/cm rangedependent	± 0.5% + 0.001 mS/cm	0 to 100mS/cm
Water	Conductivity	YSI EXO2 MPS Multi Probe System: YSI 4electrode cell with autoranging	0.001 mS/cm to 0.1 mS/cm rangedependent	±0.5% @ 0 to 100 mS/cm ±1% @ 100 to 200 mS/cm	0 to 200mS/cm
Water	Turbidity	YSI 6600 MPS Multi Probe	0.01 NTU	± 2%	0-1000 NTU
Water	Turbidity	YSI EXO2 MPS Multi Probe	.01 FNU @ 0 to 999 FNU 0.1 FNU @	±2% @ 0 to 999 FNU ±5% @ 1000	0-4000 FNU
Matrix	**Parameter**	**Measurement Method**	**Precision**	**Accuracy**	**Measurement Range**
			1000 to 4000 FNU	to 4000 FNU	
Water	Blue Green Algae, Phycocyanin	YSI EXO2 MPS Multi Probe	0.01 µg/L; 0.01 RFU	**Linearity:** R^2 >0.999 for serial dilution of Rhodamine WT solution from 0 to 100 µg/mL BGAPC equivalents	0 to 100 µg/L; 0 to 100 RFU

Table 10. Nutrient, phytoplankton, and algal toxin parameters and the laboratory to which each will be shipped for analysis.

Parameter	Laboratory	Method	Reporting Limit (mg/L)	MDL (mg/L)
Total Phosphorus	AR	SM18 4500PF	0.002	0.002
Soluble Reactive Phosphorus	AR	SM18 4500PF	0.001	0.001
Total Nitrogen	AR	SM204500NC	0.100	0.045
Nitrate + Nitrite	AR	SM 184500NO3F	0.010	0.005
Ammonia	AR	SM 184500NH3H	0.010	0.006
Chlorophyll *a* / Pheophytin *a*	AR	SM1810200H	0.0001	0.0001
Phytoplankton speciation and enumeration	AA	APHA Standards	NA	
Total Organic Carbon	AR	SM205310B	0.250	0.095
Total Suspended Solids	AR	SM20 2540D	0.50	0.30
Volatile Suspended Solids	AR	SM20 2540E	0.50	0.40
Alkalinity	AR	SM182320B	1.00	0.20
Carbonaceous Biochemical Oxygen Demand	AR	SM20 5120B	2.00	1.00
Microcystin-LR	US EPA	ELISA	1.8 □g/l	1.8 □g/l
Microcystin (LR,LA,YR,RR,LF,LW) Anatoxin-a	GreenWater Laboratories	LC-MS/MS	1.0 □g/l	1.0 □g/l

Table 11. Laboratory methodologies, containers, preservatives and holding times.

Parameter	**Method**	**Containers (number, size/volume, type)**	**Preservation Requirements (chemical, temperature, light protection)**	**Maximum Holding Times**
Total Phosphorus	SM18 4500PF	1 X 250ml, polyethylene bottle	4C	28 Days
Soluble Reactive Phosphorus	SM18 4500PF		4C	48 hours
Total Nitrogen	SM204500NC		4C	28 days
Nitrate + Nitrite	SM184500NO3F		4C	48 hours
Ammonia	SM184500NH3H		4C	48 hours
Alkalinity	SM18 2320B		4C	14 days
Chlorophyll *a* / Pheophytin *a*	SM1810200H	1 X 1L, polyethylene bottle	4C	
Total Organic Carbon	SM205310B	1 X 100ml, amber glass bottle	4C	28 day
Dissolved Organic Carbon				
Total Suspended Solids	SM20 2540D	1 X 1L, polyethylene bottle	4C	7days
Volatile Suspended Solids	SM20 2540E			
Microcystin (GreenWater)	Anatoxin, LCMS/MS	1 X 250ml, clear glass bottle	Freeze and ship at <4C	14 days
Microcystin (EPA)	ELISA	1 X 60ml, clear glass bottle	Freeze and ship at <4C	14 days
Carbonaceous Biochemical Oxygen Demand	SM20 5120B	500ml, polyethylene bottle	4C	48 hours

Table 12. Summary of Field and QC Samples for Karuk Tribe Water Monitoring Program.

Matrix/ Media	Analytical Parameter[1]	No. of Sampling Locations	Depth (surface, mid, or deep)[1]	No. of Field Duplicates[2]	Inorganics No. of[4]		No. of Field Blanks[5]	Total No. of Samples
					Dup	MS		
Analysis:								
Surface Water	Total Phosphorus	8	Surface	4	1	1	1	49
Surface Water	Dissolved Phosphorus	8	Surface	4	1	1	1	49
Surface Water	Total Nitrogen	8	Surface	4	0	0	1	47
Surface Water	Ammonium Nitrogen	8	Surface	4	1	1	1	49
Surface Water	Nitrate + Nitrite	8	Surface	4	1	1	1	49
Surface Water	Phytoplankton	8	Surface	4	10% of samples		1	51
Surface Water	Chlorophyll	8	Surface	4	1	1	1	49
Field Measurements:								
Surface Water	Temperature	16	Surface	4			0	46
Surface Water	pH	16	Surface	4			0	46
Surface Water	Conductivity	16	Surface	4			0	46
Surface Water	Turbidity	10	Surface	4			0	46

[1] Samples will be collected at depth of 6-12 inches. If depth of water is less than 12 inches, sample will be collected at mid depth and noted in the field logbook.

[2] Field duplicates will be collected at a frequency of 10% of the samples collected for laboratory analysis. Field duplicates will be collected at a frequency of 10% or one per day, whichever is more frequent, for samples collected for field measurements.

[4] Includes number of associated analytical QC samples if collection of additional sample volume and/or bottles is necessary. If the QC samples listed are part of the analysis but no additional sample volume and/or bottles are needed, include “NAS” (for

Surface Water	Dissolved Oxygen	16	Surface	4			0	46

[1] All analyses will be performed at an off-site laboratory. There will be no field screening analyses. Field measurements will be performed at each sample collection location.

"no additional sample") in the column. (Note: MS=matrix spike, MSD=matrix spike duplicate, dup=laboratory duplicate/replicate.)

[5] Field blanks will be collected at a frequency of 10% of the samples collected, or one per day, whichever is less frequent. Field blanks will not be collected, as they were determined not to be critical, to support laboratory analysis of Total Dissolved Solids, alkalinity, total coliform, e. coli or for field measurements.

Table 13. Field Equipment Calibration, Maintenance, Testing, and Inspectio.n

Analytical Parameter	Instrument	Calibration Activity	Maintenance & Testing/ Inspection Activity	Frequency	Acceptance Criteria	Corrective Action
Temperature (Sensor)	6600 and EXO2 MPS Multi Probe System: YSI Precision ™ Thermistor		See Manufacturer's manual	Initial Post: Once a week check and calibrate as needed	± 0.15°C of true value at both endpoints	Remove from use if doesn't pass calibration criteria
Temperature (Sensor)	Onset HOBO Water Temp Pro Loggers	Water bath calibration against NIST thermometer (US Fish and Wildlife Protocol)	See Manufacturer's manual	Initial	±0.2°C of true value at both endpoints	Remove from use if doesn't pass calibration criteria
pH (electrode)	6600 and EXO2 MPS Multi Probe System: YSI Glass Combination electrode	Initial: Twopoint calibration bracketing expected field sample range (using 7.0 and 10.0 pH buffer)	See Manufacturer's manual	Initial and bi-weekly (every other week)	Initial: Two-point calibration done electronically	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria.

		Post: singlepoint check with 7.0 pH buffer			Post: ±0.1 pH units of true value	
Dissolved oxygen (sensor)	6600 and EXO2 MPS Multi Probe Optical Sensor	Initial: Onepoint calibration with saturated air (need temp, barometric pressure). Post: singlepoint check at full saturation	See Manufacturer's manual	Initial and bi-weekly (every other week)	Initial: Onepoint calibration done electronically Post: ±0.5 mg/L of true saturated value	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria.
Turbidity (sensor)	YSI 6600 and EXO2 MPS Multi Probe System	Initial: Onepoint calibration using 0 NTU (or deionized water) Post: singlepoint check at 0 NTU	See Manufacturer's manual	Initial and bi-weekly (every other week)	Initial: Onepoint calibration done electronically Post: ±1 NTU of true value	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria.
Conductivity (sensor)	YSI 6600 and EXO2 MPS Multi Probe System: YSI 4electrode cell with autoranging	Initial: One-point calibration at high end of expected field sample range (1000 mS/cm standard) Post: two-point check with high (1000 mS/cm) and low (0 mS/cm) standards	See Manufacturer's manual	Initial and bi-weekly (every other week)	Initial: one point calibration done electronically Post: high standard ±5% of true value and low standard ±10% of true value	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria.

APPENDIX C

Field Operations and Sampling Forms

ISCO Program - Bottle Retrieval - Field Form

Sample Date	Sample Time	PST / PDT?	Bottle Number

General Notes:

Next Sample Programmed (periodic) Date/Time: _____

Trigger Parameter (episodic) Date/Time: _____

Trigger Level (ft?, FNU? Etc.): _____

Intitials: _____

Field Inspection Sheet - Total Load Sediment

Station Number:		**Date:**			
Station Name:					
Party:		**Weather:**			
Flow:		**H20 Temperature:**		°C	
Meas. Type:		**Stage:**			
Location:			**gage.**		
Sampler Type (84164):					
Nozzle Size:					
		ISOKINETIC SAMPLE?:			

Discharge Measurement Details:									
Width:		**Area:**		**Velocity:**		**Gage Height:**		**Discharge:**	

ONLY FILL OUT SEDIMENT CHANNEL EDGE OF WATER LOCATIONS AND NUMBER OF VERTICALS IF SAMPLING VIA EWI

Sediment Channel REW		**Sediment Channel LEW**		**Sediment Channel Width**		**Number of Verticals**	

SUSPENDED SEDIMENT									
Method (82398)	Station	Start Time	Finish Time	Number of Bottles	Set	Number of Verticals	Recorded GH	WW/OSS	Analysis Requested

Observer Contacted:		**USGS Therm:**		°C	**Cases**		
Thermometer Checked:		**Observer Therm:**		°C			

Remarks: _____

_____

SedLogin Notes:

APPENDIX D

Standard Operation Procedures SSC Plan

Suspended Sediment Sampling – SOP

Klamath River water quality monitoring and SSC sampling

General order of operations at the site

ISCO automated sampler servicing

1. Pause program & collect sample time information
    a. Option 1. Download program / sample log to a computer
    b. Option 2. Fill out ISCO sample history field form as you page through the ISCO or datalogger display
2. Put on gloves as you handle bottles
3. Cap and label bottles with date/time or appropriate information to match sample date/time to bottles back in the office
4. Remove full bottles one by one as you label them with appropriate sample time from log/sheet
5. Replace full bottles with capped empty/clean bottles one by one in tray
6. When done handling all the full / empty bottles, change gloves
7. Uncap empty bottles, store clean caps in ziplock in gagehouse for next visit
8. RESART the program (you may leave it unstarted during EDI sampling so you can get before/after EDI grabs)

Discharge Measurement (if needed)

1. Complete a gage inspection and obtain initial GH readings using SVMAQ
2. Complete a discharge measurement with an ADCP and obtain the EDI stationing information for the EDI sample using QRev
3. Enter the Qm info as you normally would in SVMAQ
4. If an EDI rating has been developed based on rated Q and you are not able to make a Qm, EDI stations can be obtained from the rating.

Equal Discharge Increment (EDI) Sediment Sampling

NOTE: if water temp is <10degC and you are using a bag sampler, see 2013 memo for revised transit rates (policy_memos folder)

"Although a given one-way transit rate must be constant, neither the descending and ascending transit rates in any one vertical need to be equal nor do the transit rates need to be equal among verticals. The number of transits in each vertical can vary if no sample bottle overfills. Although different diameter nozzles for the isokinetic sampler can be used from vertical to vertical, it may complicate the data collection procedure, hence, the practice is discouraged."

"If an equal amount of sample is collected at each vertical, the samples can be composited and analyzed as a single sample. However, to realize the full benefits of the EDI method, samples should be analyzed separately and the resulting SSC values summed and then divided by the number of subsections to derive a mean water discharge-weighted SSC. One advantage of this method is that data describing the cross-sectional variation in SSC are produced. Additionally, a bottle containing an abnormal amount of

sediment – particularly sand – compared to others in the set (because of recirculation or to gouging the nozzle into the bed) can be identified and excluded from the calculated mean cross-sectional SSC to minimize the potential for bias"

1. Collect an ISCO Grab sample prior to the START of sampling
    a. Fill a 3-liter bottle if turbidity is <10 FNU from EXO reading
2. Note the time of the grab on the ISCO bottle
3. Collect the EDI sample (set A & B)
    a. Do an intake efficiency test if you are using a D-96 bag sampler (see tab in this sheet)
    b. Select appropriate transit rate and/or nozzle to fill each bottle for each veritcal with roughly the same volume
        i. See transit rate tables, use rule of thumb = 0.4 x mean velocity = transit rate in sec/ft
        ii. If using transit rate tables in ft/sec, divide 1 by rate to get sec/ft on B reel, e.g., transit rate is 2 ft/sec from table, then 1/2 = 0.5 and transit rate on B reel is 0.5 sec/ft or 1 sec for every two feet as you are reeling/watching on the B-reel dial
        iii. BEGIN SAMPLNG: Lower field-rinsed sampler at the predetermined constant transit rate until slight contact is made with the streambed. **Do not pause** upon contacting the streambed. Raise the sampler immediately until sampler completes the vertical traverse.
            1. Take care not to disturb the streambed by bumping the sampler on it; bed material may enter the nozzle, resulting in erroneous data.
            2. Do not overfill the sampler container.
            3. Inspect each subsample as it is collected, looking for overfilling or underfilling of the sampler container and (or) the presence of anomalously large amounts of particulates that might have been captured because of excessive streambed disturbance during sample collection.
            4. If the sampler is overfilled or the nozzle digs into the streambed, dump sample and re-collect sample starting at the first vertical from the previous sample
            5. Transit rates can vary when lowering and raising through the water column, so long as the transit rate does not exceed the velocity of the water, and that the same volume is collected at each sampling location in the cross section.
        iv. Move sampling equipment to the next vertical. Collect sample.
    c. For A-set samples, retain all containers from each EDI station (minimum 5 locations)
    d. For B-set samples, composite all of the samples from individual EDI stations into 3-L bottles, or whatever size bottle will hold all of the sample
    e. <u>For SedLogin:</u> Analyze the A-set containers individually, Analyze the B-set samples as a composite with particle size distribution
4. Collect an ISCO Grab sample in the ~middle of sampling
5. Note time for each vertical as you are sampling
6. Collect an ISCO Grab sample prior to the END of sampling
    a. Fill a 3-liter bottle if turbidity is <10 FNU from EXO reading

7. Complete sample, and fill out bottle labels and field sheet fully (see “SSC_fieldsheet.pdf”)

Equipment List

1. ISCO form
2. ISCO computer cable
3. Axiom computer cable
4. ISCO labels and pens
5. Ziplocks
6. Gloves
7. Clean ISCO bottles
8. 3L grab sample bottle (<10 FNU EXO Turb)
9. Appropriate sediment sampler for expected conditions
    a. Light samplers: DH-48, DH-59, DH-81, DH-95
    b. Heavy samplers: D-74, D-95, D-96
10. A-reel, B-reel, or E-reel
11. Nozzles (3/16”, ¼”, 5/16”)
12. Appropriate sediment bottles and carrier (3-L, 1-L, glass quart, glass pint)
13. 4-wheel crane and counterweights (if site conditions require)
14. Boom truck and crane (if site conditions require)
15. Boat (if site conditions require)

1. Pre-trip preparation

- Load equipment listed above
- Ensure all manuals are available on tablet
    - ISCO
    - AXIOM
    - SatLink3
    - EXO
    - Analite

Continuous Water Quality Monitors – SOP

Klamath River water quality monitoring and SSC sampling

I. ANALITE high-range turbidity service Protocols

1. Place cal-checked Analite NEP5000 from the office adjacent to deployed sensor
2. Wipe both sensors (field and site)
3. Obtain pre-clean readings, enter in SVMAQ
4. Remove deployed sensor, clean it.
    a. Q-tip on optics face and wiper
    b. Tooth brush or similar on sensor body and cable
    c. Chimney brush to clean deployment tube
    d. Long pool brush or similar to clean outside of deployment tube
    e. Inspect wiper, inspect wiper position ensure it is normal (about 190deg from the optics, or slightly more than 180deg from optics)
    f. Look for scratches on optics face
5. Replace cleaned site sensor in cleaned deployment tube
6. Obtain post-clean readings, enter in SVMAQ
7. Quarterly Cal Checks:
    a. Remove cleaned sensor again from deployment tube
    b. Check in 0 DI water after rinsing 3 times in DI water
        i. Rinse again and check again in DI water if readings are >1.5 FBU above/below zero (FBU = formazin backscatter unit, which is what this sensor measures in, not NTU)
    c. Check in 5000 NTU (really FBU) standard after rinsing 3 times
        i. Use previously used standard to triple rinse, dump out in waste container
        ii. Use new standard to check, and pour out in rinse container for next rinse
    d. Record cal check readings in SVMAQ, cover the range of conditions with polymer (e.g., if conditions <5000 FBU, you do not need to use 10000 or 30000 to check)
    e. DO NOT recalibrate in the field
    f. Swap in the spare sensor if:
        i. >1.5 FBU different from zero DI after several attempts to ensure proper rinsing
        ii. >5% off in 5000 or other polymer standard, will be alerted in SVMAQ by orange data
    g. If spare sensor is swapped in, cal check the old sensor again in the office and recalibrate as necessary.

II. EXO Service Protocols

California sites – Operated by Karuk and Yurok Natural Resources Departments

1. In general, it has been agreed that the Karuk tribal members will perform cal checks on EXOs.
2. Deploy cal-checked field EXO from the office
3. Enter pre-clean readings in SVMAQ for the field and site EXOs
4. Clean the deployed EXO (see below) and re-deploy
5. Enter post-clean readings in SVMAQ

6. Save SVMAQ file and send to Karuk email members
7. Let Karuk know if calibration appears off after cleaning, i.e., there is large disagreement in post-clean readings

Oregon Sites – Operated by U.S. Geological Survey

Cleaning YSI EXO2 sondes in the field

1. Place cal-checked YSI EXO from the office adjacent to deployed sensor
2. Wipe both sensors (field and site)
3. Obtain pre-clean readings for all water quality parameters, enter in SVMAQ
4. Remove deployed sensor, clean it.
    a. Q-tip on optics face and wiper
    b. Tooth brush or similar on sensor body and cable
    c. Chimney brush to clean deployment tube
    d. Long pool brush or similar to clean outside of deployment tube
    e. Inspect wiper, inspect wiper position ensure it is normal (about 190deg from the optics, or slightly more than 180deg from optics)
    f. Look for scratches on optics face
5. Replace cleaned site sensor in cleaned deployment tube
6. Obtain post-clean readings, enter in SVMAQ

Quarterly Calibration checks

Calibration of deployed EXO2 sondes will occur approximately quarterly at USGS-operated continuous water quality monitoring sites. When calibration checks reveal only a small amount of calibration drift, it may not be necessary to recalibrate the instrument. Calibration criteria will be used to determine if sensor require re-calibration (Table 1). In practice, a calibration check of cleaned sensors using calibration standards is compared to the calibration criteria. If calibration drift is within the calibration criterion, the sensor is considered stable and recalibration is not required (Wagner and others, 2006)

[±, plus or minus value shown; °C, degree Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; mg/L, milligram per liter; pH unit, standard pH unit; turbidity unit is dependent on the type of meter used]

Measurement	Calibration criteria (variation outside the value shown requires recalibration)
Temperature	±0.2 ºC
Specific conductance	±5 µS/cm or ±3 % of the measured value, whichever is greater
Dissolved oxygen	±0.3 mg/L
pH	±0.2 pH unit
Turbidity	±0.5 turbidity unit or ±5% of the measured value, whichever is greater

Table 1: Calibration criterion for continuous water-quality monitors (Wagner and others, 2006)

If calibration checks result in re-calibration of sensors, the following procedures will be followed:

Before Calibrating

1. Clean all probes with the correct brushes (Kimwipe for DO and Phycocyanin probe, SC brush for SC probe, pipe cleaner for pH Probe) before calibrating. Clean the body of the probes and any other surfaces inside of the calibration cup with a toothbrush
2. Check that all the probes are tight. They should be tight, **but not torqued.**

Preparation:

1. Use the lab calibration cup and probe guard for all calibrations and checks.
2. Prepare sonde for dissolved oxygen (DO) calibration. Remove the calibration cup, probe guard and the probe guard end-cap with holes, exposing the sensors. Carefully dry the temperature and DO probe surfaces using a Kimwipe, **do not use condensed air to dry the DO probe.**
3. Replace the black probe guard, minus the holy end-cap, over sensors (removing end-cap now will aid in further rinses later on) without wetting the DO or temperature probe tips. (Note the different threads on each end of the probe guard & match accordingly, the finer threads correspond with the sonde body). Be careful not to cross-thread as the plastics are soft.
4. With the calibration cup still detached and resting on the benchtop, add approximately 1 inch of tap water.
5. Mount the sonde vertically (probes pointed downward) by carefully placing the sonde into the water filled calibration cup, but carefully without wetting the DO or temperature probe tips. The sonde's probes should now be hovering above the water in the calibration cup.
6. Loosen the calibration cup almost completely. This will ensure that the barometric pressure inside the cup is the same as the pressure outside of the cup. **It is important to wait at least 15 minutes** for the temperature reading to stabilize and for the air inside the calibration cup to become 100% water-vapor saturated before calibrating the DO probe.

Connecting to EXO Sondes: (Via PC Notebook)

1. Activate the Bluetooth connectivity of the sonde by holding the associated magnetic wand tool (or any magnet) over the magnet symbol on the sonde.
2. The solid Blue LED light on the sonde should now be on, displaying the sonde's Bluetooth is active (a Red LED should also be blinking letting the user know the sonde is now 'awake').
3. Open the KOR-EXO software on the Desktop.
4. Connect to the EXO sonde via Bluetooth (if PC is Bluetooth capable & allows devices to connect) by selecting the "Connections" menu (Green/Blue Circling arrows) and selecting the "Rescan" button on the left. If the computer you are using before has connected to this EXO before it will pop up here. If not, then, select the "Search Bluetooth" button. This will "Discover Devices" and sometimes multiple attempts are required. Select your sonde and "Connect". **Note: The sonde Bluetooth range is rated at 30 feet, but 10 feet is more realistic to prevent problems initially connecting.**
5. If the Bluetooth does not work for some reason, you can connect to the EXO sonde via the USB Signal Output Adapter to the sonde's upper right 6-pin communications port and to the laptop's associated (COM) USB port.
6. Sonde is now connected and it's corresponding model & S/N will now be displayed in a box in the upper right-hand of KOR (sonde connection is also displayed by the sonde symbol having a green check mark). You will also be automatically take you the "Dashboard" screen (Green Runner) with the various sensor parameters displayed. Proceed to calibrations.

Dissolved Oxygen Calibration:

1. After sonde "Preparation" for DO (as described above) and at least 15 minutes, it is time to calibrate.
2. Check that the temperature and DO readings are stable via the Dashboard (Runner Icon). The temperature may change very slowly (e.g. one-hundredth of a mg/L every 10 seconds or so), but this is stable enough.
3. To determine what value to calibrate to, enter in pressure and temperature in CHIMPS or SVMOBILE, where the value will auto populate.
4. Navigate to the Calibration screen (Crosshair symbol) to begin the calibration sequence. Select "Port-3 ODO" and then select "ODO mg/L". A "Device Calibration" window will now appear in a separate window.
5. Select "1 Point" calibration and enter the value from the DO concentrate on table into the "Standard Value" box.
6. "Sal psu" value should be '0'. DO NOT ENGAGE WIPE SENORS.
7. Select "Start Cal". Real time readings will be displayed. Once the values have stabilized (green "Stable Data") Select "Apply" and then "Complete".
8. A "Calibration Summary" for DO will now be provided.
   Record the calibration DO values and also the ODO Gain value from this summary. DO gain should be somewhere between 0.85 and 1.15. If the gain is drastically out of range, or the QC score has a red 'X' or yellow '!' the DO probe may need to be serviced or replaced. Otherwise, go by the QC score in the calibration summary, a 'green check' should be displayed in the summary indicating proper probe function.

9. Verify the calibrated value is equal to the value you entered for the sensor to calibrate to.
10. Next, remove the calibration cup so it's just the probe guard and place the sonde in the 100% air-saturated water bucket.
11. View real time readings by selecting the Dashboard. At the top right of the screen, select "Wipe Sensors" and wait for the sensors to be cleaned. This will remove air bubbles from the ODO probe.

12. After the DO reading has stabilized, record the temperature reading of the water and check that the barometric pressure has not changed.
13. Use the DO table in the lab folder to find the DO mg/L value the sonde should read in the 100% air-saturated water.
14. Record the DO mg/L value the sonde reads in the water in the comments section in CHIMPS or SVMOBILE. If the sonde reads outside the range of ± 0.06 mg/L of the DO concentration table value, the DO sensor needs to be recalibrated.

Notes about the YSI ROX Optical DO probes:

- The Optical Dissolved Oxygen sensor does not require any special sonde setup or burn-in.
- Calibration data is stored in the probe so it can be calibrated in one sonde and then used in another without recalibrating the probe in the new sonde.
- Calibration data are automatically transferred to the host sonde as soon as the sonde powers up the sensor.
- Field DO calibrations should be avoided!
- The DO sensor must remain hydrated at all times.

If you believe that you have calibrated a probe in error, then you can return the probe back to its original factory calibration by using the "uncal" command. At the "Device Calibration" screen where you would type in the "Standard Value" for a DO calibration, press the "Advance" button in the lower left and select the "uncal" button.

Specific Conductance (SC) (Combined with Temperature on same probe):

1. Reinstall the calibration cup onto the sonde body. **Note: Make sure the threads are nice and tight! As this is a compression fitting and sonde could slip loose from cup and crash.**
2. Rinse the calibration cup (accessed via the calibration cup's endcap) and sensors vigorously three times with a small amount of 1000 µS/cm standard solution and discard. Use the bottles labeled "flush" for these rinses. Shake the sonde each time to rinse all surfaces in the cup with the standard flush solution.
3. Put *FRESH* 1000 µS/cm standard solution in the cal cup, **just enough to submerge the SC sensor completely when the sonde is laid on its side. Use the least amount of solution as possible, as this stuff is expensive!!!** The vent holes in the side of the probe must be under the solution. It is important not to have trapped bubbles in the cells. Gently shake the sonde to help dislodge any air bubbles that may be trapped in the conductivity sensor.
4. Navigate to the Calibration screen (Crosshair symbol) to begin the calibration sequence. Select "Port-1 Conductivity" and then select "SpCond µS/cm ". A "Device Calibration" window will now appear in a separate window.
5. Enter the value of 1000 µS/cm as your "Standard Value." Make sure the probe is fully submerged in standard and clear of bubbles to proceed with "Start Cal".
6. Select "Start Cal." Real time readings will be displayed. Once the values have stabilized (green "Stable Data") Select "Apply" and then "Complete".
7. A "Calibration Summary" for SC will now be provided.
8. Record the values, and don't forget the cell constant value which will be listed under "Additional Post Calibration Info."

1. Check the conductivity cell constant is in a somewhat acceptable range of 4.5 - 6.5. Numbers drastically outside of this range may indicate a problem in the calibration process, with the standard that was used or that the sensor needs to be serviced or replaced. Otherwise, mainly go by the QC score in the calibration summary, a 'green check' should be displayed in the summary indicating proper probe function. A red 'X' or yellow '!' indicate the probe may need to be serviced or replaced.
9. If the sonde reports "Out of Range" after the calibration, investigate the cause! Never override a calibration error message without knowing the reason. Typical causes for this error message are incorrect entries, low solution level, fouled probe contacts, air bubbles in the probes cell, calibrating conductivity instead of specific conductance (SpCond), and/or bad standard or the sensor needs to be serviced or replaced.
10. Pour the standard solution used for calibration into the 1000 µS/cm bottle marked "flush."
11. Proceed to the Dashboard menu to check the SC calibration in 180 µS/cm and 50 µS/cm standards. Starting with the 180 µS/cm standard, rinse the probes and calibration cup three times with each standard (flush). Fill the cup to cover the SC probe with *FRESH* solution, and record the measured values.
12. Record the lot numbers of the FRESH standards used.
13. Pour the solution used to check the SC calibration into the appropriate flush bottles. The sonde SC should read within ± 3 µS/cm of the measured value of the check standards. If a check standard is out of range, first try tapping or shaking the sonde to get air bubbles out of the conductivity sensor. If that does not work, try to re-flush with the same standard. If that does not work, clean the SC probe with a conductivity brush and repeat the calibration in the 1000 µS/cm standard solution.
14. Dry the SC probe and record the SC value in air using canned air. This should be between 0 and 1 µS/cm. If a different value is found, try blowing through the probe with compressed air to remove any remaining solution. If the SC reading is 2 µS/cm or less, the probe is acceptable for deployment. If it reads higher than this, try re-calibrating the probe, or try cleaning the SC probe ports with a dilute Liquinox solution and a conductivity brush. If the probe still does not read below 2 µS/cm, replace the probe.

Notes about the SC/Temperature sensors:

- The accuracy of the **reference** temperature probe must be checked by comparison with a traceable thermometer (NIST). Temperature compensation is used in every sonde measurement, so its accuracy should be verified and recorded. These thermistor checks should be done quarterly at 5 temperatures. More verifications may be needed if there is evidence the probe is not working properly.
- Never calibrate with conductivity standards that are less than 1000 µS/cm. You are setting the slope on a linear device, so a good strong conductivity signal will give the best performance.

pH

1. Rinse the calibration cup (accessed via the calibration cup's endcap) and sensors three times with a small amount of pH 7 buffer flush. After the three rinses, fill the calibration cup with just enough *FRESH* pH 7 standard so that the pH and temperature sensors are completely immersed when sonde is laid on its side**. Use the least amount of solution as possible, as this stuff is expensive!!!**. Check that there are no bubbles in contact with the bulb of the pH sensor.
2. Record the lot number of the FRESH pH 7 standard.
3. Make sure before you start the calibration process that the pH value is stable. Usually, 2-3 minutes is needed for the values to become stable, as the values slowly drift.
4. After confirming the pH values are stable, navigate to the Calibration screen (Crosshair symbol) to begin the calibration sequence. Select "Port-2 pH" and then select "pH". A "Device Calibration" window will now appear in a separate window.

5. Select a '2 Point" calibration
6. Wait for the temperature reading near the left to stabilize, and record the temperature. (This will be the temperature used to correct for both pH 7 and pH 10)
7. Enter the temperature information into SVMOBILE or CHIMPS, the program will auto populate the correct value to calibrate to.
8. Begin the calibration sequence for pH by selecting "Start Cal". Real time readings will be displayed for pH 7. Once the values have stabilized (green "Stable Data") Select "Apply" and then "Proceed". **Note: The "Proceed" button actually finalizes the calibration for pH 7. Do not proceed to pH 10 before selecting "Proceed".**
9. A "Proceed to Standard: 10 pH" prompt will appear.
10. **BEFORE YOU CONTINUE** – rinse the probes and calibration cup three times with pH 10 flush solution and fill with FRESH pH 10 standard solution to completely cover the pH probe.
11. Press "Ok"
12. Real time readings will be displayed for pH 10. Once the values have stabilized (green "Stable Data") Select "Apply" and then "Complete".
13. A "Calibration Summary" for pH will now be provided.
2. Record the values, along with pH millivolts for each calibration point via the summary. The acceptable millivolt output for the pH 7 buffer is around 0 ± 35 mv. The acceptable millivolt output for the pH 10 buffer is around -180 ± 35 mv. Otherwise, mainly go by the QC score in the calibration summary, a 'green check' should be displayed in the summary indicating proper probe function. A red 'X' or yellow '!' indicate the probe may need to be serviced or replaced.
3. Record the "Delta Slope" of the sensor from the summary (Delta Slope value will be listed under "Additional Post Calibration Info"). This is the calculated difference (in mv) between the two calibration points that were used. For example, if you record +3 mv for the pH 7 buffer and -177 mv for the pH 10 buffer, the slope would be 180. The acceptable range for the slope is 165 to 180. If the difference is out of this range but the QC score checks out OK then the probe is probably OK, but this is usually a sign that the probe tip needs to be replaced soon.

Notes about the pH sensor:

- Do not use a probe that has given the warnings "Calibration Error" or "Out of Range."

Turbidity

1. Clean the optics of any fouling, fingerprints, etc.
2. Start with the 0 FNU standard (DI Water). Rinse the calibration cup and probes three times with DI water.
3. Fill the calibration cup, very carefully down the side of the cup, with DI water. Be very careful, avoiding aerating the water at all. **THERE SHOULD BE NO BUBBLES!**
4. Replace the 'end cap'. Carefully invert sonde into the upright position, resting it on its 'end cap'. Verify that there are no air bubbles on the probe face and engage the wiper (if applicable). If bubbles remain on the probe surface, engage wipers again (via the Dashboard Menu- Wipe Sensors) or replace with fresh DI water.
5. Navigate to the Calibration screen (Crosshair symbol) to begin the calibration sequence. Select "Port-5 Turbidity" then "Turbidity FNU" and select "2-Point" Calibration.
6. Enter 0 FNU for the first calibration point (DI Water). Also, enter your value of the formazin standard you will be using for the second calibration point, replacing the "NaN" value. (This standard value is up to the user and is typically based on the environmental water conditions that will be expected in the field.)

7. Begin the calibration sequence for turbidity by selecting “Start Cal”. Real time readings will be displayed for the DI value. Once the values have stabilized (green “Stable Data”) Select “Apply” and then “Proceed” to calibration point 2 or 2.
8. BEFORE YOU CONTINUE – rinse the probes and calibration cup three times with your formazin flush solution and then fill with FRESH formazin standard solution to completely cover the pH probe when in the upright right position.
9. Return the sonde to its upright vertical position. Press “Ok”
10. Real time readings will be displayed for your formazin standard. Once the values have stabilized (green “Stable Data”) Select “Apply” and then “Complete”.
11. A “Calibration Summary” for Turbidity will now be provided.
12. Record the “Pre” and “Post” FNU values for both points onto your Calibration Form. Circle Y under Cal? on your Calibration Form.

Notes about the turbidity sensor:

- Never override a calibration error message without understanding the cause of the problem. Error messages indicate that a problem exists that could result in incorrect field readings.
- The calibration of YSI turbidity sensors must be done with either YSI distributed standards, Hach StablCal, diluted Hach 4000 NTU Formazin, or standards that have been prepared according to the instructions in Standard Methods (Section 2130B). Standards from other vendors are NOT approved, and their use will likely result in a bad calibration and incorrect field readings.

- When a sonde is deployed in clean water and it reports negative turbidity data, the cause can usually be traced to the zero calibration. Despite the best practices it is sometimes impossible to clean the sonde and the calibration equipment to a point where the zero standard is not contaminated by some small amount. This is especially true when using previously deployed equipment.

III. Equipment List

- Chimney brush
- Pool brush
- Qtips
- Toothbrush
- Tablet with synced SVMAQ
- Cal-checked reference sensor EXO and/or Analite
- Calibration standards for pH and specific conductance
- 0 DI water from HIF
- 5000 polymer standard (Analite only)
- 10000 polymer standard (Analite only, if needed)
- 30000 polymer standard (Analite only, if needed)
- Cal cup (250 mL brown HDPE wide mouth bottles)
- Waste container (containerize used calibration standards)
- Rinse container for polymer standards (one per standard)

IV. Pre-trip preparation

- Calibrate field EXO/Analite
- Load equipment listed above
- Ensure all manuals are available on tablet
    - ISCO
    - AXIOM
    - SatLink3
    - EXO
    - Analite

APPENDIX E

YSI EXO Datasonde User and Calibration Manual

xylem
Let's Solve Water

USER MANUAL
ITEM# 603789REF
REVISION H

EXO User Manual

ADVANCED WATER QUALITY MONITORING PLATFORM

YSI
a xylem brand

The information contained in this manual is subject to change without notice.

Effort has been made to make the information in this manual complete, accurate, and current.

The manufacturer shall not be held responsible for errors or omissions in this manual.

Consult **YSI.com/EXO** *for the most up-to-date version of this manual.*

THIS IS AN INTERACTIVE DOCUMENT

When viewing this document as an Adobe™ PDF, hovering your cursor over certain phrases will bring up the finger-point icon. Clicking elements of the Table of Contents, website URLs, or references to certain sections will take you automatically to those locations.

Product Components

Carefully unpack the instrument and accessories and inspect for damage. If any parts or materials are damaged, contact YSI Customer Service at 800-897-4151 (+1 937 767-7241) or the authorized YSI distributor from whom the instrument was purchased.

Technical Support

Telephone: 800 897 4151 (USA), +1 937 767 7241 (Globally)

Monday through Friday, 8:00 AM to 5:00 ET

Fax: +1 937 767 9353 (orders)

Email: info@ysi.com

YSI.com

Safety Information

Please read this entire manual before unpacking, setting up or operating this equipment. Pay attention to all precautionary 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.

Precautionary Symbols

NOTE: *Information that requires special emphasis*

NOTICE: Indicates a situation which, if not avoided, may cause damage to the instrument

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

⚠ **WARNING:** Indicates a potentially hazardous situation which could result in death or serious injury

TABLE OF CONTENTS

Bluetooth®

Section 1
EXO Platform Overview

1.1 EXO1 Sonde
Overview

The EXO1 sonde is a multiparameter instrument that collects water quality data. The sonde collects the data with up to four user-replaceable sensors and an integral pressure transducer. Each sensor measures its parameter via a variety of electrochemical, optical, or physical detection methods. Each port accepts any EXO sensor and automatically recognizes its type. Depending upon user-defined settings, the EXO1 will collect data and store it onboard the sonde, transfer the data to a data collection platform (DCP), or relay data directly to a user's PC or the EXO Handheld. See Section 6 for information specific to vented level sondes.

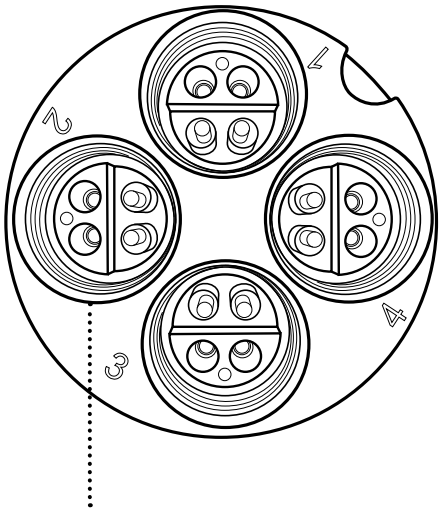
Users communicate with the sonde via a field cable to an EXO Handheld, **Bluetooth**® wireless connection to a PC or EXO Classic Handheld, or a USB connection (via communications adapter) to a PC.

Specifications

Operating Environment *Depth Rating*	 250 meters, 820 feet
Material	Xenoy®, Lexan®, titanium, 316 stainless steel
Internal Logging Memory Capacity	512 MB
Software	KorEXO Software
Communications *Sonde* *Adapters*	 **Wireless:** *Bluetooth* **Field Cable:** RS-485 RS-232, Mod Bus, USB, SDI-12
Power *External* *Internal*	 9-16 VDC (2) D-cell batteries
Temperature *Operating* *Storage*	 -5 to 50°C -20 to +80°C
Battery Life	90 days*
Dimensions *Diameter* *Length* *Weight w/ battery*	 4.70 cm,1.85 in 64.77 cm, 25.50 in 1.42 kg, 3.15 lb

**Battery life will depend on the type of sensors and measurement frequency.*

EXO1 Bulkhead



Universal Sensor Ports

EXO1 Sonde
599501-xx

Removable Bail
599473

6-Pin Cable Connector

Upper Battery Compartment Seal
O-ring kit 599680

Battery Compartment

Battery Cover
599052

Lower Battery Compartment Seal

Pressure Transducer Opening

Red LED Indicator - Sonde Status

Blue LED Indicator - *Bluetooth*

On/Off Magnetic Switch for Power and *Bluetooth*

Bulkhead

Sensors

Port Plug
599475

Calibration Cup
599786

Sensor Guard
599666, 599563

Guard Weight
599471

1.2 EXO2 Sonde
Overview

The EXO2 sonde is a multiparameter instrument that collects water quality data. The sonde collects the data with up to seven user-replaceable sensors and an integral pressure transducer. Each sensor measures its parameter via a variety of electrochemical, optical, or physical detection methods. Each port accepts any EXO sensor and automatically recognizes the type of sensor. Depending on user-defined settings, the EXO2 will collect data and store it onboard the sonde, transfer the data to a data collection platform (DCP), or relay it to a user's PC or EXO Handheld via cable, USB connection, or **Bluetooth®** connection.

In addition to six standard sensor ports, the central port (port 7) can accept either a central wiper or an additional sensor. The auxiliary port on top of the sonde will allow the user to connect the EXO2 to other EXO sondes, making this our most expandable and flexible sonde. See Section 6 for information specific to vented level sondes.

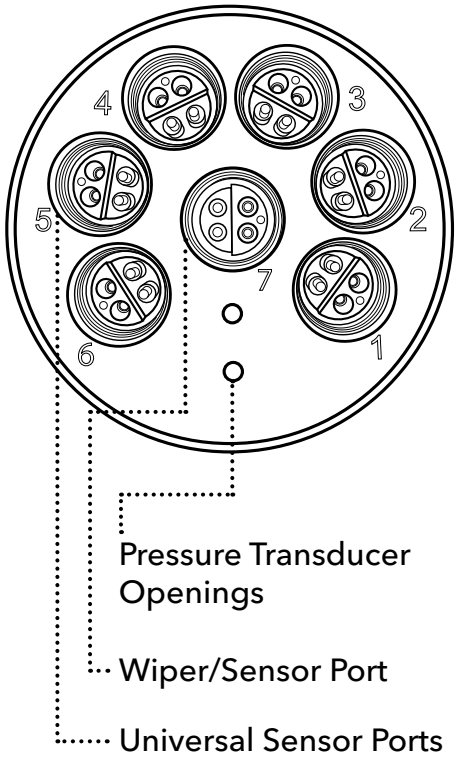
Users communicate with the sonde via a field cable to an EXO Handheld, *Bluetooth* wireless connection to a PC or EXO Classic Handheld, or a USB connection (via communications adapter) to a PC. See Section 2.6 for a communication overview.

Specifications

Operating Environment *Depth Rating*	 250 meters, 820 feet
Material	Xenoy®, Lexan®, titanium, 316 stainless steel
Internal Logging Memory Capacity	512 MB
Software	KorEXO Software
Communications *Sonde* *Adapters*	 **Wireless:** *Bluetooth* **Field Cable:** RS-485 RS-232, Mod Bus, USB, SDI-12
Power *External* *Internal*	 9-16 VDC (4) D-cell batteries
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Battery Life	90 days*
Dimensions *Diameter* *Length* *Weight w/ battery*	 7.62 cm, 3.00 in 71.1 cm, 28.00 in 3.60 kg, 7.90 lb

**Battery life will depend on the type of sensors and measurement frequency.*

EXO2 Bulkhead



EXO2 Sonde
599502-xx

Removable Bail
599474

Auxiliary Port

6-Pin Cable Connector

Battery Cap/Pressure Relief Valve
O-ring kit 599681

Battery Compartment Opening

Battery Compartment

On/Off Magnetic Switch for Power and *Bluetooth*

Red LED Indicator - Sonde Status

Blue LED Indicator - *Bluetooth*

Bulkhead

Sensors

Port Plug
599475

Sensor Guard
599667, 599564

Calibration Cup
599316

Central Wiper
599090-01

Guard Weight
599472

1.3 EXO2^{S} Sonde
Overview

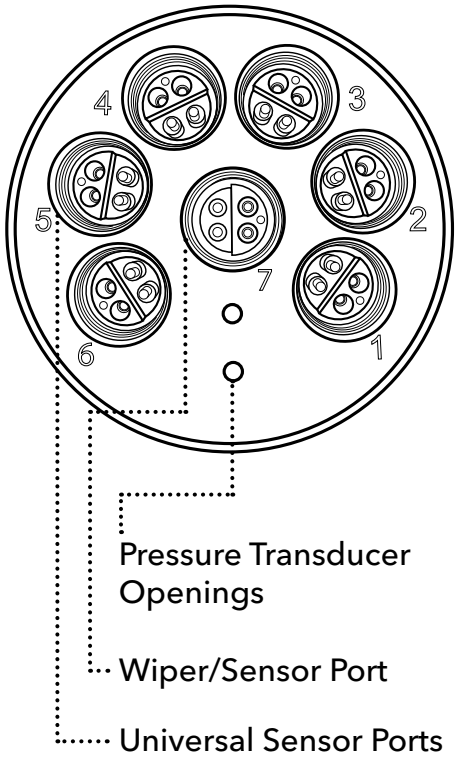
The EXO2^{S} sonde is compact, battery-less, factory-customized version of the EXO2 sonde for use where external power is available. One orders an EXO2^{S} by first selecting the appropriate depth of an EXO2 sonde (599502-xx) and a conversion kit (119077) that is used by our team to convert the EXO2 sonde into an EXO2^{S}. The sonde supports up to seven user-replaceable sensors and an integral pressure transducer. The EXO2^{S} features the same logging and communication options as the standard EXO2; however, an external power source is required. Power can be supplied via a DCP, the EXO handheld or EXO GO. See Section 2.6 for a communication overview.

Specifications

Operating Environment *Depth Rating*	 250 meters, 820 feet
Material	Xenoy®, Lexan®, titanium, 316 stainless steel
Internal Logging Memory Capacity	512 MB
Software	KorEXO Software
Communications *Sonde* *Adapters*	 **Wireless:** *Bluetooth* **Field Cable:** RS-485 RS-232, Mod Bus, USB, SDI-12
Power *External*	 9-16 VDC
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Battery Life	90 days*
Dimensions *Diameter* *Length* *Weight w/ battery*	 7.62 cm, 3.00 in 47.0 cm, 18.50 in 1.10 kg, 2.42 lb

**Battery life will depend on the type of sensors and measurement frequency.*

EXO2^{S} Bulkhead




EXO2S Sonde
599502-xx and 119077
Removable Bail
Auxiliary Port
6-Pin Cable Connector
On/Off Magnetic Switch for
Power and *Bluetooth*
Red LED Indicator - Sonde Status
Blue LED Indicator - *Bluetooth*
Bulkhead
Sensors
Port Plug
599475
Sensor Guard
599667, 599564
Calibration Cup
599316
Central Wiper
599090-01
Guard Weight
599472

1.4 EXO3 Sonde
Overview

The EXO3 sonde is a multiparameter instrument that collects water quality data. The sonde collects the data with up to four user-replaceable sensors and an integral pressure transducer. The EXO3 also has a central port for an EXO wiper (or an additional sensor). Each sensor measures its parameter via a variety of electrochemical, optical, or physical detection methods. Each port accepts any EXO sensor and automatically recognizes the type of sensor. Depending on user-defined settings, the EXO3 will collect data and store it onboard the sonde, transfer the data to a data collection platform (DCP), or relay it to a user's PC or EXO Handheld via cable, USB connection, or **Bluetooth**® connection.

Users communicate with the sonde via a field cable to an EXO Handheld, *Bluetooth* wireless connection to a PC or a USB connection (via communications adapter) to a PC. See Section 2.6 for a communication overview.

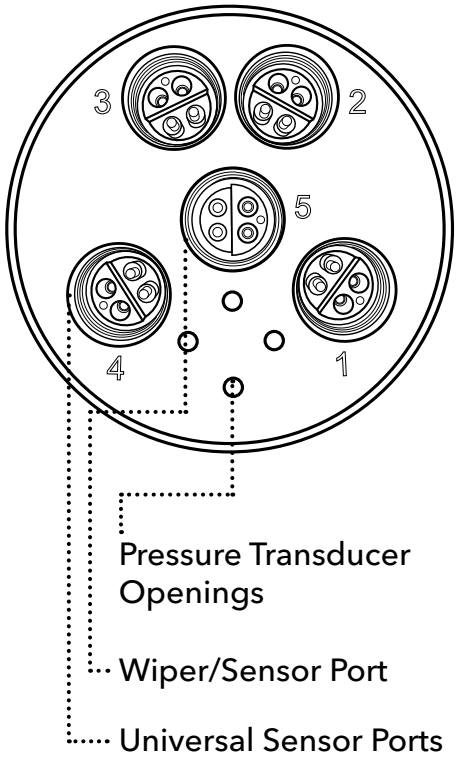
NOTE: *The EXO3 Sonde includes integral SDI-12 communications for use with cables up to 66 meters in length. With EXO3, a 599820 Signal Output Adapter (SOA) is not necessarily required. See Section 2.11 for details.*

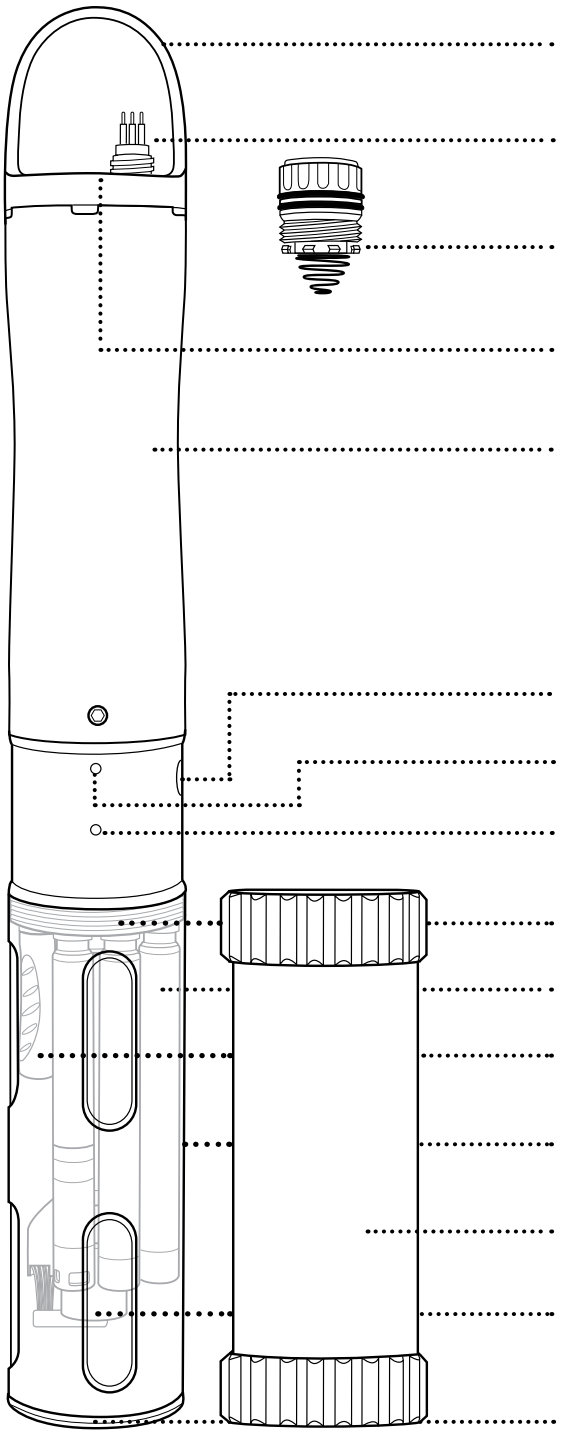
Specifications

Operating Environment *Depth Rating*	 250 meters, 820 feet
Material	Xenoy®, Lexan®, titanium, 316 stainless steel
Internal Logging Memory Capacity	512 MB
Software	KorEXO Software
Communications *Sonde* *Adapters*	 Wireless: *Bluetooth* Field Cable: RS-485, SDI-12 RS-232, Mod Bus, USB, SDI-12
Power *External* *Internal*	 9-16 VDC (2) D-cell batteries
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Battery Life	60 days*
Dimensions *Diameter* *Length* *Weight w/ battery*	 7.62 cm, 3.00 in 58.67 cm, 23.1 in 2.0 kg, 4.41 lb

**Battery life will depend on the type of sensors and measurement frequency.*

EXO3 Bulkhead





EXO3 Sonde
599503-xx

Removable Bail
599474

6-Pin Cable Connector

Battery Cap/Pressure Relief Valve
O-ring kit 599681

Battery Compartment Opening

Battery Compartment

On/Off Magnetic Switch for Power and *Bluetooth*

Red LED Indicator - Sonde Status

Blue LED Indicator – *Bluetooth*

Bulkhead

Sensors

Port Plug
599475

Sensor Guard
599667, 599564

Calibration Cup
599316

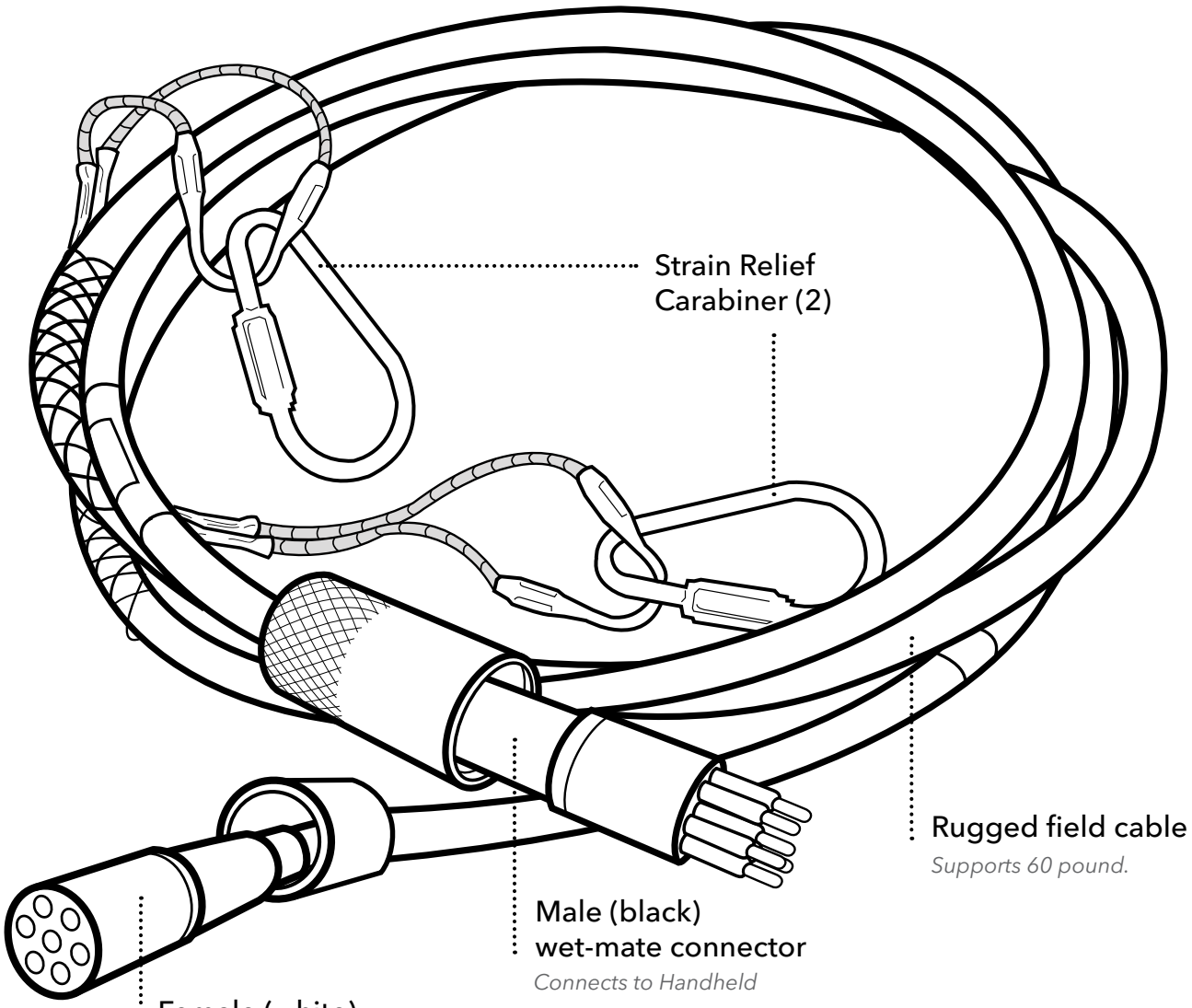
Central Wiper
599090-01

Guard Weight
599472

1.5 EXO Field Cables

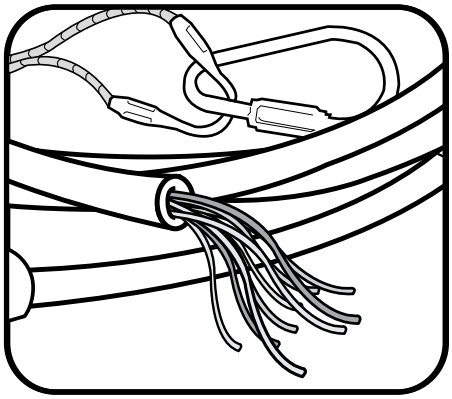
Overview

The EXO rugged field cable comes in many different lengths and options to meet the needs of your specific application. Selecting the correct cable length and coupler will ensure the best quality data for your project. For a full list of cable options and precautions for extended cables, please see Cable Options on the following page.



Flying Lead Cable Vented and Non-Vented

A flying lead cable option is available which is intended for wiring to a data collection platform (DCP) or a data logger. A vented flying lead option is for use with a vented sonde only. See Section 6 for more information.



Cable Options

599431-01	EXO Cable Coupler, Titanium
599431-02	EXO Cable Coupler, Brass
599040-2	EXO 2 meter Field Cable
599040-4	EXO 4 meter Field Cable
599040-10	EXO 10 meter Field Cable
599040-15	EXO 15 meter Field Cable
599040-33	EXO 33 meter Field Cable
599040-66	EXO 66 meter Field Cable
599040-100	EXO 100 meter Field Cable
599040-150	EXO 150 meter Field Cable
599040-200	EXO 200 meter Field Cable

599040-250	EXO 250 meter Field Cable
599040-300	EXO 300 meter Field Cable
599008-10	EXO 10 meter Flying Lead Cable
599008-15	EXO 15 meter Flying Lead Cable
599008-33	EXO 33 meter Flying Lead Cable
599008-66	EXO 66 meter Flying Lead Cable
599008-100	EXO 100 meter Flying Lead Cable
599210-4	EXO 4 meter VENTED Flying Lead Cable
599210-10	EXO 10 meter VENTED Flying Lead Cable
599210-15	EXO 15 meter VENTED Flying lead Cable
599210-33	EXO 33 meter VENTED Flying Lead Cable

Extended Field Cables Precaution

There are some limitations for applications using EXO cable lengths greater than 100 meters - whether by extended cables, or by means of cable-coupling.

NOTICE: To prevent system problems related to power and signal integrity, make sure you understand the system limitations if you plan to use cable couplers or extended cables.

Voltage drop through long cables can adversely affect the available power at the sonde.
Here are some techniques to prevent such problems:

•Use Alkaline or high-capacity NiMH batteries in the sonde. This serves a dual purpose of adding weight in the sonde for profiling applications, as well as preventing system reboots during period of high current demand.

•Do not use EXO's USB SOA or Handheld as the sole power source for systems with large payloads (many optical or high power sensors). These devices do not provide a voltage high enough for use with extended cables.

•Limit use of EXO's auxiliary port to lower power devices.

•Power the sondes with a regulated power supply (12V-14V) capable of supplying 1A. This will ensure sufficient power is reaching the sonde.

1.6 EXO Handheld
Overview

The EXO Handheld is a rugged, microcomputer-based instrument that allows the user to display sonde readings, configure sondes, store and retrieve data, and transfer data from sondes to a computer. Equipped with GPS and an integrated barometer, the Handheld communicates via field cable or USB connector.

The unit also utilizes an adjustable backlit screen for easy day or night viewing. The handheld features a built-in rechargeable Lithium-Ion battery, integrated help menus, a simplified user interface, and a more ergonomic design than the Classic handheld.

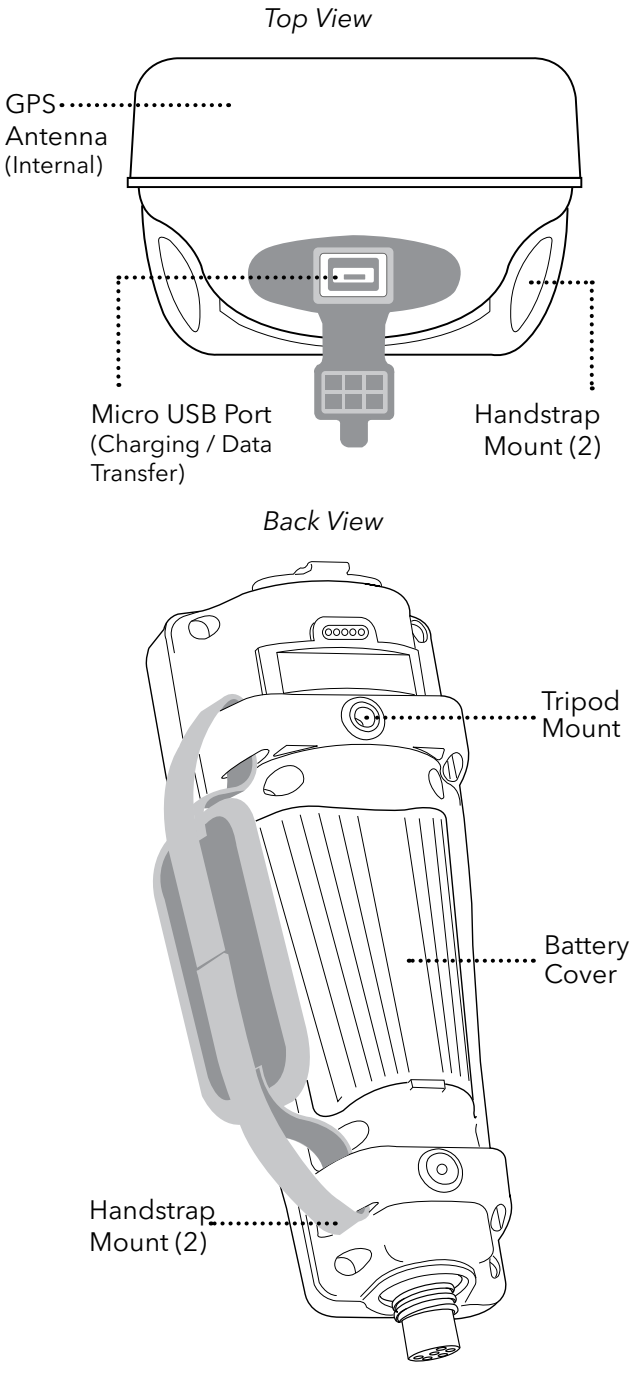
NOTE: *For operating instructions, please see the EXO Handheld Mini-Manual.*

Specifications

GPS	Yes
Display	IP-67 rated, Color-LCD graphic display
Memory	>100,000 data sets
Software	KorEXO Software
Communications	Field Cable, USB
Power *Internal*	 Rechargeable Lithium-Ion Pack
Temperature *Operating* *Storage*	 0°C to 50°C 0°C to 60°C (no battery) 0°C to 45°C (battery installed)
Barometer *Range* *Accuracy* *Resolution*	*Built-in with User Calibration* 375 to 825 mmHg ±1.5 mmHg from 0 to 50°C 0.1 mmHg
Dimensions *Width* *Length* *Depth* *Weight w/ battery*	 8.3 cm, 3.27 in 21.6 cm, 8.5 in 5.6 cm, 2.21 in 0.57 kg, 1.25 lb

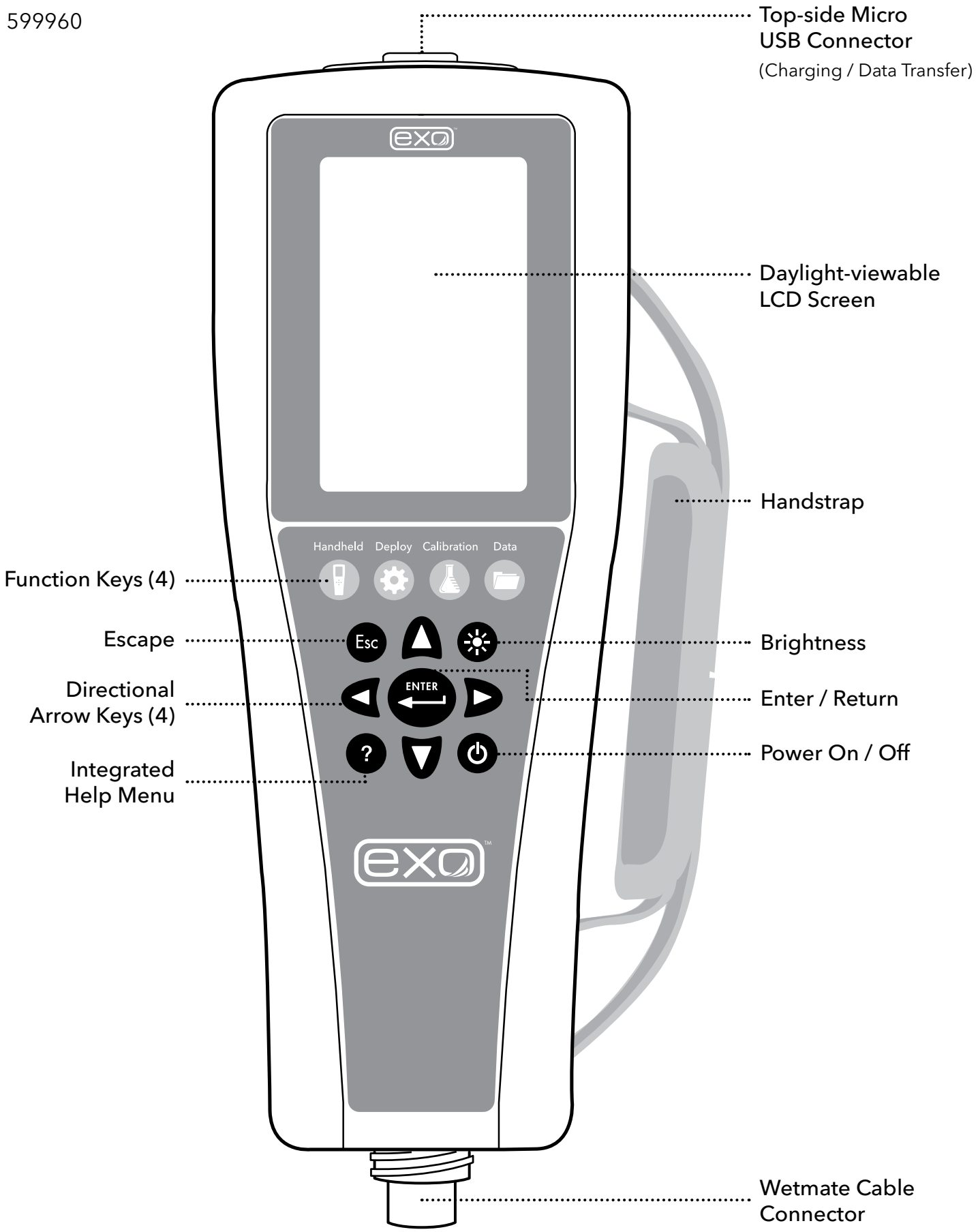
NOTE: *Barometer vent located under battery cover.*

EXO Handheld



EXO Handheld

599960



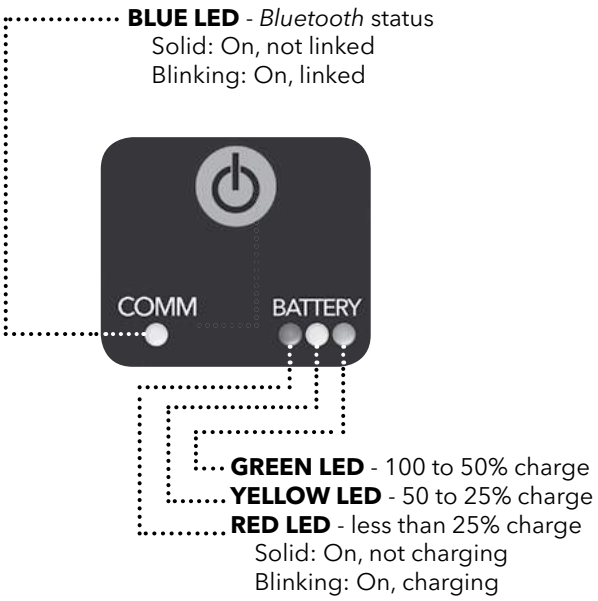
1.7 EXO GO
Overview

The EXO GO is a compact, rugged device that enables **Bluetooth**® communication between a submerged EXO sonde and a device running KorEXO Software. The EXO GO remains topside while connected to a sonde via the field cable. Pair with a tablet or laptop running KorEXO to form a complete sampling system.

With an integral barometer and GPS, the EXO GO provides barometric pressure and location data in addition to the connected sonde data. The built-in, rechargeable Lithium-Ion battery will power an EXO Sonde for a full day of sampling. LED indicators represent battery level, charge status, and *Bluetooth* status, as shown in the diagram below.

NOTE: *EXO GO is not compatible with earlier versions of KorEXO Software (prior to 2.0).*

LED Descriptions



Specifications

Communications	*Bluetooth*, USB 2.0
Bluetooth *Range*	Class 2 10 m
Barometer *Range* *Accuracy* *Resolution*	*Built-in with User Calibration* 375 to 825 mmHg ±1.5 mmHg 0.1 mmHg
GPS *Accuracy*	 2.5 m CEP (dependent on site conditions)
Battery *Operating Time* *Charge Time*	Rechargeable Lithium-Ion > 15 hours (powering full EXO3) 9 hours (from 0 to 100%)
Enclosure *Rating*	Xenoy IP-67
Temperature *Operating* *Storage*	 -5 to 50°C 0 to 45°C
Dimensions *Width* *Length* *Depth* *Weight*	 5.2 cm 17.4 cm 3.5 cm 240 g

EXO GO

577400

Section 2
Operation

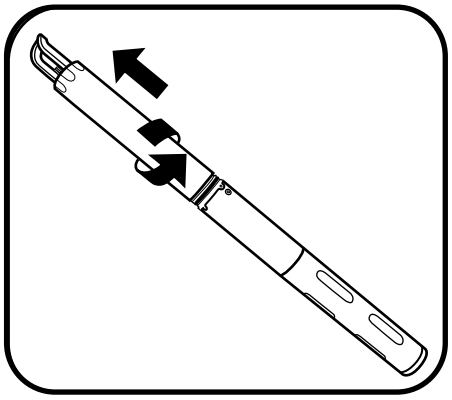
2.1 Sonde

Install / Replace EXO1 Batteries

EXO1 water quality sondes use two (2) D-cell batteries as a power source. Using alkaline batteries, users can expect approximately 90 days of deployment from a fully loaded sonde that samples once every 15 minutes. However, deployment times may vary greatly depending on water temperature, sampling rate, sensor payload, and brand of battery.

See Battery Life Specification on the next page.

NOTICE: Do not use Ni-Cad or 3.6V Lithium batteries in the EXO1 sonde.



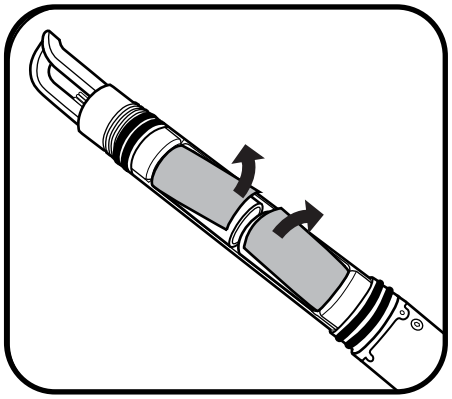
1 Remove battery cover

Start with a clean and dry sonde. Hold the sonde horizontally with the bail up and twist the battery cover counterclockwise until free. If necessary, slide the sonde tool's larger opening over the end of the battery compartment and use it as a lever to break the compartment free. Then slide off the battery cover.

NOTICE:

Do not remove the screws on the sonde.

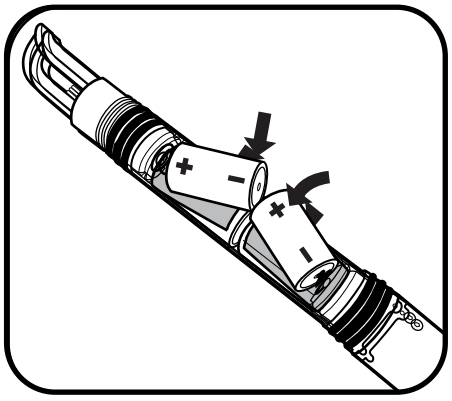
Do not clamp the sonde in a vise.



2 Remove old batteries

Expose the batteries by flipping the isolation flap up away from the batteries, and pull the batteries free of their compartment. Always dispose of used alkaline batteries according to local requirements and regulations.

Clean the inside of the battery compartment with a lint-free cloth.



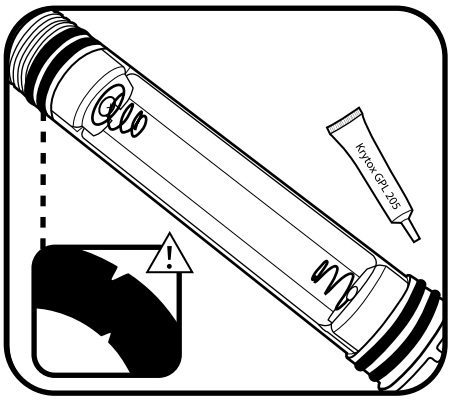
3 Install new batteries

Install the new batteries so that the positive terminals point towards the bail (away from the sensor bulkhead). Replace the isolation flap over the batteries.

NOTICE:

Do not use Ni-Cad or 3.6V Lithium batteries in the sondes.

Damage to the circuit board is not covered under warranty.

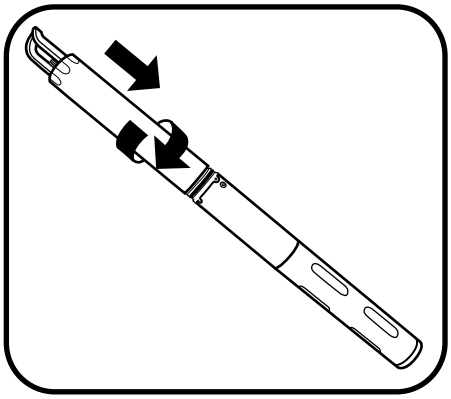


4 Check and service o-rings

NOTE: *Before replacing the battery cover, check and service the four o-rings.*

Ensure that the o-rings are not nicked or torn and that there are no contaminants or particles on them or the sealing surfaces inside the battery cover. Clean the o-rings with a lint-free cloth. Then apply a thin coat of Krytox® lubricant to each o-ring.

EXO1 replacement o-ring kits are available, part #599680.



5 Replace battery cover

Twist the battery cover clockwise until it stops at the rubber gasket. The gasket does not provide a seal and does not need to be compressed.

NOTICE: Do not overtighten; overtightening will not create a strong seal and may damage the sonde.

The EXO1 sonde has a resealing pressure relief valve; no maintenance is required.

If a battery failure occurs that results in battery acid leakage into the battery compartment, the sonde must be returned to a service center for evaluation.

Battery Life Specification (Example)

When using alkaline batteries: Estimated battery life is approximately 90 days for EXO1 at 20˚C at a 15-minute logging interval, with temperature/conductivity, pH/ORP, Optical DO, and turbidity sensors installed. Battery life is heavily dependent on sensor configuration and is given for a typical sensor ensemble. Battery life is reduced in cold-water applications.

When using rechargeable nickel metal hydride (NiMH) batteries: Estimated battery life is not available because NiMH batteries vary greatly in manufacturer capacity and discharge curves. We recommend a NiMH D-cell battery with a minimum rating of 10,000 milliamp hours that is fully charged each time it is used.

2.2 Sonde

Install / Replace EXO2 and EXO3 Batteries

EXO2 sondes use four (4) D-cell batteries as a power source. Using alkaline batteries, users can expect approximately 90 days of deployment from a fully loaded sonde that samples once every 15 minutes. However, deployment times may vary greatly depending on water temperature, sampling rate, sensor payload, wiper frequency, and brand of battery.
See Battery Life Specification on the next page.

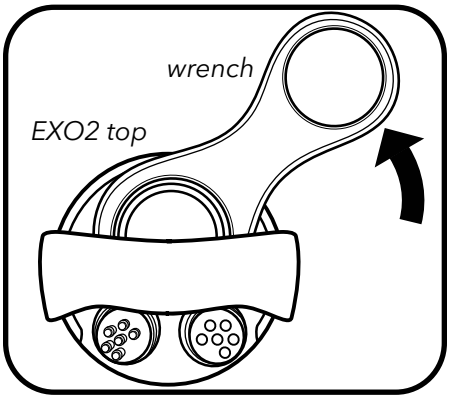
EXO3 sondes use two (2) D-cell batteries as a power source and can expect 60 days of deployment with an average sensor payload while sampling once every 15 minutes.

NOTICE: Do not use Ni-Cad or 3.6V Lithium batteries in the EXO sondes.

Pressure in Battery Compartment

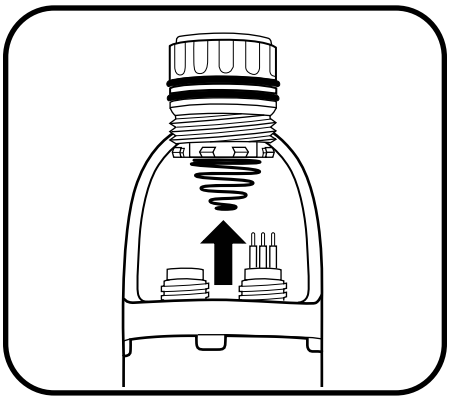
The EXO2 and EXO3 sondes are equipped with a pressure relief valve to protect against catastrophic battery failure. If the valve is open (indicating an over-pressure situation), the battery cap must be replaced. Significant water leakage into the battery compartment requires that your instrument be evaluated by the manufacturer or Authorized Service Center before the next deployment.

⚠ **WARNING:** Do not paint over or cover the pressure release valve in any way.
Blocking the pressure release valve can lead to dangerously high internal pressure.



1 Loosen battery cap

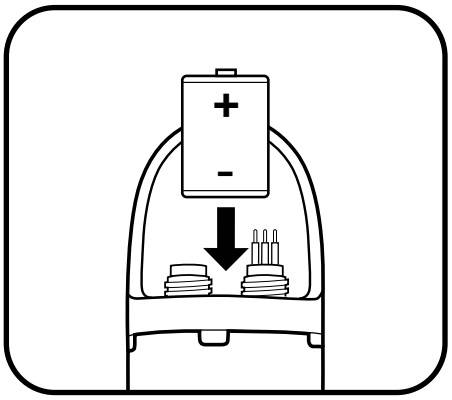
Start with a clean and dry sonde. Slide the sonde tool's smaller opening over the battery cap on top of the EXO2 or EXO3. Using the tool as a lever, firmly turn the tool counterclockwise until the battery cap is loose.



2 Remove battery cap and old batteries

Once the cap is sufficiently loose, remove the cap and old batteries from the well. Always dispose of used alkaline batteries according to local requirements and regulations.

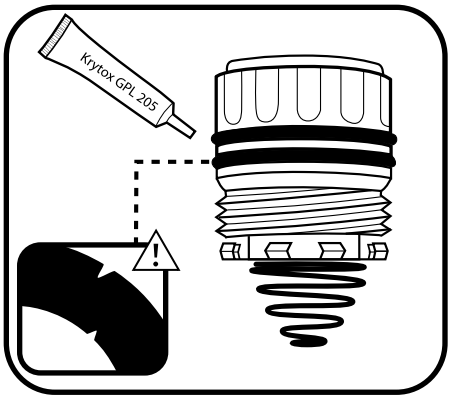
Clean the o-ring sealing surfaces of the cap with a lint-free cloth.
Inspect down into the battery tube to make sure it is clean and dry.



3 Insert new batteries

With the positive terminal facing up, insert four (4) new D-cell batteries into the battery well for EXO2 sondes, or two (2) new D-cell batteries for EXO3 sondes.

NOTICE:
Do not use Ni-Cad or 3.6V Lithium batteries in the sondes.
Damage to the circuit board is not covered under warranty.

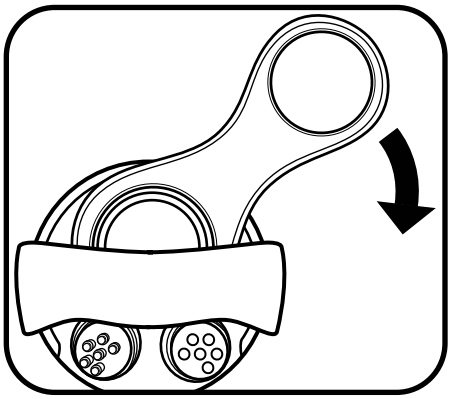


4 Check and service o-rings

NOTE: *Before replacing the battery cover, inspect and service the four o-rings.*

Ensure that the o-rings are not nicked or torn and that there are no contaminants or particles on the o-rings or the sealing surfaces inside the battery cover. Then apply a thin coat of Krytox® lubricant to each o-ring and sealing surface.

EXO2 replacement o-ring kits are available, part #599681.



5 Replace battery cap

After servicing the cap's o-rings, insert the cap in its recess. Then, using your thumb, press down on the pressure relief valve while turning the cap clockwise. Once the cap threads are engaged, use the tool to tighten until snug.

NOTICE: Do not overtighten; overtightening will not create a strong seal and may damage the sonde. When completed, the top o-ring of the cap must be below the battery compartment opening.

If a battery failure occurs that results in battery acid leakage into the battery compartment, the sonde must be returned to a service center for evaluation. Some battery acid will damage the plastic in the battery compartment.

Battery Life Specification (Example)

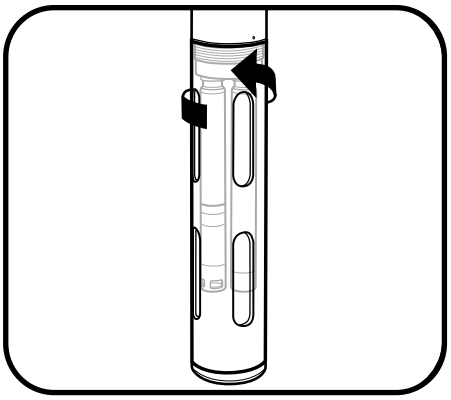
When using alkaline batteries: Estimated battery life is approximately 90 days for EXO2, and 60 days for EXO3, at 20˚C with a 15-minute logging interval, with temperature/conductivity, pH/ORP, Optical DO, turbidity, and Total Algae-PC sensors installed along with a central wiper which rotates once every logging interval. Battery life is heavily dependent on sensor configuration and is given for a typical sensor ensemble. Battery life is reduced in cold-water applications.

When using rechargeable nickel metal hydride (NiMH) batteries: Estimated battery life is not available because NiMH batteries vary greatly in manufacturer capacity and discharge curves. We recommend a NiMH D-cell battery with a minimum rating of 10,000 milliamp hours that is fully charged each time it is used.

2.3 Install / Remove Guard or Cal. Cup

Sensor guards protect EXO sensors from impact throughout deployment. Users must install the guard prior to data collection. The calibration cup (cal cup) is used for storage and calibration.

NOTE: *We recommend using two guards: one for field deployments and a second used exclusively for calibrations. Using a second guard will minimize calibration solution contamination (especially for turbidity).* EXO calibration cups install over an installed sensor guard. This configuration reduces the amount of standards required for calibration and protects the sensors during calibration.

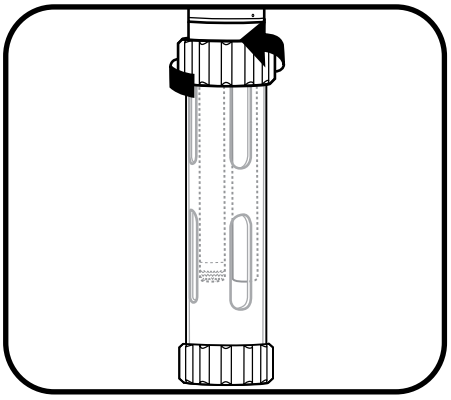


1 Install/remove sensor guard

Install guard by threading it onto the sonde bulkhead threads. Rotate the guard clockwise on the bulkhead to install, taking care not to pinch your fingers. Rotate it counterclockwise to remove. Always use one guard for deployment/storage and a second guard for calibration only.

Additional EXO sensor guards can be purchased:
EXO1 Guard Assembly Kit, part #599666
EXO2/3 Guard Assembly Kit, part #599667

NOTICE: Take care not to let the guard damage unguarded pH or pH/ORP sensors when installing and removing.



2 Install/remove calibration cup

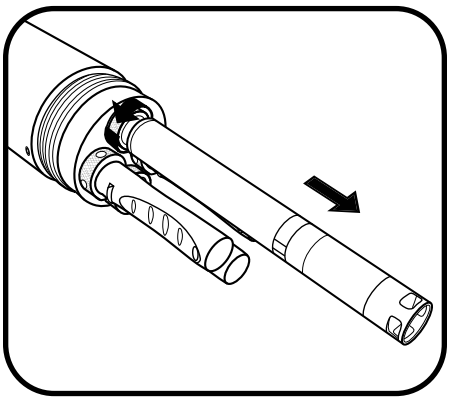
Before installation, loosen (but do not remove) the cup's clamping ring. Then, with the sonde guard already installed, slide the cal cup over the guard until the bottom of the guard rests against the bottom of the cal cup. Tighten the ring until snug. To remove the cal cup, loosen the ring by 1/4 turn and pull the guard free from the cup.

Additional EXO calibration cups can be purchased:
EXO1 Calibration / Storage cup, part #599786
EXO2/3 Calibration / Storage cup, part #599316

2.4 Install / Remove Sensors

EXO sensors have identical connectors and identify themselves via onboard firmware; therefore, users can install any probe into any universal sonde port. The exception is the wiper for the EXO2 and EXO3 sondes, which must be installed in the central port 7. Individual ports are physically identified by an engraved number on the sonde bulkhead. Although the probes are wet-mateable, users should clean, lubricate, and dry the sonde and sensor connectors prior to installation or service.

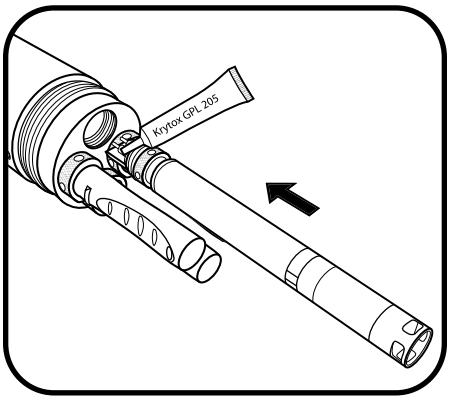
NOTE: *The data displayed on the Handheld / Desktop KorEXO, and the order of the exported data will be in the same order that the sensors are installed (e.g. a turbidity sensor in port 1 will display turbidity values first. The sensor in port 2, second, and so on).*



1 Remove probe or port plug

Remove the calibration cup and sensor guard from the sonde. Place the sonde on a clean, flat surface and prevent it from rolling.

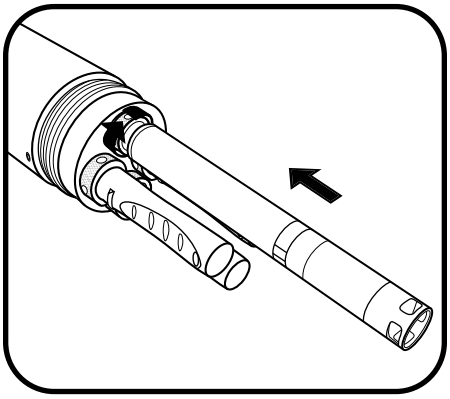
If removing a sensor or port plug, use the probe tool in the locking nut and rotate counterclockwise to loosen. Pull the probe straight out of the port and place on a clean surface. Wipe dry with a clean, lint-free cloth.



2 Clean port and install sensor

Visually inspect the port for contamination. If the port is dirty or wet, clean it with a clean, lint-free cloth or compressed air. Apply a light coat of Krytox grease to the rubber mating surfaces of the connector (not the o-ring) and a small dab of Krytox grease on the threads of the locking nut.

If the sensor is new or being taken out of storage remove any hydration caps or buffer bottles on the probe. Insert the sensor into the port by properly aligning the connectors' pins and sleeves (male and female contacts); then press them firmly together.



3 Tighten locking nut

Taking care not to cross-thread the grooves, finger-tighten the locking nut clockwise. When the nut and o-ring are seated against the bulkhead, tighten the nut with probe tool 1/4 turn until snug. Once sensors or plugs are installed, reinstall the sensor guard to protect sensors from impact damage.

NOTICE: Take care not to twist the probe body when tightening and loosening the locking nut. Excessive twisting of the probe can damage the connector and is not covered under warranty.

2.5 Sonde States and LED Descriptions

States

An EXO sonde is always in one of three operational states: *Off, Awake,* or *Asleep*. These states determine the sonde's power usage and logging potential. When *Off*, the sonde is not powered (no batteries installed, no topside power) and cannot collect data. Users can apply power to the sonde internally, using batteries, or externally with an EXO field cable attached from the topside port to an EXO Handheld, DCP or other approved power source. Once power is applied to a sonde, it is either *Awake* or *Asleep*.

When *Asleep*, the sonde remains in a very low power setting and waits for a user command or its next scheduled logging interval. An *Awake* sonde is fully powered and ready to collect data. Once awakened, a sonde remains *Awake* for five minutes after its last communication via *Bluetooth* or 30 seconds after its last communication via the topside port. The sonde also automatically awakens 15 seconds before its next scheduled logging interval.

Power States

Off: Not powered, no data collection.

Asleep: Low power. Waiting for command.

Awake: Full power. Ready to collect.

LED Indicators

● **Blue LED** – *Bluetooth*

None: Off, not active

On Solid: On, not linked

2 Hz (0.5s Blink): On, linked

● **Red LED** – Sonde State

None: Off or Asleep, with logging disabled

0.1 Hz (10s Blink): Asleep, logging enabled

1 Hz (1s Blink): Awake, sensors are active and may collect data

On Solid: Awake with faults

LED Indicators

Each sonde has two LED indicators that show the sonde's status. The blue LED indicates the *Bluetooth's* wireless connection status. The red LED indicates the sonde's power state.

The *Bluetooth* light (blue) is activated by a magnet swipe at the magnetic activation area. When the blue LED is off, the *Bluetooth* is disabled. When the light is on continuously, the *Bluetooth* is enabled, but no link has been established. When the blue LED blinks at 2 Hz, the sonde's *Bluetooth* is on, and has established a link.

When the red LED is off, the sonde is either *Off* or *Asleep* and not logging. When it blinks at 0.1 Hz (once every 10 seconds), the sonde is *Asleep* and logging is enabled. When the red light blinks at 1 Hz, the sonde is *Awake* and has no faults. If the red light is lit continuously, the sonde is *Awake* and has detected faults that need to be fixed prior to use.

Modes

Within the *Awake* state, the sonde has three modes, which are activated via KorEXO software. When "Inactive (Off)," the sonde does not log any data. In "Real-Time" mode, the sonde continuously collects data at a user-specified interval (default is 2 Hz). "Sample/Hold" mode allows users to easily synchronize data between the sonde's data logger and an external data collection platform.

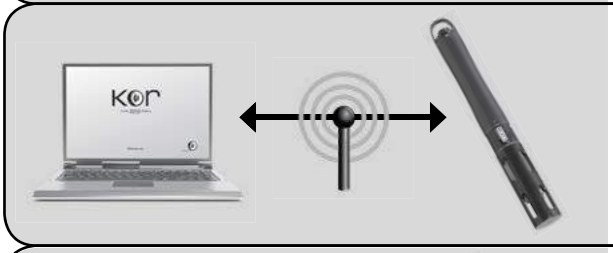
2.6 Connection Methods

Overview

Below is a high level overview of various methods you can use to connect and communicate with your EXO sonde:

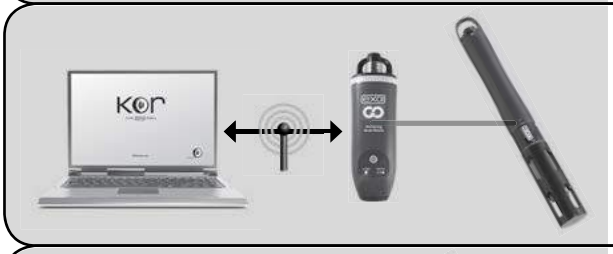
Field Cable, Sonde-to-Handhelds

- Lab Calibration
- Hardware Setup
- Transfer Data from Sonde
- Field Sampling



Wireless *Bluetooth*, Computer-to-Sonde

- Lab Calibration
- Hardware Setup
- Transfer & Export Data

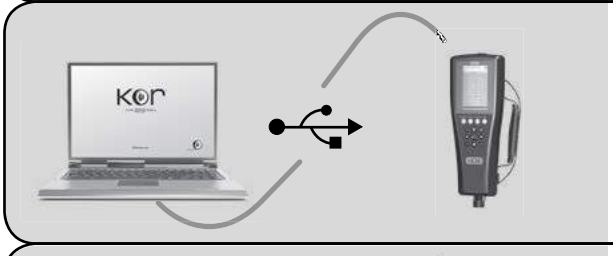


EXO GO *Bluetooth*, Sonde-to-Computer

- Lab Calibration
- Hardware Setup
- Transfer & Export Data
- Field Sampling
- Update Firmware

SOA-USB Adapter, Sonde-to-Computer

- Lab Calibration
- Hardware Setup
- Transfer & Export Data
- Field Sampling
- Update Firmware

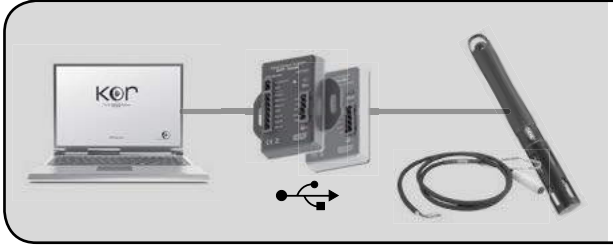


Direct USB, Computer-to-Handhelds

- Transfer & Export Data
- Update Firmware

Flying Lead Cable, Sonde-to-Com. Adapter

- Long-Term Monitoring with a Data Collection Platform or SCADA Modbus



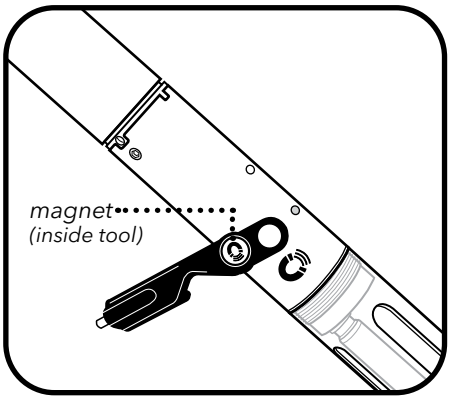
USB Passthrough Mode

- Direct USB communication to sonde, through DCP 2.0 / Modbus using KorEXO software.

2.7 Awaken Sonde

Activate *Bluetooth*

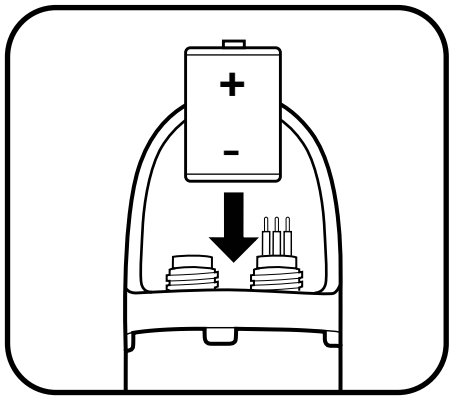
Once power is applied to the sonde, internally or externally, users can awaken their sondes from *Sleep* state using any of several methods. Primarily, users activate EXO sondes and the *Bluetooth* connections via a magnetic switch installed in the sonde's electronics compartment. The sonde will automatically disable the connection and go to sleep if it has received neither a *Bluetooth* signal for 5 minutes, nor a signal from the topside connector for 30 seconds. In order to activate their sondes, users should keep a magnet with them when setting up and deploying sondes. For more information on sonde states and LEDs, see Section 2.5.



1 Awaken sonde with magnet

Users can make their sonde go to the Awake state by holding a magnet at the magnetic activation area on the sonde's bulkhead (identified by the illustrated magnet symbol on the label). Simply hold the magnet within one (1) cm of the symbol until the LEDs activate. EXO Classic Handhelds and sensor removal tools contain embedded magnets identified by the same symbol.

NOTE: *The sensor removal tool was updated in 2014. Item #599469 "EXO Sensor Tool Kit".*

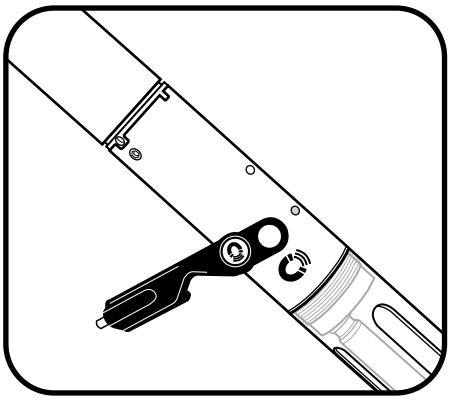


2 Awaken sonde without magnet

Users can also make their sonde go to the Awake state using any of the following methods.

- Cycling power to the sonde (uninstalling/installing batteries).
- Communicating via the topside port.
- Inserting a sensor.

In addition to these manual methods, the sonde also automatically awakens for scheduled unattended logging (programmed in KorEXO).



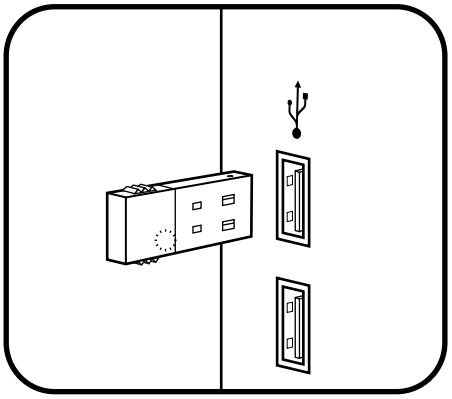
3 Activate sonde's *Bluetooth*

Users activate *Bluetooth* by holding a magnet at the magnetic activation area in the same way as described in Step 1. In addition to magnetic activation, users can also activate *Bluetooth* by:

- Cycling power to the sonde (uninstalling/installing batteries).
- Enabling *Bluetooth* via a connection at the topside port using KorEXO.

2.8 Connect Sonde
Bluetooth

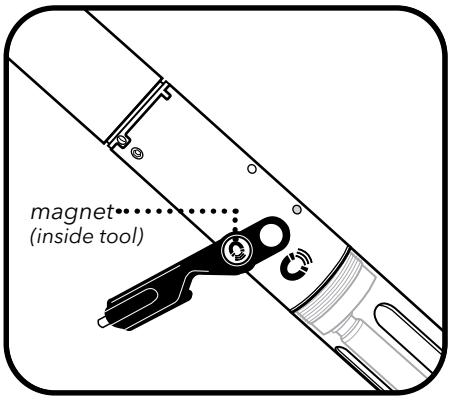
Before users can communicate wirelessly with their EXO sondes, they must establish a *Bluetooth* link. All EXO sondes are equipped with *Bluetooth*. This technology provides a secure, two-way, reliable communication channel with which users can communicate with their sondes above water without cables. Many new computers are equipped with *Bluetooth* wireless installed internally; those without *Bluetooth* can use a *Bluetooth* dongle (not included). Follow the manufacturer's instructions for installing the dongle's software and hardware.



1 Install *Bluetooth* dongle (optional)

If your computer is not equipped with internal *Bluetooth* radio, insert a *Bluetooth* dongle (not provided) into any of the computer's USB ports. Wait for the computer to automatically install the device and its drivers. Once the installation is complete, the computer should indicate that the device is installed and ready to use.

The preferred *Bluetooth* configuration is Windows 7 with native Windows *Bluetooth* drivers and software.



2 Activate sonde's *Bluetooth*

Users activate *Bluetooth* wireless by holding a magnet at the magnetic activation area. In addition to magnetic activation, users can also activate *Bluetooth* by:

- Cycling power to the sonde (uninstalling/installing batteries).
- Enabling *Bluetooth* via a connection at the topside port using KorEXO.

3 Establish *Bluetooth* Connection

1. Launch KorEXO Software.
2. Click the Scan for *Bluetooth* Devices button in thte Instrument Connection Panel.
3. This might need to be repeated several times before the software finds the sonde.
4. Once the EXO Sonde appears, simply click the Connect button to establish communications.

An option to Automatically Connect to Instrument is available in the General Settings.

2.9 Communication Adapters

Overview

The EXO platform now offers expanded communication adapter (com. adapter) options. Below is a high level overview of the com. adapter options available to you. Choosing the right adapter for your application, based on the desired communication protocol, will be a key factor in the success of your project.

NOTE: *Each communication adapter requires its own USB driver update, go to* **YSI.com/KorEXO** *to download the latest software and drivers.*

EXO USB Signal Output Adapter (599810)

This adapter supports a connection between an EXO sonde and a PC through a wired USB interface with the top-side connector. Transfer files and make changes to the sonde from your laptop or other USB ready smart device.

See Section 2.10 for EXO SOA connection instructions.

EXO DCP Signal Output Adapter 2.0 (599820)

The DCP-SOA is intended for use in long term monitoring applications and requires an EXO sonde, data logger, and flying lead cable to function. This adapter converts an EXO sonde signal into either SDI-12 or RS-232.

See Section 2.11 for more information on the EXO DCP SOA 2.0

EXO Modbus Signal Output Adapter (599825)

The Modbus SOA is intended for use in a SCADA system and requires an EXO sonde and flying lead cable to function. This adapter converts an EXO signal into a Modbus protocol over RS-232 or RS-485.

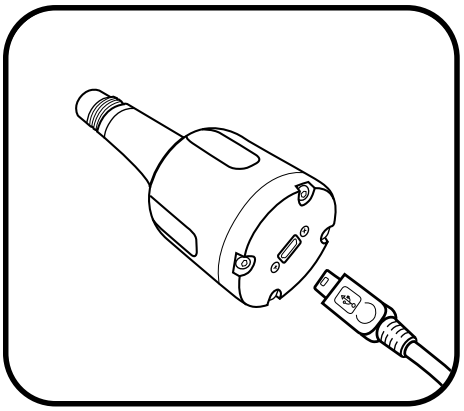
See Section 2.14 for more information on the EXO Modbus SOA.

2.10 Communication Adapters
USB

The USB signal output adapter (USB-SOA 599810) allows users to connect to an EXO sonde over a standard USB connection. Although the USB-SOA is rugged and water resistant, users should protect its connectors with the included cap when not in use.

NOTICE: The SOA should never be submerged.

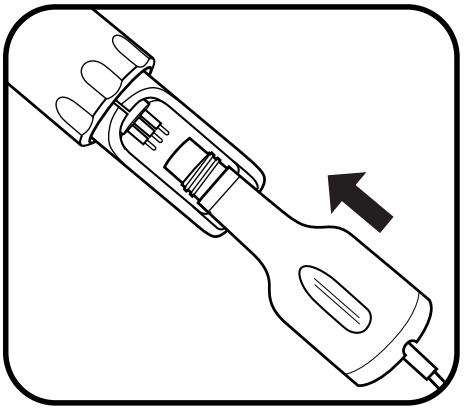
Prior to use, users must install KorEXO software and its drivers on the associated PC. The USB-SOA will not work without the drivers that accompany KorEXO. Drivers are included with the KorEXO Software download. Visit **YSI.com/KorEXO** for the latest drivers.



1 Connect USB cable to SOA and PC

Remove the protective cap from the USB end of the SOA, and ensure that the connector is clean and dry. Then insert the small end of the provided USB cable into the SOA connector and the large, standard side into one of the PC's USB ports. *The sonde should not be connected at this time.*

Attaching the adapter to the PC causes a new device to be recognized. Windows automatically installs the drivers and creates a new port. Each new adapter that is attached creates a new port.



2 Connect SOA to sonde

Remove the plug from the male 6-pin connector on the sonde. Apply a light layer of Krytox grease to the male pins on the sonde and the female connector on the USB-SOA. Then align the connector's six pins and jackets, and press them firmly together so that no gap remains.

Ports

KorEXO automatically scans ports for USB adapters. To view the USB adapter and its associated com port, go to the Control Panel on your computer, click Device Manager, then click Ports.

2.11 Communication Adapters

Data Collection Platform 2.0 (DCP)

Delivering quality data where and when you need it most.

Introduction:

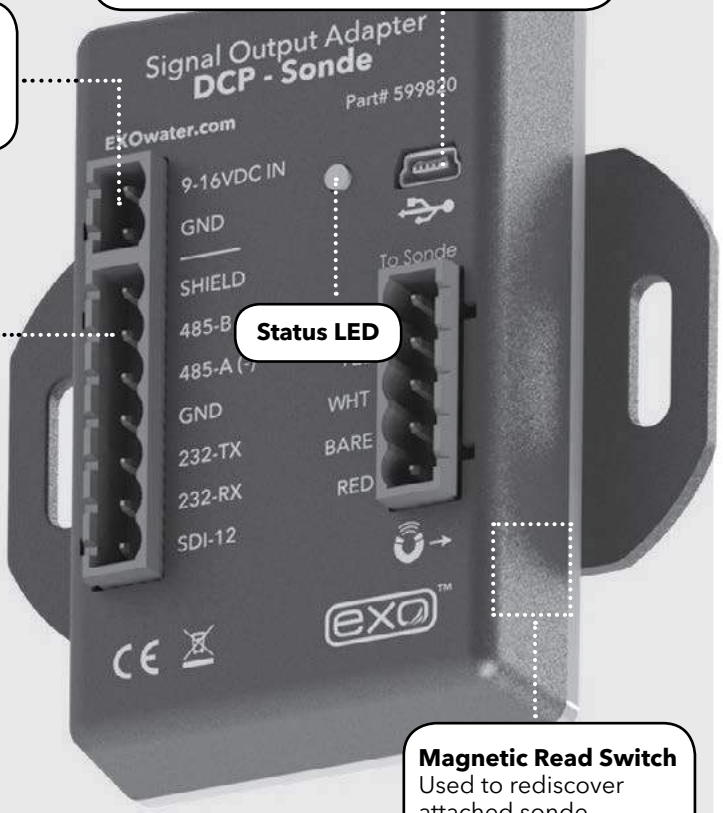
The 599820 is a communication adapter for the EXO multiparameter sonde platform. It converts the proprietary signal from the water quality sonde into either SDI-12 or RS-232 signals. The adapter simplifies integration into 3rd party DCP systems, and also features a USB port that supports passthrough communication directly to the connected sonde. This feature allows configuration, calibration, and data transfer without having to disconnect the field cabling.

Adapter Overview:

Mini USB Connector
Provide power to the adapter, and passthrough communication to the sonde.

Supply Power, 12VDC
Provided from external regulated power source (not included).

SDI-12 & RS-232 I/O Terminal
Use either SDI-12 or RS-232 terminals.



Status LED

Safety:

Do not attempt electrical wiring beyond your skill level. Follow all applicable code and regulations subject to electrical wiring and operation of the system.

Magnetic Read Switch
Used to rediscover attached sonde.

Specifications

Supply Voltage: 9 - 16 VDC or USB 5 VDC

Current Draw Adapter: ~20mA typical (@12VDC)

Current Draw Sonde: ~sleep 0.25mA reading and 100mA during operation

Max Net Current Draw for Systems: ~120mA (@12VDC)

Dimensions: L=3.5", W=3.5", H=1.5" (8.9cm x 8.9cm x 3.8cm)

Operating Temp: -40°C to +60°C

Storage Temp: -50°C to +80°C

Humidity: 0 to 99% non-condensing

What's Included:

The 599820 EXO Communication Adapter comes with:

- (1) DCP 2.0 Adapter
- (3) green wiring terminal blocks (Sonde 5-pin, Power 2-pin, DCP 7-pin)
- (1) Panel mounting bracket
- (1) Hook and loop fastener

If any item is missing, please contact **info@ysi.com** for replacements.

You'll also need:

- Flat blade screwdriver for terminal blocks
- Phillip's screwdriver for panel mount bracket
- EXO magnetic sensor tool (optional)
- EXO Flying Lead Field cable (599008-x)
- EXO sonde system, sensors, and associated hardware
- Latest KorEXO software (available from **YSI.com**)

Getting Started

Mounting:

The adapter should be protected from the elements, and it is recommended it be mounted inside of a sealed enclosure with desiccant to prevent condensation.

The adapter includes a panel mount in addition to self-adhesive hook and loop fastener. Either of these two methods can be used to securely mount the adapter. Use the provided Phillips screw to secure the panel mount:

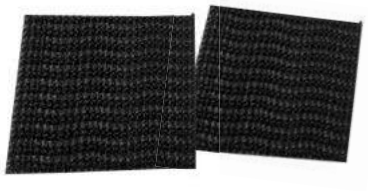
Panel Mount

1:

2:

Back Front

Self-Adhesive Hook and Loop Fastener



NOTE: *If using self adhesive hook and loop, clean and dry both surfaces before applying.*

NOTE: *This adapter is not required for use of SDI-12 with an EXO3 sonde. It is however, still required, if you need RS-232 communications.*

Status LED Indications	
Off	No power
On, no flashing	No Sonde connected
Flashing at 1 Hz	Sonde connected, everything normal
Flashing at 0.1 Hz	Low power sleep (Will flash on for 1 second when magnetic switch is activated.)

Wiring

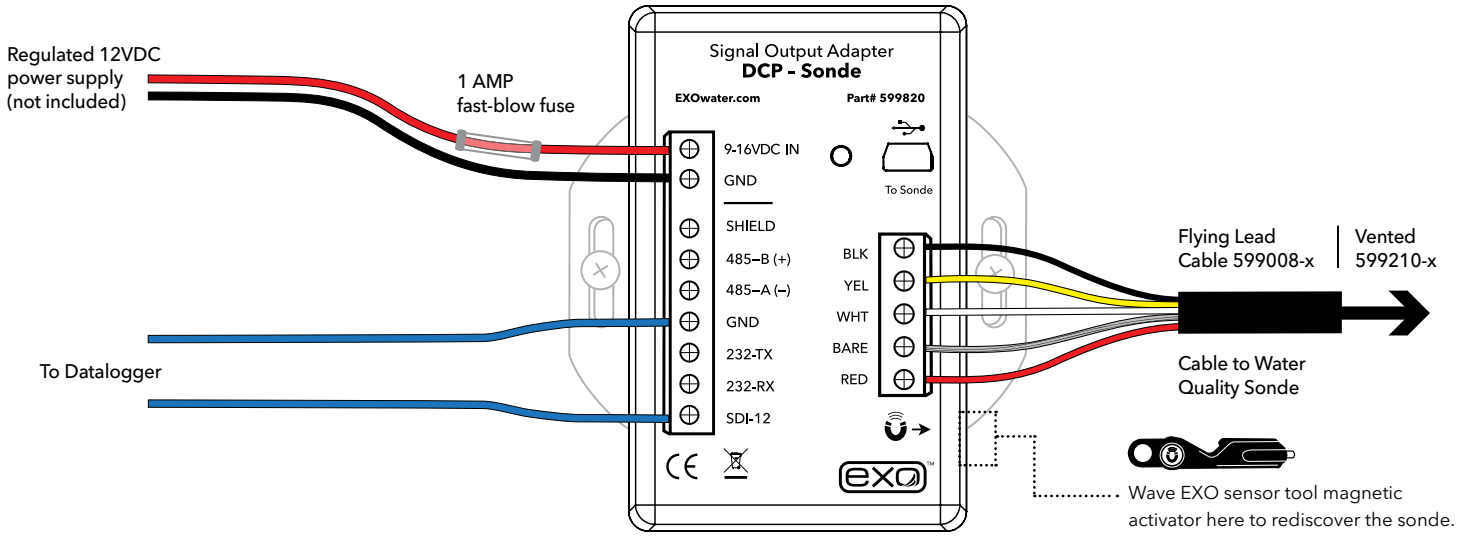
Have the following ready:

- EXO Sonde
- DCP 2.0 Adapter
- Flying Lead Cable
- Desiccant if using Vented Cable
- Flat blade screwdriver
- Power & Data Logger Wires

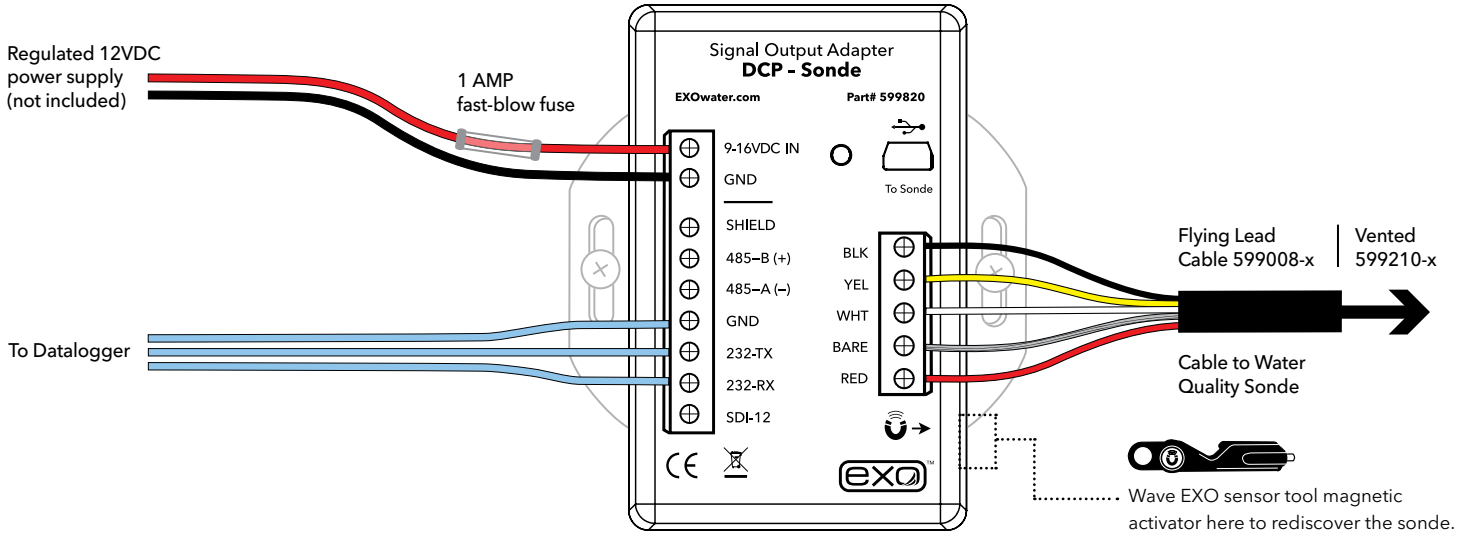
Webinar | A Simple Guide to Collecting Water Quality Data
Learn the basics of wiring your Sonde up to a DCP:
https://goo.gl/B4PPK7

Wiring Continued

Next wire the flying lead cable, power, and DCP ports as labeled in one of the following configurations:



OR



When connecting new sondes to the DCP adapter, it may be necessary to redetect the sonde. This can be done by power cycling the adapter or by using the magnetic read switch at the lower right hand side of the enclosure. Waving the magnet in the EXO sensor tool over the area referenced by the square above, will force a network redetect where all new sensors and configurations will be discovered.

NOTE: *The orange wire on the flying lead cable to the sonde will not be used. It can be taped back during installation.*

USB Passthrough Mode

The 599820 DCP Signal Output Adapter can function in a similar fashion as the 599810 USB communication adapter. After the Signal Output Adapter is wired as shown in the previous configuration, connecting to the USB port on the adapter will allow direct communications with the sonde using KorEXO software. **USB passthrough drivers** will automatically be installed along with KorEXO 2.0 software, they are also available separately from **YSI.com/KorEXO**. Install these drivers on your PC to communicate with a signal output adapter (SOA) through any version of Desktop KorEXO:

NOTE: *USB utilizes Communication Device Class (CDC) and installs as com port on PC: "YSI SOA/DCP Gen2". The USB connection may also be used to update firmware on the adapter using KorEXO software.*

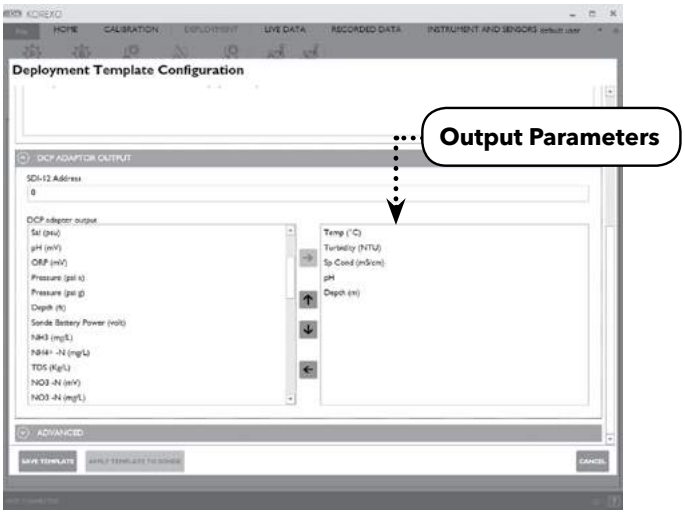
Output Configuration

In order to appropriately setup a sonde to communicate measurements to a datalogger, it is critical to align the settings from the sonde and the logger.

In the KorEXO software |**Deployment Settings**| choose the parameters and sort order, then push the template to the sonde.

The complete list of parameters is shown in the left column and the selected parameters to output via the DCP 2.0 adapter are shown on the right. This template can be saved locally on the PC, but it must also be pushed down to the sonde for the settings to take effect. So be sure to apply the template to the sonde.

NOTE: *There are two options when applying the template to the sonde, apply without logging or with logging. Either option may be used. When deploying with logging the sonde will create a redundant log file inside the sonde. Without logging the data will only be available to the RS-232 or SDI-12 outputs.*



KorEXO Version 2.0.x

For access to the beta software, or assistance changing the default settings, please contact Technical Support at **info@ysi.com**.

EXO DCP Signal Output Adapter Programming Basics

1. SDI-12 Interface

• General

- Compatible with v1.3 of SDI-12 specification
- Supports following standard commands:
  - '!' Address Query
  - 'A' Change Address
  - 'C' Concurrent Measurement
  - 'D' Data
  - 'I' Identification
  - 'M' Start Measurement
  - 'V' Start Verification

• Extended Commands

- SDI-12 'Z' command
- Supports the following RS-232 commands:
  - 'sn' Serial Number
  - 'para' Parameter List
  - 'twipeb' Start wipe
  - 'ver' S/W version
  - 'ssn' Sensor Serial Numbers

2. RS-232 Interface

• General

- Command Line
- '#' is user prompt
- Commands are not case sensitive
- Only spaces are recognized as delimiters
- A command is terminated by a <CR>
- Minimum time from power up to valid readings is 19 seconds

• Command List

See RS-232 commands in Section 2.12
See SDI-12 Port Settings in Section 2.13

An example of a NEMA enclosure where the DCP Signal Output Adapter is wired.

2.12 Communication Adapters
RS-232

The EXO DCP Signal Output Adapter (SOA) supports limited RS-232 commands. The SOA supports both SDI-12 and RS-232 communications. The order of the RS-232 parameter output is controlled by the SDI-12 tab on the deployment menu.

[ ] indicates argument is optional **<i>** indicates argument is an integer

data
Returns one line of data readings. Data parameters specified in para command. Data delimiter is specified in the setdelim command.

dowait [<i>]
Turns "wait for DO" on if <i>=1 and off if <i>=0. The response is "OK". If you do not supply <i>, then the response is the current value of dowait. When enabled the SOA/DCP will not return data until sonde has been on for "dowarmup" seconds.

dowarmup [<i>]
Sets DO sensor warmup time where <i>=warmup time in seconds. The response is "OK". If you do not supply <i>, then the response is the current value for dowarmup. When "dowait" is enabled the SOA/DCP will not return data until sonde has been on for "dowarmup" seconds.

fltreset
Resets all sonde sensor filters. The response is "OK".

hwipesleft
Returns a value other than 0 if a wiper event is in progress. The value returned is normally the amount of "half" wipes that are left to go. When wiping is completely finished, the value will go to 0.

para
Returns the parameter numbers of all parameters selected for output. Each number returned matches one for one with the values returned in the data command. The numbers are space delimited.

para [<i1> <i2> <i3> <i4> ...]
Sets the data parameter codes used with the data and run commands. The parameters are space delimited. If you do not supply any parameters then the response is the current list of parameters. Maximum number of parameters is 32.

pwruptorun [<i>]
Turns "power up to run" on if <i>=1 and off if <i>=0. The response is "OK". If you do not supply <i>, then the response is the current value of pwruptorun.

run
Causes the sonde to SOA/DCP to take sonde readings at a 1Hz rate. The output is similar to the Data command except that readings are taken continuously. No headers are output. To abort send '0', <esc>, or turn power off to the SOA/DCP and then reapply.

setcomm [<i1>] [<i2>]
Changes the SOA/DCP's comm port baud rate and data length. The baud rate will be immediately changed after this command, so you will need to reconfigure your terminal to match.

<i1> can be:

2 - 1200 baud

3 - 2400 baud

4 - 4800 baud

5 - 9600 baud (default)

6 - 19200 baud

7 - 38400 baud

8 - 57600 baud

9 - 115200 baud

<i2> can be:

0 - 7 bits

1 - 8 bits

Send these commands to the DCP via an RS-232 hyperterminal window configured with the following:

Bits per second	9600
Data bits	8
Parity	None
Stop bits	1
Flow control	None

setdelim [<i>]
Changes the SOA/DCP's delimiter used in the data command response. If you do not supply <i>, then the response is the current value for delimiter.

<i> can be: 0 = space, 1 = TAB, 2 = comma, 3 = none

setecho [<i>]
Enables (<i>=1) or disables (<i>=0) command echoes. When echoes are disabled, commands sent to the SOA/DCP will not be 'echoed' back and there will be no '# ' prompt. If you do not supply <i>, then the response is the current value for echo.

setmode [<i>]
Sets the RS232 mode. If <i>=0, mode is normal. If <i>=1 mode is NMEA. If you do not supply <i>, then the response is the current value for mode.

setradix [<i>]
Sets the radix point used for data output. If <i>=0 radix will be '.'. If <i>=1 radix will be ','. Note that in SDI-12 mode, the response to a 'D' command will always be with '.' regardless of this setting. The response is "OK". If you do not supply <i>, then the response is the current value for radix.

setsonde [<i>]
Selects a sonde for RS-232 communications when sondes are daisy-chained. <i> represents the order of the sonde in the chain where 1st sonde = 0, 2nd = 1, 3rd = 2. The response is "OK". If you do not supply <i>, then the response is the current value for the sonde.

sn
Returns the unique serial number programmed into every YSI sonde.

ssn
Returns the unique serial number for the sonde and all attached sensors.

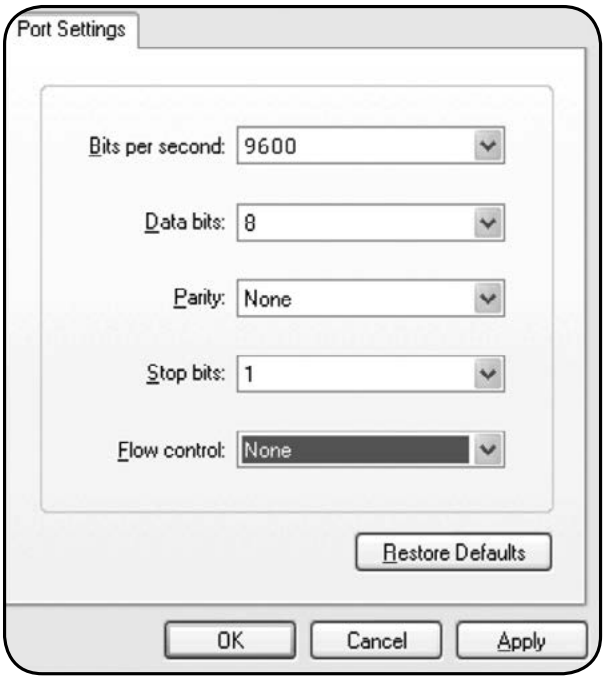
setperiod [<i>]
Sets the period for the data output in RUN mode. The period is set to <i> milliseconds. Minimum value is 250 (1/4 second), maximum value is 30000 (30 seconds). If you do not supply <i>, then the response is the current value for period. For periods less than 1000 and baud rates below 9600, the data output may be unreliable.

time [<hh:mm:ss>]
Allows user to set time in the sonde in the HH:MM:SS format. The response is "OK". If you do not supply <hh:mm:ss>, then the response is the current value of time.

twipeb
Starts a wiper event. The response is the approximate time in seconds it will take to perform the wipe.

ver
Returns the software version number of the sonde.

verdate
Returns the time and date at which the current version of software in the sonde was compiled.



RS-232 settings should resemble this image.

2.13 Communication Adapters

SDI-12

The sonde can be connected to an SDI-12 bus using a DCP Signal Output Adapter (SOA). The SOA provides the necessary SDI-12 electrical interface and communicates to the sonde via the topside RS-485 interface. The SOA will automatically recognize when a sonde is connected and retrieve the SDI-12 address and ID from the sonde. The SDI-12 data parameter list is set by the user in the Deploy menu. Go to Deploy | Open Template | Edit Template menu and click on the SDI-12 tab.

- Maximum of 23 codes in sonde parameter list.

Parameter	Code
Temperature, °C	1
Temperature, °F	2
Temperature, °K	3
Conductivity, mS/cm	4
Conductivity, µS/cm	5
Specific Conductance, mS/cm	6
Specific Conductance, µS/cm	7
TDS, g/L	10
Salinity, PPT	12
pH, mV	17
pH	18
ORP, mV	19
Pressure, psia	20
Pressure, psig	21
Depth, m	22
Depth, ft	23
Battery, V	28
Turbidity, NTU	37
NH3 (Ammonia), mg/L	47
NH4 (Ammonium), mg/L	48

Parameter	Code
Date, DDMMYY	51
Date, MMDDYY	52
Date, YYMMDD,	53
Time, HHMMSS	54
TDS, kg/L	95
NO3 (Nitrate), mV	101
NO3 (Nitrate), mg/L	106
NH4 (Ammonium), mV	108
TDS, mg/L	110
Chloride, mg/L	112
Chloride, mV	145
TSS, mg/L	190
TSS, g/L	191
Chlorophyll, ug/L	193
Chlorophyll, RFU	194
ODO, %Sat	211
ODO, mg/L	212
ODO, %Sat Local	214
BGA-PC, RFU	216
BGA-PE, RFU	218

Parameter	Code
Turbidity, FNU	223
Turbidity, Raw	224
BGA-PC, ug/L	225
BGA-PE, ug/L	226
fDOM, RFU	227
fDOM, QSU	228
Wiper Position, V	229
External Power, V	230
BGA-PC, Raw	231
BGA-PE, Raw	232
fDOM, Raw	233
Chlorophyll, Raw	234
Potassium, mV †	235
Potassium, mg/L †	236
nLF Conductivity, mS/cm	237
nLF Conductivity, µS/cm	238
Wiper Peak Current, mA	239
Vertical Position, m	240
Vertical Position, ft	241

† **NOTE:** *Potassium is considered future functionality, there is currently no EXO probe for Potassium (as of 2015).*

2.14 Communication Adapters
Modbus

Delivering quality data where and when you need it most.

Introduction:

The 599825 is a communication adapter for the EXO multiparameter sonde platform. It converts the proprietary signal from the water quality sonde into a Modbus protocol over either RS-232 or RS-485 signals. The adapter simplifies integration into 3rd party SCADA systems, and also features a USB port that supports passthrough communication directly to the connected sonde. This feature allows configuration, calibration, and data transfer without having to disconnect the field cabling.

Adapter Overview:

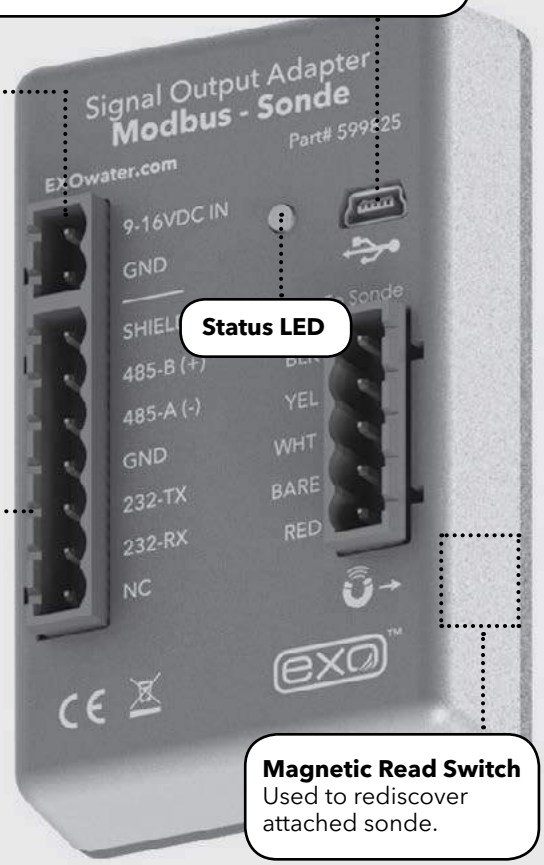
Mini USB Connector
Used to configure adapter settings, provide power to the adapter, and passthrough communication to the attached sonde.

Supply Power, 12VDC
Provided from external regulated power source (not included).

Modbus I/O Terminal
Use either 485 (default) or RS-232 terminals.

Status LED

Magnetic Read Switch
Used to rediscover attached sonde.



Safety:

Do not attempt electrical wiring beyond your skill level. Follow all applicable code and regulations subject to electrical wiring and operation of the system.

Specifications

Supply Voltage: 9 - 16 VDC or USB 5 VDC
Current Draw Adapter: ~20mA typical (@12VDC)
Current Draw Sonde: ~sleep 0.25mA reading and 100mA during operation
Max Net Current Draw for Systems: ~200mA (@12VDC)
Dimensions: L=3.5", W=3.5", H=1.5" (8.9cm x 8.9cm x 3.8cm)
Operating Temp: -40°C to +60°C
Storage Temp: -50°C to +80°C
Humidity: 0 to 99% non-condensing

What's Included:

The 599825 EXO Communication Adapter comes with:

- (1) Modbus Adapter
- (3) green wiring terminal blocks (Sonde 5-pin, Power 2-pin, Modbus 7-pin)
- (1) Panel mounting bracket
- (1) DIN rail mounting bracket
- (1) Hook and loop fastener

If any item is missing, please contact info@ysi.com for replacements.

You'll also need:

- Flat blade screwdriver for terminal blocks
- Phillip's screwdriver for panel mount bracket or din rail bracket
- EXO magnetic sensor tool (optional)
- EXO Flying Lead Field cable (599008-x) or Vented Flying Lead cable (599210-x)
- EXO sonde system, sensors, and associated hardware
- Latest KorEXO software (available from YSI.com)

Mounting:

The adapter should be protected from the elements, and it is recommended it be mounted inside of a sealed enclosure with desiccant to prevent condensation.

The adapter includes a panel mount or a DIN rail mount in addition to self-adhesive hook and loop fastener. Any of the three methods can be used to securely mount the adapter. Use the provided Phillips screw to secure the panel or din rail mount:

Panel Mount

1:

2:

Back Front

DIN Rail Mount

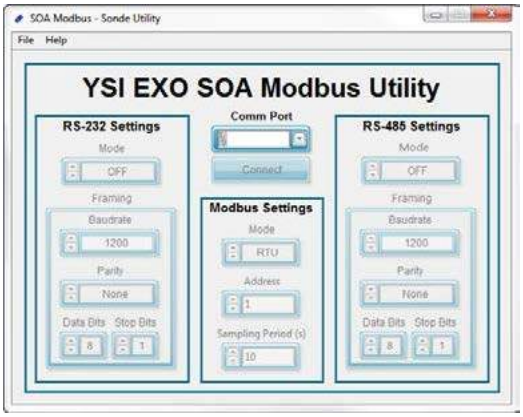
Self-Adhesive Hook and Loop Fastener

NOTE: *If using self adhesive hook and loop, clean and dry both surfaces before applying.*

Status LED Indications	
Off	No power
On	No Sonde connected
Flashing at 1 Hz	Sonde connected, everything normal
Flashing at 1/10 Hz	Low power sleep (Will flash on for 1 second when magnetic switch is activated.)

Configuration:

Downloading the SOA Modbus Utility
The EXO SOA Modbus Utility must be installed on your computer in order to change settings. The utility is available for download from the YSI **Software Downloads** page.



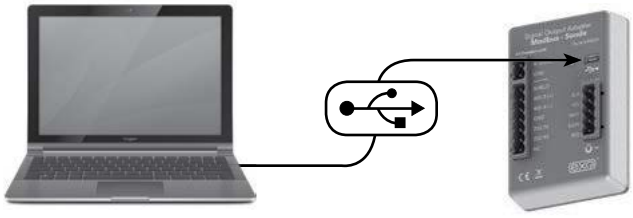
Connecting to the SOA Modbus Adapter
Method 1: Select the port by using the Comm Port selection box and then click Connect.

Method 2: Use the List Comm Ports user interface (UI) located in the Help menu to select a port. In the UI, double-click an application port and the application will automatically connect.

Configuring the SOA Modbus Adapter
Once you are connected, the application retrieves all of the current settings and displays them. To change a setting, modify the value of interest and the application will automatically update the SOA.

Default Settings	
Bus: RS-485	**Parity:** None
Mode: RTU	**Data Bits:** 8
Baud rate: 9600	**Stop Bit:** 1
Modbus Address: 1 (AKA slave address)	

USB passthrough drivers will automatically be installed along with KorEXO 2.0 software, they are also available separately from **YSI.com/KorEXO** website. Install these drivers on your PC to communicate with a signal output adapter (SOA) through any version of Desktop KorEXO:

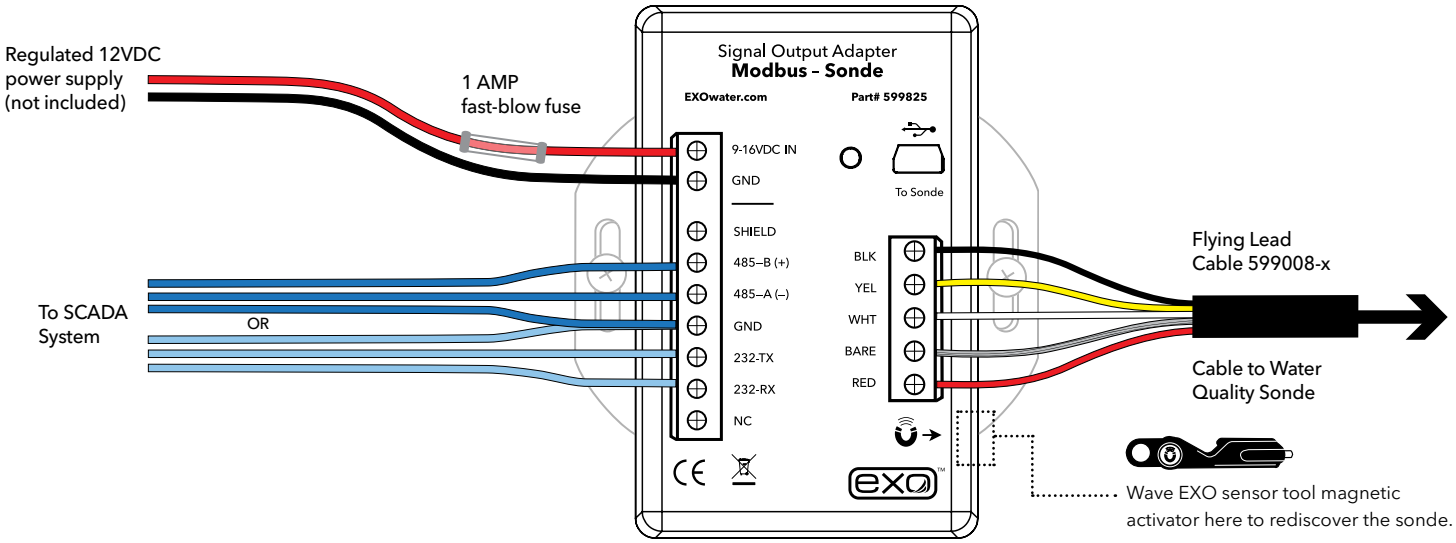


Wiring

Have the following ready:

- EXO Sonde
- Com Adapter
- Flying Lead Cable
- Flat blade screwdriver
- Power & SCADA Wires

Next wire the flying lead cable, power, and Modbus ports as labeled:



NOTE: *The orange wire on the flying lead cable to the sonde will not be used. It can be taped back during installation.*

NOTE: *3rd party RS-485 to TCP adapters may be used in conjunction with the EXO Modbus Adapter, however we are unable to provide specific support or configuration settings for these modules. The gridconnect "Net485" adapter has been successfully used in applications requiring TCP Modbus interface.*

When connecting new sondes to the Modbus adapter, it may be necessary to redetect the sonde. This can be done by power cycling the adapter or by using the magnetic read switch at the lower right hand side of the enclosure. Waving the magnet in the EXO sensor tool over the area referenced by the square above, will force a network redetect where all new sensors and configurations will be discovered.

USB Passthrough Mode

The 599825 Modbus Adapter can function in a similar fashion as the 599810 USB communication adapter. It will power the device and provide limited power to the sonde. After the Modbus adapter is wired as shown in the previous configuration, connecting to the USB port will allow direct communications with the sonde using KorEXO software.

NOTE: *USB utilizes Communication Device Class (CDC) and installs as com port on PC: "YSI SOA/DCP Gen2".*
The USB connection may also be used to update firmware on the adapter using KorEXO software.

General Modbus Information

- Register references are to the typical Holding Registers. Depending on your SCADA system these may be the 400,000 registers, the 40,000 registers, or simply the register values defined in this document. In this document the register value will generally be used. In all cases the register value will be +1 from the address value.

- The Output adapter makes use of the Modbus Holding register system to transfer data. It will respond to the Modbus commands "Read Holding Registers", "Write Single Register" and "Preset Multiple Registers". For all other commands the 599825 Modbus Adapter will return an illegal function exception. In general if you attempt to read or write from to a reserved or unused area, the 599825 Modbus adapter will return an illegal data access exception.

- The 599825 Modbus adapter is a slave device.

- The Modbus adapter maintains a current set of data in the holding registers. Use the "Read Holding Registers" command to obtain the most recent set of data from sonde connected to the 599825 Modbus adapter. Each parameter from the EXO water quality sonde is stored in a different register (or register pair). Also in different registers is status information from the 599825 Modbus adapter and the same command is used to read status. Values in still other registers control which parameters are enabled in the sonde. Programmers can enable and disable sonde parameters by writing to these registers using the "Preset Multiple Register" command.

- There are 3 main register areas to deal with the parameters:
  - Parameter type
  - Parameter status
  - IEEE floating point parameter data (Scaled integer parameter data, available but not recommended for use.)

Each of these areas is 32 registers long, except for the floating point data area which is 32 register pairs long. The first register (or register pair for the floating point data) in each area corresponds to the first parameter, the second corresponds to the second parameter, etc.

An example of a NEMA enclosure where PLC + Modbus adapter are wired.

General Modbus Information

40,000 Read Holding Address	40,000 Read Holding Register	Read/Write	Description
0	1	Read/Write Single Reg	**Sample Period:** The period in seconds at which the SOA will sample the sonde data and update holding registers (value between 0-3600)
1	2	Write Only Single Reg	**Force Sample:** Write any value here to force the SOA to update holding registers with sonde data allow 15 seconds for values to show up in data registers
2	3	Write Only Single Reg	**Force Wipe:** Write any value here to force the connected sonde to run its wiper
3-127	4-128	--	Unused – reserved for future special functions
128-159	129-160	Read/Write	**Parameter type:** The PLC must write to this area to tell the SOA what parameters it wants. Up to 32 parameters can be written here. After the last parameter the PLC must write a "0. The table on the "**Available Parameters Codes**" page lists the valid parameter type codes.
160-225	161-256	--	Reserved for future parameter type
256-287	257-288	Read Only	**Parameter status:** The PLC can read back the values in these registers to check the status of the parameters. The value in register 257 corresponds to the parameter type in register 129 and so on. The meaning of the returned value is: 0 – The parameter is available. 1 – The parameter type has not been set (i.e. type = 0) 2 – The parameter requested is not currently available.
288-383	289-384	--	Reserved for future parameter status
384-447	385-448	Read Only	**IEEE 754 Floating point parameter data:** This is the actual parameter data in floating point form. Two registers are used for each value to make up the 32 bits required for a 4 byte IEEE floating point number. The value in register pair 385:386 corresponds to the parameter type in register 129 and so on. It is highly recommended that this be used rather than the scaled integer format.
448-639	449-640	--	Reserved for future IEEE floating point parameter data
640-671	641-672	Read Only	**Scaled integer parameter data:** The PLC should only read data from the SOA using this method if it cannot handle floating point data. Most PLCs can manipulate floating point values, so you should try to avoid reading scaled integer values. The value in register 641 corresponds to the parameter type in register 129 and so on. The values are scaled according to a fixed table in the SOA. The scaled data is in an unsigned integer format. Each parameter type has a specific range and resolution. Refer to the scaled integer range table (page 8) for values for each parameter. For example, temperature °C has the range of –50 to 605.35, with a resolution of 0.01. Here are some integer values that could be returned along with their engineering equivalents: **0:** -50°C or less. **1:** -49.99°C **2:** -49.98°C **5000:** 0°C **7234:** 22.34°C **7500:** 25°C **65534:** 605.34°C **65535:** 605.35°C or higher
672-767	673-768	--	Reserved for future scaled integer parameter data
768+	769+	--	Unused

Common Acronyms: PCL Programmable Logic Controller
SCADA Supervisory Control and Data Acquisition

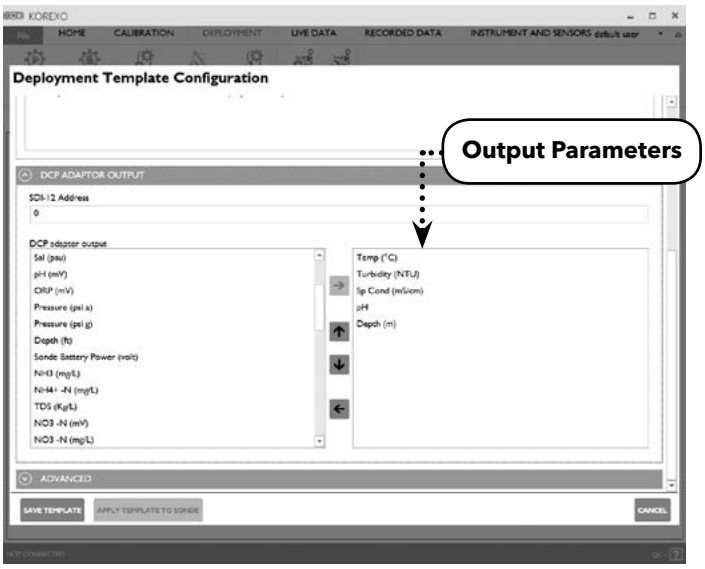
Registry Configuration

This section deals with mapping the water quality parameter types to the respective holding register 129-160. These are the measurement values generated by the water quality sonde. There are two methods to set the parameter map. The preferred method is to use the deployment templates available in any version of KorEXO. This standard functionality allows the parameters to be selected and saved. Alternatively the registers may be directly written by the SCADA system.

In the KorEXO software |**Deployment Settings**| choose the parameters and sort order, then push the template to the sonde.

The complete list of parameters is shown in the left column and the selected parameters to output via the Modbus adapter are shown on the right. This template can be saved locally on the PC, but it must also be pushed down to the sonde for the settings to take effect. So be sure to apply the template to the sonde.

NOTE: *There are two options when applying the template to the sonde, apply without logging or with logging. Either option may be used. When deploying with logging the sonde will create a redundant log file inside the sonde. Without logging, the data will only be available to the SCADA system.*



KorEXO Version 2.0.x

In the example below: Temp °C, Turbidity, SpCond, pH, and Depth M were chosen. This will automatically create a register map as follows:

Read Holding Address	Read Holding Register	Read/Write	Value	Description
128	129	Read/Write	1	The parameter code for Temp °C is displayed here
129	130	Read/Write	223	The parameter code for Turbidity (FNU or NTU) is displayed here
130	131	Read/Write	6	The parameter code for Sp Cond ms/cm is displayed here
131	132	Read/Write	18	The parameter code for pH is displayed here
132	133	Read/Write	22	The parameter code for Depth M is displayed here
133	134	Read/Write	0	Zero indicates the end of the register/parameter map

These register maps are stored in the sonde, and automatically program the 599825 Modbus adapter when power cycled or the magnetic read switch is activated. The alternative method is to write these parameter codes using the SCADA system in the format indicated above.

Available Parameter Codes

The alternative setup method is to write these parameter codes using the SCADA system in the format indicated.
The table below is the reference list of all available parameter codes for Read Holding Registers 129-160.

Parameter	Code
Temperature, °C	1
Temperature, °F	2
Temperature, °K	3
Conductivity, mS/cm	4
Conductivity, µS/cm	5
Specific Conductance, mS/cm	6
Specific Conductance, µS/cm	7
TDS, g/L	10
Salinity, PPT	12
pH, mV	17
pH	18
ORP, mV	19
Pressure, psia	20
Pressure, psig	21
Depth, m	22
Depth, ft	23
Battery, V	28
Turbidity, NTU	37
NH3 (Ammonia), mg/L	47
NH4 (Ammonium), mg/L	48

Parameter	Code
Date, DDMMYY	51
Date, MMDDYY	52
Date, YYMMDD,	53
Time, HHMMSS	54
TDS, kg/L	95
NO3 (Nitrate), mV	101
NO3 (Nitrate), mg/L	106
NH4 (Ammonium), mV	108
TDS, mg/L	110
Chloride, mg/L	112
Chloride, mV	145
TSS, mg/L	190
TSS, g/L	191
Chlorophyll, ug/L	193
Chlorophyll, RFU	194
ODO, %Sat	211
ODO, mg/L	212
ODO, %Sat Local	214
BGA-PC, RFU	216
BGA-PE, RFU	218

Parameter	Code
Turbidity, FNU	223
Turbidity, Raw	224
BGA-PC, ug/L	225
BGA-PE, ug/L	226
fDOM, RFU	227
fDOM, QSU	228
Wiper Position, V	229
External Power, V	230
BGA-PC, Raw	231
BGA-PE, Raw	232
fDOM, Raw	233
Chlorophyll, Raw	234
Potassium, mV †	235
Potassium, mg/L †	236
nLF Conductivity, mS/cm	237
nLF Conductivity, µS/cm	238
Wiper Peak Current, mA	239
Vertical Position, m	240
Vertical Position, ft	241

† **NOTE:** *Potassium is considered future functionality, there is currently no EXO probe for Potassium (as of 2015).*

The subsequent values for the parameter map are displayed in IEEE floating point parameter format (IEEE 754). The Parameter data is stored in read only address 385-448. Two address are used for each value to make up the 32 bits required for a 4 byte IEEE floating point number. The value in address pair 385:386 corresponds to the parameter type in register 129, etc.

In our example let's assume the following values: Temp 25.11°C, Turbidity 2.34 FNU, SpCond 3.02 ms/cm, pH 7.23, and Depth 1.45 M

Read Holding Address	Read Holding Register	Read/ Write	Value (IEEE 754)	Description
384	385	Read	0xE147	The least significant 16 bits of the 32-bit floating point value for 25.11
385	386	Read	0x41C8	The most significant 16 bits of the 32-bit floating point value for 25.11
386	387	Read	0x47AE	The least significant 16 bits of the 32-bit floating point value for 3.02
387	388	Read	0x4041	The most significant 16 bits of the 32-bit floating point value for 3.02
388	389	Read	0x5C29	The least significant 16 bits of the 32-bit floating point value for 7.23
389	390	Read	0x40E7	The most significant 16 bits of the 32-bit floating point value for 7.23

Advanced Configuration

The 599825 Modbus adapter will automatically sleep after 60 seconds of not being queried. To prevent the adapter from sleeping, query the adapter more frequently than 60 seconds. Alternatively program a sample interval into register 1. This is the interval the 599825 Modbus adapter will refresh its readings from the underwater sonde. It can be advantageous to sample at a 10 or 15 minute interval to extend the life of the sensors.

As an example a 10 minute (600 second) sample value in register 1 will query the sonde every 10 minutes to refresh the values in 385-448 IEE floating point registers. It is recommended you program a sample interval into the 599825 Modbus adapter half that of your scan interval. As an example if your SCADA will query the adapter every 20 minutes (1200 seconds) then it is recommended you write a 10 minute (600 seconds) sample value in address 1. This methodology will ensure the queried data is never more than 10 minutes old.

Activating the wiper: The EXO2/3 system is likely equipped with an central wiper to clean the sensors. There are two different mechanisms to activate the wiper.

The first is to write any number into register #3, this will trigger the EXO sonde to wipe the sensors in both directions. 60 seconds should be allocated for the wiping to complete, and the data presented to the Modbus holding registers during the wiping sequence will not be representative of the water quality because of the effects of the wiper passing over the sensors. It may be helpful to program a routine wipe interval into the SCADA system as well as an operator button to manually trigger the wipe sequence.

The second method is to program the sonde to autonomously sample at an interval that is greater than every two minutes. By default the sonde will wipe all the sensors before taking a reading. So programming a 1 hour deployment in the KorEXO software the sonde with automatically wipe the sensors. Note the real time data presented over Modbus during the wiping sequence will not be representative of the water quality because of the effects of the wiper passing over the sensors. This methodology will generate a redundant set of data internal to the sonde to compliment the data presented to the SCADA system.

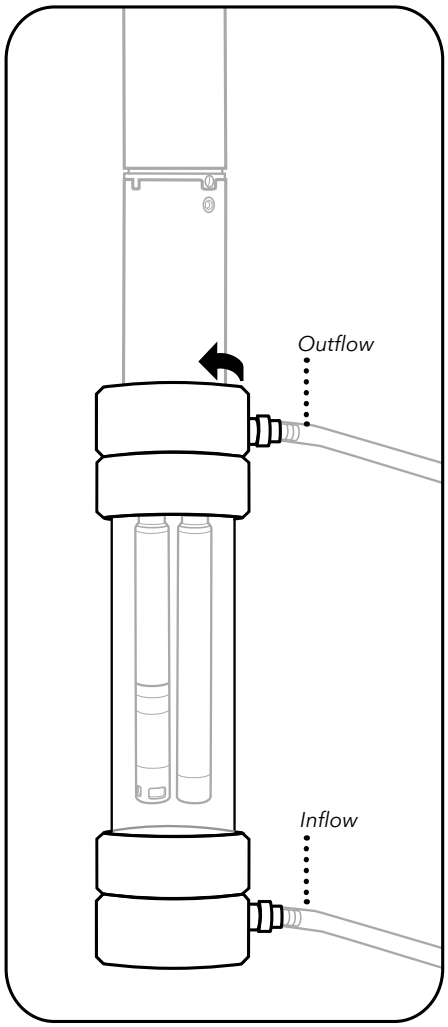
Scaled Integer Range Table

Parameter	Code	Scale Low	Scale High
Temperature, °C	1	-50	605.35
Temperature, °F	2	-50	605.35
Temperature, °K	3	0	655.35
Conductivity, mS/cm	4	0	655.35
Conductivity, uS/cm	5	0	65535
Specific Conductance, mS/cm	6	0	655.35
Specific Conductance, uS/cm	7	0	65535
TDS, g/L	10	0	65.535
Salinity, PPT	12	0	65.535
pH, mV	17	-1638.4	1638.35
pH	18	-27.768	39.767
ORP, mV	19	-1638.4	1638.35
Pressure, psia	20	-50	605.35
Pressure, psig	21	-50	605.35
Depth, m	22	-50	605.35
Depth, ft	23	-50	605.35
Battery, V	28	0	65.535
Turbidity, NTU	37	0	6553.5
NH3 (Ammonia), mg/L	47	0	655.35
NH4 (Ammonium), mg/L	48	0	655.35
Date, DDMMYY	51	N/A	N/A
Date, MMDDYY	52	N/A	N/A
Date, YYMMDD,	53	N/A	N/A
Time, HHMMSS	54	N/A	N/A
TDS, kg/L	95	0	65.535
NO3 (Nitrate), mV	101	-1638.4	1638.35
NO3 (Nitrate), mg/L	106	0	655.35
NH4 (Ammonium), mV	108	-1638.4	1638.35
TDS, mg/L	110	0	65535
Chloride, mg/L	112	0	655.35

Parameter	Code	Scale Low	Scale High
Chloride, mV	145	-1638.4	1638.35
TSS, mg/L	190	0	6553.5
TSS, g/L	191	0	6.5535
Chlorophyll, ug/L	193	0	655.35
Chlorophyll, RFU	194	0	655.35
ODO, %Sat	211	0	655.35
ODO, mg/L	212	0	65.535
ODO, %Sat Local	214	0	655.35
BGA-PC, RFU	216	0	655.35
BGA-PE, RFU	218	0	655.35
Turbidity, FNU	223	0	6553.5
Turbidity, Raw	224	0	655.35
BGA-PC, ug/L	225	0	655.35
BGA-PE, ug/L	226	0	655.35
fDOM, RFU	227	0	655.35
fDOM, QSU	228	0	655.35
Wiper Position, V	229	0	65.535
External Power, V	230	0	65.535
BGA-PC, Raw	231	0	655.35
BGA-PE, Raw	232	0	655.35
fDOM, Raw	233	0	655.35
Chlorophyll, Raw	234	0	655.35
Potassium, mV	235	-1638.4	1638.35
Potassium, mg/L	236	0	655.35
nLF Conductivity, mS/cm	237	0	655.35
nLF Conductivity, uS/cm	238	0	65535
Wiper Peak Current, mA	239	0	65.535
Vertical Position, m	240	-50	605.35
Vertical Position, ft	241	-50	605.35

2.15 Connect Sonde
Flow Cell

There are two versions of the EXO flow cell: EXO1 flow cell (599080) and EXO2 / EXO3 flow cell (599201). Flow rate through the flow cell is typically between 100 mL and 1 L per minute. Maximum flow rate depends on tubing type, size, and length. Maximum pressure for each flow cell is 25 psi. Flow cell volumes (without sensors installed) are approximately 410 mL for EXO1, and 925 mL for EXO2 and EXO3.



1 Inspect sonde and flow cell

Remove the sensor guard and/or calibration cup so that the sensors are exposed.

Make sure that the threads of the sonde and flow cell as well as all o-rings are clean and free of any particles such as sand, grit, or dirt.

2 Insert sonde into flow cell

Insert the sonde into the top of the flow cell. Be careful not to bump or scrape the sensors on the sides of the flow cell.

Screw the sonde into the flow cell by turning the sonde clockwise until it is hand-tightened into place; do not use a tool.

3 Connect tubing to flow cell

Install the Quick Connect tube fittings onto the flow cell by inserting them into the Quick Connect coupling body. They should snap into place.

Connect the tubing from your pump (not included) to the Quick Connect tube fittings, making sure that the tubing is pushed securely onto the fittings. The inflow should be at the bottom of the flow cell and the outflow should be at the top.

Keep flow cell vertical to purge it and ensure air release from Conductivity/ Temperature sensor.

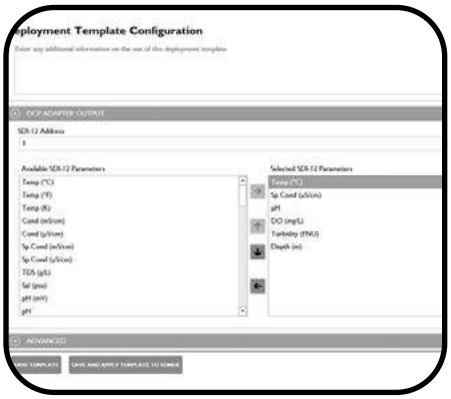
NOTICE: Do not turn on water to the system *until* the flow cell is securely connected.

2.16 Daisy Chaining
Sonde Expansion

It is possible to daisy chain up to three EXO2 sondes using the built-in topside auxiliary port.
Below is a quick start guide for setting up sondes for long-term deployment in this application.

NOTE: *Daisy chaining is only possible with EXO2 sondes.*

NOTE: *These instructions are for the DCP-SOA 1.0. With the new 2.0 model, you no longer have to be this meticulous about the order in which you connect the instruments. Simply hook all the components together and then use the magnetic activation on the side of the DCP-SOA 2.0 to allow it to reset and rebuild the map.*



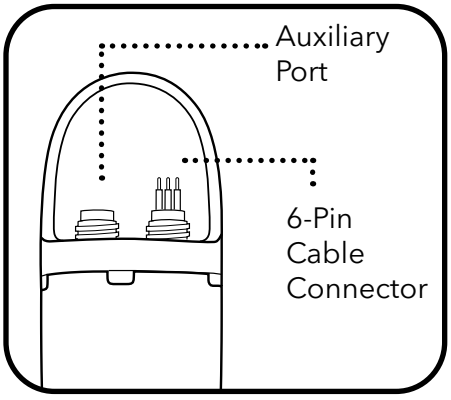
1 Set Deployment Times

Connect to each sonde individually via KorEXO. One by one, use the Deploy menu to Read Current Sonde Settings and make changes to the deployment templates. If using SDI-12 communications (recommended), set each sonde with a unique SDI-12 address.

2 Connect the Sondes

Remove power from the DCP adapter and remove all batteries from the instruments, then connect the 2-3 sondes in series using standard EXO field cables (connecting one sonde's communications connector with another sonde's topside auxiliary port).

NOTE: *Total cable length cannot exceed 300m, and the sondes themselves cannot exceed 250m depth.*



3 Connect Sondes to SOA-DCP

Using a flying lead cable, connect the topmost sonde to an EXO DCP Signal Output Adapter. Install batteries in the sonde furthest from the DCP adapter first. Then install batteries in the next sonde furthest from the adapter and then the sonde closest to the adapter if there are three sondes attached. Make sure the installed batteries are new and have around 6.0 volts supplied.

The final step is to apply power to the DCP adapter.

4 Test the System

Once the batteries have been installed and power has been supplied to the DCP adapter - use the SDI-12/RS232 commands in Section 2.12 and 2.13, communicate with each daisy chained sonde to ensure data is collected.

NOTE: *Deploy the daisy chained system with a support cable connected to the bail of each sonde. If any changes are made to the configuration of the setup, the DCP adapter will need to be power cycled so the changes will take effect.*

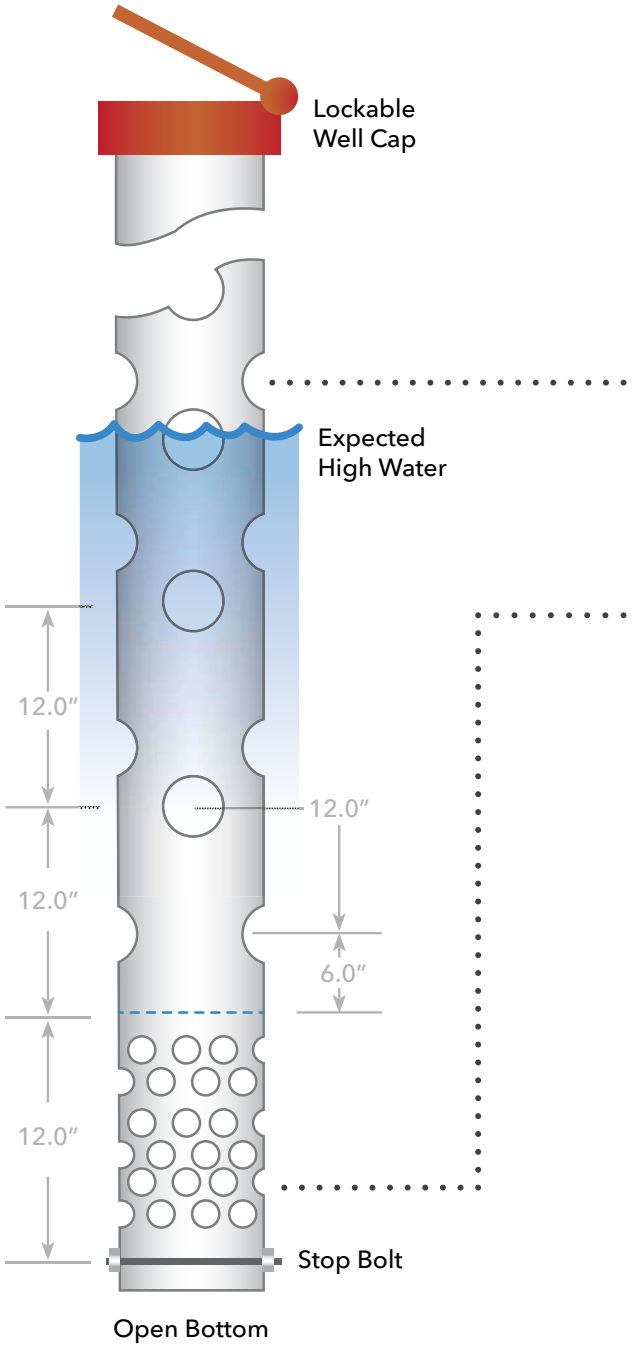
2.17 Sonde Clamping / Mooring

Long-Term Monitoring

In long-term monitoring applications, where the sonde will be left unattended for long periods of time, it is critical that you properly mount and protect your EXO sonde. This will ensure you receive quality data and that your instrument is not lost in a flood or other natural event. While there are many options available to you to secure your sonde for long-term monitoring, including mooring cages and protective housing, below you will find a general guide for the most common method - the deployment tube.

Vertical Deployment Tube

The most common configuration for a deployment tube, typically off a pier or other fixed location. Highly recommended for the highest quality data as it ensures a proper flow of water to the sensors, and avoids stagnation.



MATERIALS

- SCH 40 or SCH 80 - 4″ PVC Pipe
- 1/2″ SS Bolt, 6″ Long
- 1/2″ Flat Washers, Lock and Nut
- 4″ Lockable Well Cap, Plastic or Aluminum
- 5200 Marine Sealant (for bonding pipe to cap)

INSTRUCTIONS

<u>Vent or tube flushing hole pattern</u>:
2.5″ internal diameter.

Start one set 6″ from end or top of sensor holes. Drill two holes at 0° and 180°. Start second set of two holes at 12″ from sensor holes, drill at 90° and 270°.

<u>Sensor area hole pattern</u>:
Starting 1.0″ above the stop bolt, drill 1.0″ internal diameter holes around the entire sensor area. Should resembled Swiss-cheese. This allows for maximum flow of water to the sensors.

Mounted to Pier

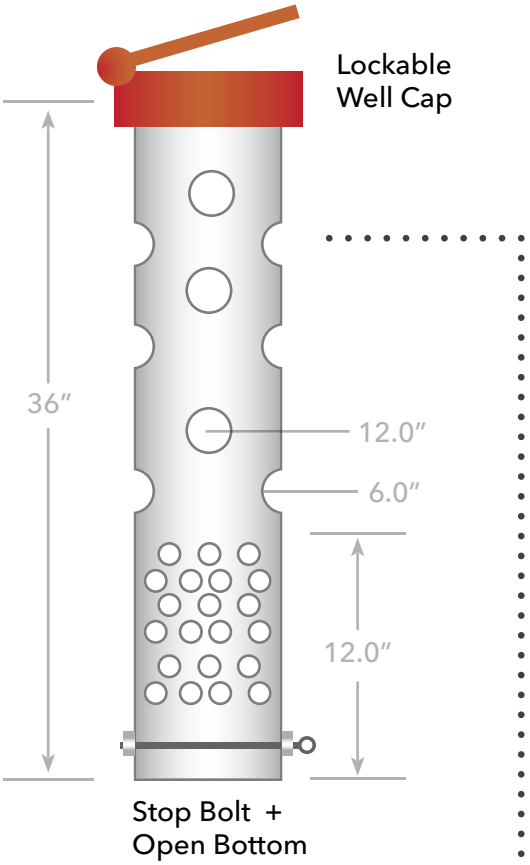
Copper Design

NOTES

- Clean and degrease pipe prior to modifications
- In marine and other fouling sites paint inside and out with anti-fouling paint
- Clean pipe at least twice a year

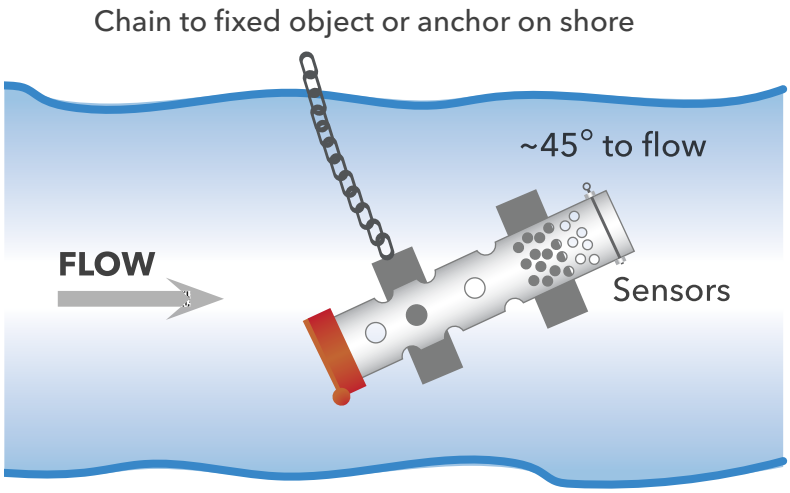
Horizontal Deployment Tube

In shallow water applications it is possible to deploy your EXO sonde horizontally. However, care must be taken that the sensors stay submerged and hydrated. This configuration has inherent risks such as sediment build up and is somewhat susceptible to flooding events even when properly fixed in place.



MATERIALS

- SCH 40 or SCH 80 - 4″ PVC Pipe, 36″ Long
- 1/2″ SS Bolt or Eye Bolt, 6″ Long
- 1/2″ Flat Washers, Lock and Nut
- 4″ Lockable Well Cap, Plastic or Aluminum
- 5200 Marine Sealant (for bonding pipe to cap)
- Two heavy weighted slabs to support pipe



Shows exposed sensors.
No debris deployments only.

INSTRUCTIONS

<u>Vent or tube flushing hole pattern</u>:
2.5″ internal diameter.

Drill one set of two, starting 6″ from sensor holes at 0° and 180°. Drill second set of two 12″ holes upwards at 90° and 270°.

<u>Sensor area hole pattern</u>:
1.0″ internal diameter, 1.5″ on centers 12″ area from 1″ above stop bolt.

NOTES

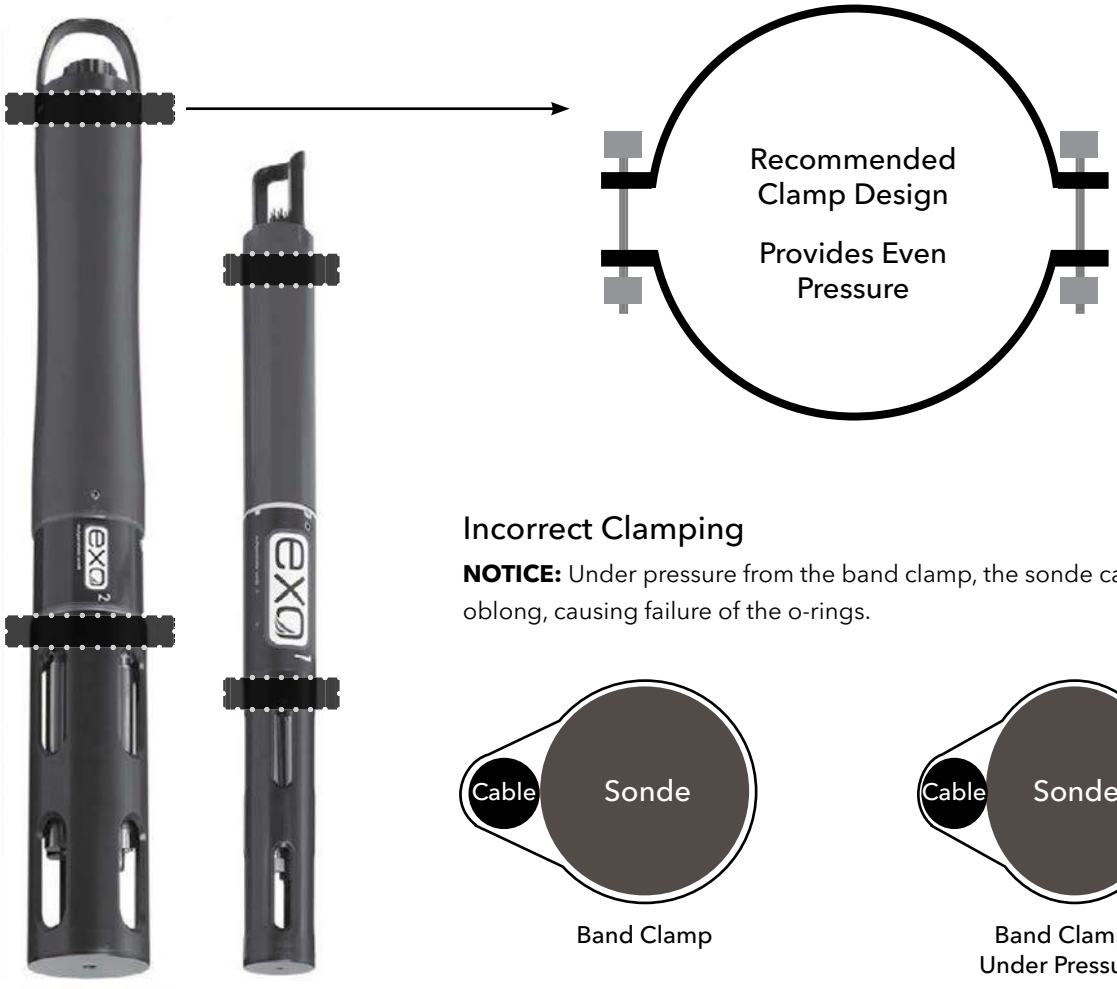
- PVC pipe must be firmly secured to its base or mount to prevent loss in high flows
- Mount and pipe should be treated with anti-fouling paint if in fouling environment
- Secure submerged parts to shore with chain or SS wire rope to a fixed object
- Never clamp sonde directly to mount

Sonde Clamping Guide

Great care should be taken when securing an EXO sonde to other objects. The preference is to deploy the sonde inside of a PVC pipe without clamps as described previously. However, if clamping is desired, the sonde should never be mounted directly to a mooring line, steel cable or piling as the pressure from a band clamp will deform the sonde and potentially cause leaks.

NOTICE: Damage and leaks from improper clamping is not covered under warranty.

Preferred Clamping Areas



Incorrect Clamping

NOTICE: Under pressure from the band clamp, the sonde can become oblong, causing failure of the o-rings.

Band Clamp

Band Clamp
Under Pressure

Mooring Cages

Some users prefer to house their Sonde in a protective mooring cage for their application.

Section 3
KorEXO Software

3.1 KorEXO Software
Introduction

KorEXO Software and drivers require permissions for successful installation. Administrative privileges may be necessary for a business or networked PC.

System Requirements

Supported 32 bit (x86) and 64 bit (x64) Microsoft Operating Systems:

- Microsoft Windows 7 Home Basic SP1
- Microsoft Windows 7 Home Premium SP1
- Microsoft Windows 7 Professional SP1
- Microsoft Windows 7 Enterprise SP1
- Microsoft Windows 7 Ultimate SP1
- Microsoft Windows 8 Home Basic
- Microsoft Windows 8 Home Premium
- Microsoft Windows 8 Professional
- Microsoft Windows 8 Enterprise
- Microsoft Windows 8.1 Basic
- Microsoft Windows 8.1 Professional
- Microsoft Windows 8.1 Enterprise
- Microsoft Windows 10 Home
- Microsoft Windows 10 Professional
- Microsoft Windows 10 Enterprise
- Microsoft Windows 10 Education

Ram Memory Requirement:

- Minimum of 2 GB of RAM installed

Hard Disk Free Space:

- Minimum of 500 MB of free hard drive space

Screen Resolution:

- 1024x768 or higher

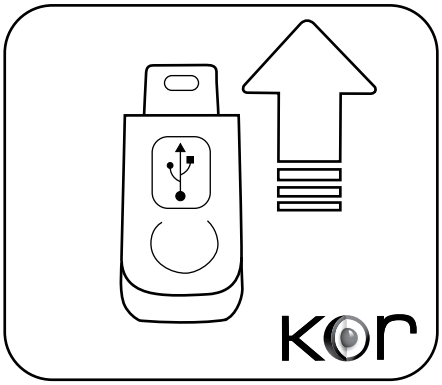
Internet access is required to support software and device updates. For any questions or concerns related to the installation or operation of KorEXO Software, please contact Technical Support at **info@ysi.com.**

3.2 KorEXO Software
Installation

KorEXO Software is supplied with all EXO Sondes on a USB flash drive. Installation will require administrative privileges.

NOTE: *It is important to install KorEXO Software prior to connecting EXO hardware, as the required drivers are installed along with the software.*

Follow these steps to complete the installation process:



1. Insert the supplied USB flash drive into a USB port on your computer.
2. Double-click Start.exe in the EXO DRIVE window to launch the Installer.
3. Click INSTALL DRIVERS and click INSTALL ALL to install all EXO hardware drivers. Follow the prompts to complete each driver installation.
   NOTE: *Administrative Privileges are needed to perform each driver installation.*
4. After drivers are installed, click BACK to return to the KorEXO Installer main menu.
5. Click INSTALL APPLICATION and check the box to agree to license terms and conditions, and then click INSTALL.
   NOTE: *Administrative Privileges are needed to perform the software installation.*
6. After successful install, close the Installer.
7. Open the KorEXO Software program for the first time. You may be asked if you want to allow a program from an unknown publisher to make changes on the computer. If so, select YES.
   NOTE: *Administrative Privileges may be needed to run KorEXO Software for the first time; Administrative Privileges will not be needed for subsequent launches of the software.*

Installation Troubleshooting:

Issue - Software Crash	**Solution**
This is the first time KorEXO has been installed on this PC and the software crashes the first time you open it.	Contact your IT Department or obtain read/write permissions to C:\ProgramData\YSI

3.3 KorEXO Software

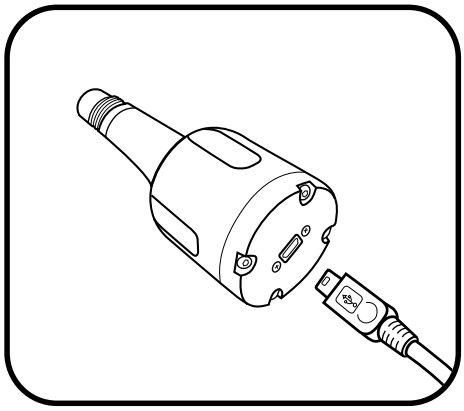
Instrument Connection Panel

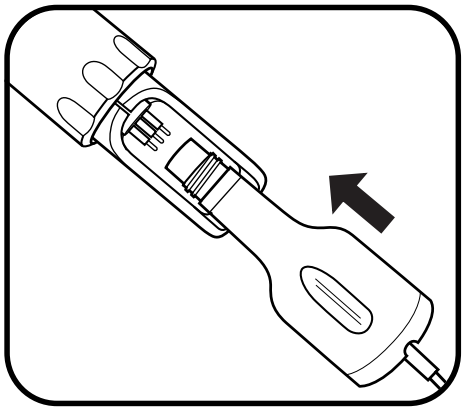
KorEXO Software connection to any EXO device is established through the Instrument Connection Panel. There are two types of connection:

- Wired via USB cable
- Wireless via *Bluetooth* (not available for EXO Handheld)

Wired Connection:

There are a few ways to establish a wired connection to an EXO Sonde. The most common method involves using a USB Signal Output Adapter (SOA) which plugs into the sonde directly. Alternatively, one can use the EXO Handheld or the EXO GO which connects to the sonde via a field cable and connects to the computer via a USB cable. The following instructions pertain to connection via the USB SOA:





1 Connect the USB Cable to the Signal Output Adapter (SOA) and the PC

Remove the protective cap from the USB end of the SOA, and ensure that the connector is clean and dry. Insert the Mini USB end of the cable into the SOA connector and the USB A end of the cable into one of the PC's USB ports. The sonde should not be connected at this time.

Attaching the adapter to the PC causes a new device to be recognized. Windows automatically installs the drivers and creates a new COM port. Each new adapter that is attached creates a new COM port. To confirm that the SOA is successfully recognized as a COM port, open the Device Manager on the PC and view it under Ports.

2 Connect the SOA to the EXO Sonde

Remove the plug from the male 6-pin connector on the sonde. Apply a light layer of Krytox grease to the male pins on the sonde and the female connector on the USB-SOA. Then align the connector's six pins and jackets, and press them firmly together so that no gap remains.

3 Open KorEXO Software

The PC connection via the SOA will supply power to the EXO Sonde; batteries are not required. Upon launching the software, the EXO Sonde should appear in the Instrument Connection Panel. Simply click the CONNECT button to establish communication with the sonde. An option to Automatically Connect to Instrument is available in the General Settings.

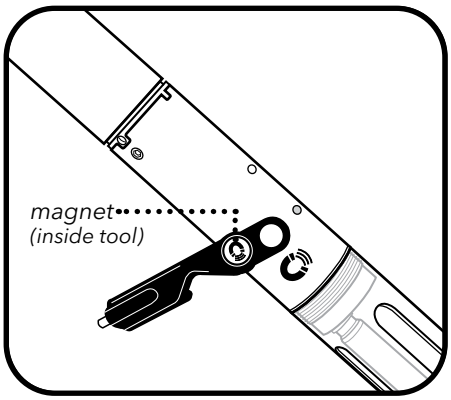
SOA Troubleshooting:

Issue - Cannot Find EXO Device	**Solution**
After you install the driver, the device shows up as "USB Serial Device" or with an exclamation point in Device Manager.	Run the installer as an administrator by right clicking on "Start.exe" and choosing "Run as Administrator."

Wireless Connection:

Every EXO Sonde includes a built-in *Bluetooth* chip which allows for wireless communication with a computer that has BT capabilities. This is extremely convenient for calibration and sampling at the surface level. However, the *Bluetooth* communication is severed when the sonde is submerged under water. The EXO GO adapter provides a *Bluetooth* connection to an EXO Sonde that may be submerged. The following instructions pertain to connection via the EXO Sonde's internal *Bluetooth*.

NOTE: *To wirelessly connect to an EXO Sonde, your computer must either have internal* Bluetooth *or a USB Bluetooth dongle.*



1 Activate the Sonde's *Bluetooth*

Tap a magnet on the designated icon on the EXO Sonde to awaken and activate *Bluetooth*. A magnet is built into the probe installation/removal tool with a matching icon. If no magnet is available, you may cycle power to the sonde by removing the batteries and reinstalling them to awaken and activate *Bluetooth*.

A blue LED will illuminate continuously for up to 5 minutes to indicate that *Bluetooth* is active and the sonde is discoverable. Once a link has been established with KorEXO Software, the blue LED blinks at 2 Hz to indicate the sonde is communicating.

An alternative to using the EXO Sonde's built-in *Bluetooth* is using the EXO GO communication adapter. Simply connect the EXO GO to the sonde using a field cable, power on the EXO GO which activates its own *Bluetooth*, and proceed to scan for it using KorEXO Software.

2 Scan for *Bluetooth* Device

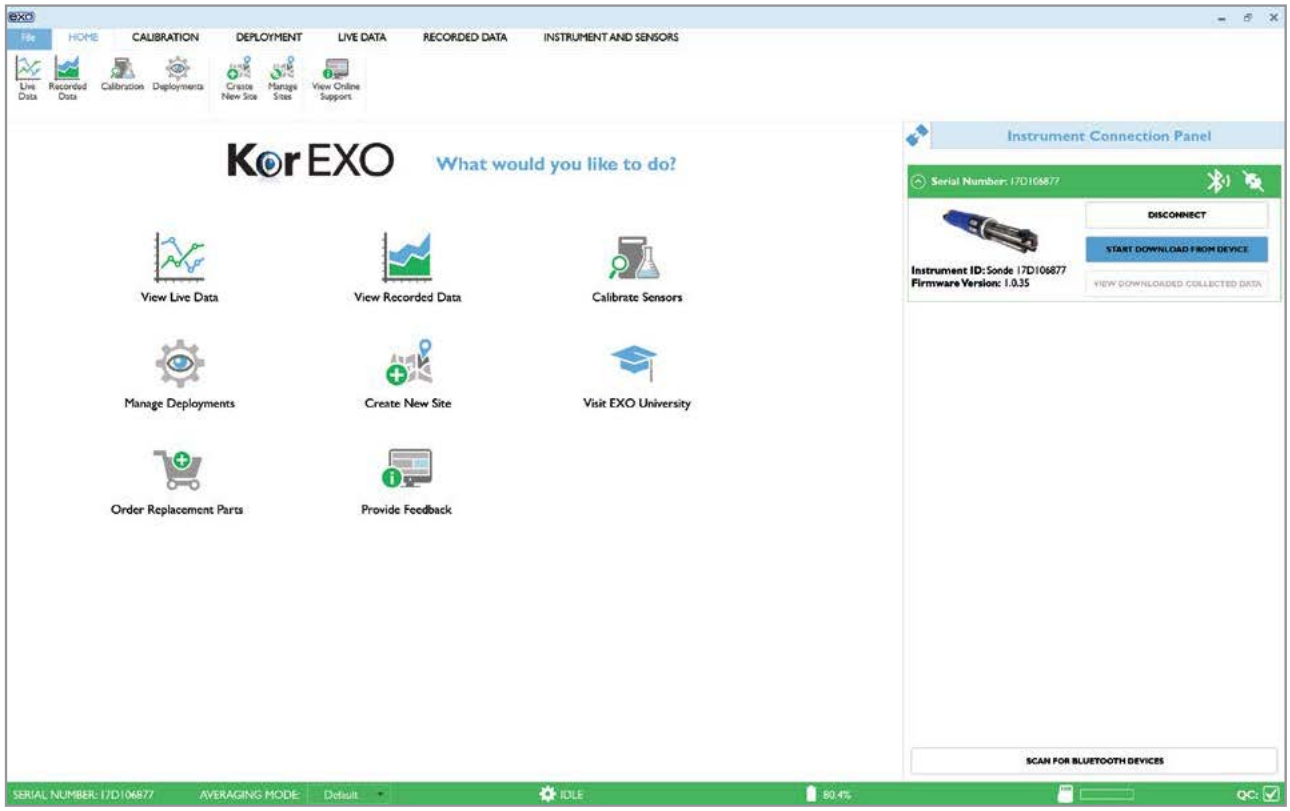
Using KorEXO Software, click the SCAN FOR BLUETOOTH DEVICES button in the Instrument Connection Panel. This might need to be repeated several times before the software finds the sonde. Once the EXO Sonde appears, simply click the CONNECT button to establish communication. An option to Automatically Connect to Instrument is available in the General Settings.

Upon connection, the KorEXO Software will automatically check the SmartQC score of the sonde. Also, depending on software settings, data may automatically start downloading; otherwise, data may be manually downloaded by clicking START DOWNLOAD FROM DEVICE.

3.4 KorEXO Software

Home Screen

The KorEXO Home screen provides quick access to the most common functions of the software and links to helpful pages on YSI.com.



Instrument Connection Panel – Displays any EXO hardware that is connected or available for connection.

View Live Data – Navigates to the Dashboard with live readings from the sonde. These measurements may be saved locally to the software database. An EXO must be connected to see data.

View Recorded Data – Navigates to the Recorded Data screen where users can access the database to find measurement data files that have been captured from the Live Data screen or downloaded from the EXO Sonde or EXO Handheld.

Calibrate Sensors – Navigates to the Calibration screen with a list of available sensors to calibrate. An EXO must be connected to perform a calibration. Users can also view and export calibration records from this screen.

Manage Deployments – Navigates to the Deployment screen which displays deployment settings for the connected EXO Sonde. Users can edit the sonde's deployment settings and deploy the sonde. An EXO must be connected to view its settings and start a deployment. Users may also view and create deployment templates and sites from this screen.

Create New Site – Allows users to create a new site which can be saved locally to the software.

Visit EXO University – Navigates to the EXO University channel on YSI.com. An internet connection is required to access this site.

Order Replacement Parts – Navigates to the YSI.com webstore. An internet connection is required to access this site.

Provide Feedback – Navigates to an online form to provide software feedback. An internet connection is required to access this site.

Menus

The top of the software screen is home to several menu options:

- **FILE**
- **HOME**
- **CALIBRATION**
- **DEPLOYMENT**
- **LIVE DATA**
- **RECORDED DATA**
- **INSTRUMENT AND SENSORS**

Ribbon

A ribbon resides below the menu bar which contains options unique to the menu that is selected. For example, the ribbon on the calibration screen includes options to find, export, and print calibration records. Users may choose to hide the ribbon from view or keep it open as they navigate the software.

Status Bar

The status bar displays important information about the connected EXO Sonde.

- Instrument Serial Number
- Averaging Mode – Select from drop-down list
  - Default = Normal Averaging
  - Accelerated = Faster Averaging
  - Rapid = Fastest Averaging
- Deployment Status – Idle (not logging) or Deployed (logging or scheduled to log)
- Battery Percentage
- Free Memory
- QC Score (see Section 4.4 for more information on SmartQC) – Clicking the QC Score will take you to the INSTRUMENT AND SENSORS screen.

3.5 KorEXO Software
File Menu

The File Menu allows users to view software information and adjust software-specific settings.

- Import
- Settings
- About
- Exit

Import

Users can import various files transferred from version 1.0.X of KorEXO Software or from other instances of KorEXO version 2.X installed on different computers. These files may be transferred remotely through email or manually using a USB flash drive. Take note of which folder the file is transferred to on the computer.

IMPORT CALIBRATION – Allows users to import calibration files from another instance of KorEXO Software. Compatible files will have the ".cal or .xml" extension.

IMPORT DEPLOYMENT – Allows users to import deployment templates from another instance of KorEXO Software. Compatible files will have the ".dep or .xml" extension.

IMPORT EXO BINARY FILE – Allows users to import data files from another instance of KorEXO Software. Compatible files will have the ".bin" extension.

IMPORT SITE – Allows users to import sites created from an older version (1.0.X) of KorEXO Software. Compatible files will have the ".sit" extension.

Settings

Users can adjust general settings related to the software as well as parameter specific settings. It is important to note that these settings are saved locally and only pertain to the software itself. These settings are not pushed to any EXO devices nor are they carried over to instances of KorEXO Software installed on other computers.

General Settings

AUTOMATION SETTINGS

- Automatically Update Software and Firmware – Toggle On/Off
  The software will indicate if there is an update available in the File menu. An internet connection is required to check for software and firmware updates.
- Automatically Connect to Instrument – Toggle On/Off
  The EXO device will automatically connect as soon as it is discovered by the Instrument Connection Panel.
- Automatically Download Data from Instrument to PC – Toggle On/Off
  Upon connection to the EXO device, it will automatically download any new data that has been collected since it was last connected to the software.
- Automatically Update Instrument Time to PC Time – Toggle On/Off
  The software will update the EXO clock to sync with the PC time.

FILE EXPORT

- CSV Delimiting Character – Select from drop-down list
  The delimiting character represents a boundary and acts to separate data in a CSV file. The default option is a comma ',' but some users may prefer a period '.' or Tab as the delimiter.
- CSV Export Type – Select from drop-down list
  There are two options for the CSV export of a measurement file:
  - With Header – Includes a section for mean values and standard deviation for every column of measurement data. Additionally, detailed parameter names are included as well as a dedicated row for sensor serial numbers.
  - Without Header – A simplified view where the top row of the spreadsheet features column labels with the respective data in the rows that follow. Parameter names are shortened and occupy the same cell as their respective sensor serial number.

STARTUP OPTIONS

- Require User Login – Toggle On/Off
  This requires the user to select a User Name when the software is launched. The selected User Name will be the default ID tagged to any data captured in the Live Data screen and any calibration that is performed. The User Name can be switched at any time without having to exit or restart the software.

LANGUAGE SETTINGS

- Select Language – Select from drop-down list
  Available languages include:
  - Chinese (Simplified)
  - Chinese (Traditional)
  - English (United States)
  - English (United Kingdom)
  - French
  - German
  - Italian
  - Japanese
  - Korean
  - Norse
  - Portuguese
  - Spanish (Spain)
  - Spanish (Americas)
  - Vietnamese
- Override Regional Settings – Select radio button
  There are two options for regional settings:
  Use Selected Language Regional Settings – Sets the regional settings based on the language selected in KorEXO Software.
  Use Local OS Regional Settings – Matches the regional settings to the computer's local operating system.

Parameter Settings

Parameter-specific display preferences are found in the Settings menu. This is where users can enable or disable parameters and select the units of measure for display in Live Data view and Recorded Data view. Note that these settings are saved locally to KorEXO Software and do not change sensor hardware settings.

Available Parameter Settings Include

Display Settings	Parameter	Unit
Algae	Phycocyanin	RFU
		µg/L
		cells/mL (requires user input)
	Phycoerythrin	RFU
		µg/L
		cells/mL (requires user input)
Barometer	Barometer	mmHg
		mbars
		inHg
		psi
		kPa
		Atm
Conductivity	Conductivity	µS/cm
		mS/cm
	Specific Conductivity	µS/cm
		mS/cm
	Resistivity	ohms-cm
		kohms-cm
		mohms-cm
	TDS (Total Dissolved Solids)	mg/L
		g/L
		kg/L
	Salinity	psu
		ppt
	NLF Conductivity	µS/cm
		mS/cm
	Water Density	σ
		σ t
Chlorophyll	Chlorophyll	RFU
		µg/L
		cells/mL (requires user input)
Depth	Depth	m
		ft
	Vertical Position	m
		ft
	Absolute Pressure	psi a
		bar a
	Gage Pressure	psi g
		bar g

(continued)

Display Settings	Parameter	Unit
DO	Dissolved Oxygen	% Sat
		mg/L
		% Local
		% LocalB
fDOM	fDOM	QSU
		ppb
		RFU
GPS	GPS	Decimal Degrees
	Altitude	m
		ft
ISE	NH4+ -N (Ammonium)	mg/L
		mV
	NH3 (Ammonia)	mg/L
	NO3 -N (Nitrate)	mg/L
		mV
	CL- (Chloride)	mg/L
		mV
ORP	ORP	mV
PAR	PAR Channel 1	µmol·s-1·m-2 (requires user input)
	PAR Channel 2	µmol·s-1·m-2 (requires user input)
pH	pH	pH
		mV
Sonde	Cable Power	volt
	Battery Voltage	volt
Temperature	Temperature	°C
		°F
		K
Turbidity	Turbidity	FNU
		NTU
	TSS (Total Suspended Solids)	mg/L (requires user input)
		g/L (requires user input)
Wiper	Wiper Position	volt

About

Users can view software version information as well as phone, email, and online support information. A status notification will be displayed that indicates whether or not there is an update available.

Exit

This will close the software.

3.6 KorEXO Software
Calibration Screen

The calibration screen is where users calibrate EXO sensors, view calibration records, and set calibration reminders. This section will explain the calibration options and settings. Information related to calibration methods for a specific parameter calibration can be found in Section 4.

Calibrate

This displays a list of parameters that available to calibrate. The parameters are organized under each respective sensor. Every parameter has two options:

1. CALIBRATE – Select this to perform a user calibration.

2. FACTORY RESET CALIBRATION – Select this to restore the factory default calibration. Note this deletes the user calibrations from the sensor and reverts to the original factory settings. A user calibration must be performed after the factory reset.

Find Calibration Records

This opens the calibration records database where users can filter and find previous calibration records. A calibration record is generated and stored every time a parameter is calibrated. Multiple calibration records may be selected to view simultaneously.

Selected records are listed under the Calibration Records Panel. These records are sorted by calibration date and organized by sensor on the left side of the screen. Select a specific record to view its calibration details displayed on the right side of the screen. See Section 4.3 for more information on Calibration Records.

Export to CSV

Select this to save in a file format which can be opened in a spreadsheet (such as Excel).

Export to XML

Select this to save in file format which can be imported by another instance of KorEXO Software.

Print Records

Select this to print a calibration report for any record shown in the Calibration Records Panel.

Manage Sensor Reminders

NOTE: This feature is only availalbe on the Premium license.

Reminders may be enabled or disabled for select parameters based on a predefined calibration interval. This interval may be adjusted by the user. Additionally, reminders may be set for the replacement of sensor modules and ODO caps.

These settings may affect the QC Score displayed by the software. For example, if the number of days since the last calibration is greater than the interval set, the software QC Score (SoftQC) will be red.

3.7 KorEXO Software
Deployment Screen

The deployment screen is where users setup the sonde for unattended logging. The sonde log status and deployment information is displayed in the main window. Additionally, a ribbon menu includes options to create, edit, start, and stop a deployment. An EXO must be connected to view its settings and start a deployment.

Start & Stop Deployment

Click Start Deployment to begin logging at the present or a future time. Three options will be presented for Start Time:

1. NEXT INTERVAL – Logging will begin at the next time interval as specified by the deployment template.

2. NOW – Logging will begin immediately.

3. CUSTOM – Logging will begin at a user-specified date and time.

Deployment Template

A deployment template includes all the settings necessary for the sonde to accomplish unattended logging. There are three options for creating or editing a template:

Create Template

Creates a new template from scratch.

Create Template from Sonde

Pulls the deployment settings from a connected EXO Sonde which can then be edited, saved, and reapplied to the sonde.

Open Template

Opens an existing template which can be edited, saved, and applied to a connected sonde.

Each template includes the BASIC, DCP ADAPTER OUTPUT, and ADVANCED settings.

BASIC DEPLOYMENT SETTINGS:

Deployment Template Name – this is the name the template will be saved as
Logging Interval Time – this is how frequently the sonde will log data
File Name Prefix – this is the file name under which the logged data will be saved
Site Name – name of the location to be tagged with the logged data
User Name – name of the user to be tagged with the logged data
Deployment Template Description – any additional information users would like to reference for this template

DCP ADAPTER OUTPUT:

NOTE: *This section is only applicable if the sonde will be communicating to an external device via either SDI-12 or Modbus protocol.*

SDI-12 Address – address of the EXO Sonde
Available SDI-12 Parameters – all parameters available to select and organize

See Section 2.13 for more information about SDI-12 communication.

ADVANCED:
There are several advanced settings which are optional for the deployment.

Logging Mode:
Normal – The sonde will log readings based on the normal interval time specified in the BASIC settings.
Sample and Hold – This is designed to ensure that the data the sonde logs internally matches the data sent to a DCP.
Burst – The sonde will log a data point once a second for the given duration.

Burst Mode Duration – Specify the duration for Burst mode.

Additional Averaging Duration – The averaging setting will apply as the sonde logs a data point. For example, if 10 seconds is selected, then 10 '1-second' readings will be averaged to a single data point.

Samples per Wipe – Specify how many samples will be logged between the wipe interval.

System-wide Averaging Mode – Choose from three averaging modes:
1. DEFAULT – Select for continuous monitoring at a fixed site
2. ACCELERATED – Select for step profiling
3. RAPID – Select for advanced applications where the sonde is moving

See Section 4.1 for more information on Averaging Modes.

Adaptive Logging:
Adaptive logging may be enabled to change the log interval time based on up to two user specified parameters and thresholds. When the parameter reads above or below a specific threshold, the sonde begins to log at the Adaptive Logging Interval. When the parameter reading crosses back over the threshold, the sonde will return to its normal logging interval.

SAVE TEMPLATE – Saves the template locally to the software.

SAVE AND APPLY TEMPLATE TO SONDE - Saves the template locally to the software and applies the settings to the sonde.

Sites

Sites can be created to allow users to organize their data by custom Site Names. The site name will be tagged to any data logged while that site is active. A site can be active in a deployment (specified in the deployment template) and in the Live Data screen for sampling.

Create a New Site

Users can input a custom site name (required) and a site description (optional). The site creation date is auto-populated. Additional options include adding a site photo and adding up to ten custom fields. The site photo must be a 24-bit BMP file no larger than 240 pixels wide by 260 pixels tall.

Manage Sites:

Access a local site database to view, modify, or delete existing sites. This also allows users to import existing sites from an EXO Handheld.

3.8 KorEXO Software
Live & Recorded Data

Live Data

The Live Data screen display readings from a connected EXO Sonde. There are three options for viewing data on this screen:

DASHBOARD – The default, grid view of enabled parameter values which are refreshed at the specified time interval.

GRAPH – A time-based or depth-based graph view; each graph can display up to two parameters specified by the user.

TABLE – A column based view where new rows of data are added to a list at the specified time interval.

Save Single Point

Logs one data set at the time the button is pressed.

Start Saving Data

Logs continuously at the specified time interval.

Stop Saving Data

Stops the continuous logging.

Current Site

The active site that is tagged to the logged data.

Interval

The time interval in which data is refreshed and logged.

Clear All Graphs

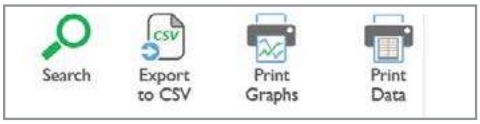
Clears data from any open graphs.

Start Wiping

Activates the wiper on an EXO Sonde.

Recorded Data

The Recorded Data screen displays data files that have been logged in the software and/or downloaded from the EXO Sonde's internal memory. Users must first select the file(s) in the Search menu before data are displayed. Data can be viewed in Table or Graph view. Additionally, data can be exported or printed.



Search

Access and filter the software database to find logged data files; multiple files can be viewed simultaneously.

Export to CSV

Saves in a file format which can be opened in a spreadsheet (such as Excel).

Print Graphs

Prints a graph of the selected data.

Print Data

Prints a table of the selected data.

3.9 KorEXO Software
Instruments and Sensors

The INSTRUMENTS AND SENSORS screen allows users to view the status and edit settings for any connected EXO devices. EXO devices are listed with the host device at the top and the sensors below. Logged data files can be manually downloaded from the sonde or handheld. The QC Score of each EXO device is available to view. Simply click on the specific device to view details related to its QC Score (See Section 4.4 for more information on SmartQC).

Update Instrument Firmware

Instrument firmware can be manually updated by clicking the Update icon in the ribbon.

> **NOTE**: *The latest firmware must be downloaded first. Check the File menu to see if there is an update available. An internet connection is required to check for updates.*

Legacy Handheld

It is possible to communicate with the legacy EXO Handheld to manage calibration, site, deployment, and measurement records.

Section 4
Sensors and Calibration

4.1 Sensors

Overview

The EXO product line includes sensors that detect a variety of physical, chemical, and biological properties of water. EXO sensors are designed to collect highly accurate data under ever-changing conditions.

Data Filtering

All EXO sensors share some common embedded software, including the filtering of real-time data. Sensors acquire environmental data at a constant rate, and use this stream of data as the input to the filtering algorithm that produces results seen by the user. EXO sondes collect data from the EXO sensors and are able to output data at rates up to 4 Hz.

Basic Rolling Filter

The filter is fundamentally a rolling or window average of past acquired inputs to the filter, such that as a new data value is added to the summation, the oldest data value is removed, and the total summation is divided by the total number of data values. It is a simple average, just rolling or moving in time. Starting with the February 2014 software release, different rolling time windows for the filter are now supported.

Averaging Modes

The Averaging Mode for EXO sensors can be modified by the user in the Deployment and Live Data settings in KorEXO Software and the EXO Handheld. Three Averaging options are available:

Default – This is the mode for all sensors set at the factory and provides optimum data filtering for most applications. It provides the highest accuracy, automatic averaging during unattended monitoring or fixed mooring. This mode has up to 40 seconds of filtering on the sensors.

Accelerated* – This mode should be used for spot sampling and slow (or paused) depth profiles. The sensors are averaging 5-10 seconds of data in a rolling window, unless there are any outliers.

Rapid* – This mode should be used where the sonde is moving quickly through the water, such as with rapid profiling and unique applications like AUV's, gliders, or towed applications. The data will be noisy and will never settle on a single steady number. This mode has 2-3 second filtering on the sensors.

*TIP: Enable the Vertical Position parameter in the Depth unit options to view the real-time position of the sonde in the water column. This is helpful in profiling applications to ensure the sonde is lowered to the desired depth without waiting for the Depth data to stabilize.

> **NOTE**: *Making any changes to the Averaging Mode will stop a deployment. As a sonde takes measurements, it compares new readings to those taken in the previous 2-30 seconds (depending on the selected option). If the new reading is not significantly different than past measurements, then it merely factors into the rolling average with older data points to create a smooth curve. If the new reading is significantly different than past measurements, then it restarts the rolling average of data points.*

To quickly check a sonde's Averaging Mode setting in KorEXO Software, check the bottom status bar and the word Default, Accelerated, or Rapid will be displayed adjacent to the sonde's serial number. To access Averaging Mode with the handheld, press the Deploy button, select Sonde Settings, and then Averaging.

Adaptive Filtering

The drawback to a basic rolling filter is that response time to an impulse event is delayed, and the more entries in the average summation, the longer the delay for the result to converge on the true value. To correct this, the filter algorithm monitors the new data arriving and compares it to the current averaged result, looking for indication of an impulse event. When new data deviate from the average by more than a predetermined tolerance, the number of data entries within the rolling average is reduced to a minimum count and the remaining values are flushed with the new data. The result is a more accurate capture of the impulse event data, entirely eliminating the inherent delay caused by the rolling average.

Outlier Rejection

Every time a newly acquired data value is added, the rolling average entries are scanned for outlier data. Although such data has already been determined to fall within the tolerances defined above, the remaining worst offenders are removed from the rolling average calculation. This outlier rejection allows for smoother continuous data results.

Calibration Stability

During calibration, the filtering is active as described, plus an additional feature works to provide stability feedback to the user. When the user attempts to calibrate a sensor, the sudden changes in environment are perceived as impulses or plunge events and the filtering reacts accordingly. The results immediately show the value of the solution, and after a few moments, the filter incrementally engages fully and supplies the smoothest data. However, as the sensor and the calibration solution work towards equilibrium, the measurement may slowly drift. The sensor will monitor the results from the filter and determine if the measurement is stable. It watches the results and calculates a slope from each and every result to the next. Once the slope settles and is consistently flat for approximately 30 seconds, the sensor is considered stable. KorEXO is then notified and the user will see a message that the calibration reading is stable.

Sensor Response Times

Response times for EXO sensors are based on laboratory testing. This testing, though stringent, cannot mimic the actual response times in the field due to the wide variety of use cases. To characterize an EXO sensor's response time, a step change in the sensor's primary output parameter is applied, and the time to reach 63% of the final stimulus value is recorded. Repeated characterization of multiple sensors provides the T63 specification.

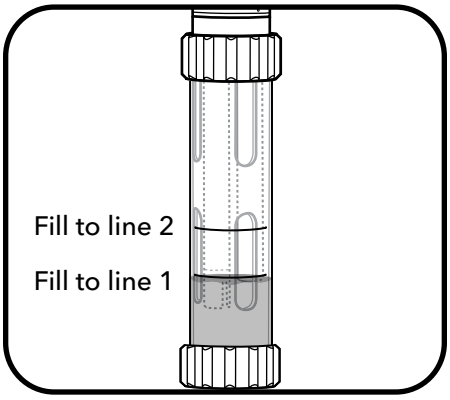
Sensor Accuracy Specifications

To maintain accuracy specifications for EXO sensors, we recommend that users calibrate sensors in the lab in standards with temperatures as close to the ambient temperature of the field water as possible.

4.2 Calibration
Basic Overview

EXO sensors (except temperature) require periodic calibration to assure high performance. Calibration procedures follow the same basic steps with slight variations for particular parameters. Calibration procedures described in this section will mainly focus on using KorEXO Software. Users should refer to the EXO Handheld Mini-Manual for calibration procedures utilizing the handheld.

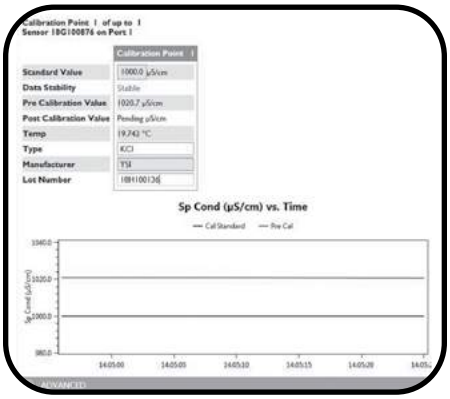
NOTE: *All EXO sensors should be user-calibrated before initial use.*



Calibration set-up

For accurate results, thoroughly rinse the EXO calibration cup with water, and then rinse with a small amount of the calibration standard for the sensor you are going to calibrate. Two to three rinses are recommended. Discard the rinse standard, then refill the calibration cup with fresh calibration standard. Fill the cup to approximately the first line with a full sensor payload or the second line with small sensor payload. Recommended volumes will vary, just make certain that the sensor is submerged. Be careful to avoid cross-contamination with other standards.

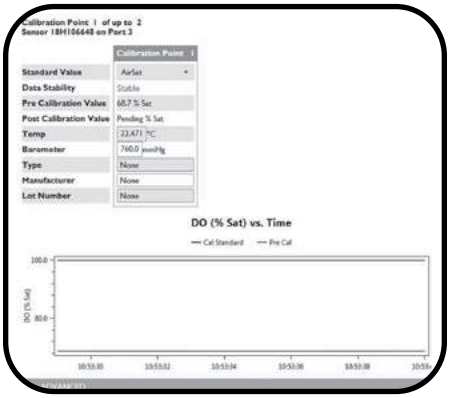
Begin with clean, dry probes installed on the EXO sonde. Install the clean calibration guard over the probe(s), and then immerse the probe(s) in the standard and tighten the calibration cup onto the EXO sonde. We recommend using one sonde guard for calibration procedures only, and another sonde guard for field deployments. This ensures a greater degree of cleanliness and accuracy for the calibration procedure.



Basic calibration in KorEXO software

Go to the Calibrate menu in KorEXO Software. This menu's appearance will vary depending on the sensors installed in the sonde. Select the sensor you are going to calibrate from the list. Next select the parameter for the sensor you are going to calibrate. Some sensors have only one parameter option, while other sensors have multiple options.

Selecting the parameter will initiate the probe's calibration in the standard; initially the data reported will be unstable and then will move to stable readings. Enter the Standard Value if necessary. The Standard Value should match that of the standard you are using. You may also enter optional information for type of standard, manufacturer of standard, and lot number by accessing the Advanced menu.

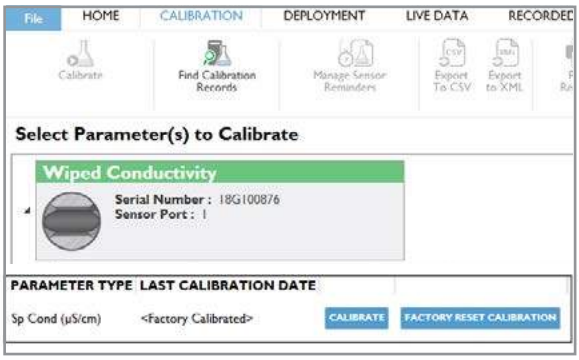


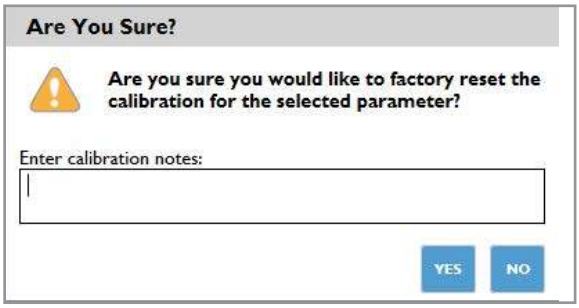
Users should confirm that the value is within their acceptable margin of error. Once readings are stable, click Apply to accept this calibration point. Repeat the process for each calibration point. **Click Complete when all points have been calibrated.**

A calibration summary appears with a QC score. View, export, and/or print the calibration worksheet. If a calibration error appears, repeat the calibration procedure.

Factory Reset Calibration

A Factory Reset Calibration can be performed to return the sensor gain and offset to factory specifications. Performing a Factory Reset Calibration will allow the user to start a calibration with default sensor metadata values. A new calibration of the sensor will then help with additional troubleshooting, if needed.





Performing a Factory Reset Calibration in KorEXO:

Step 1

Click on the Calibration tab or button.

Step 2

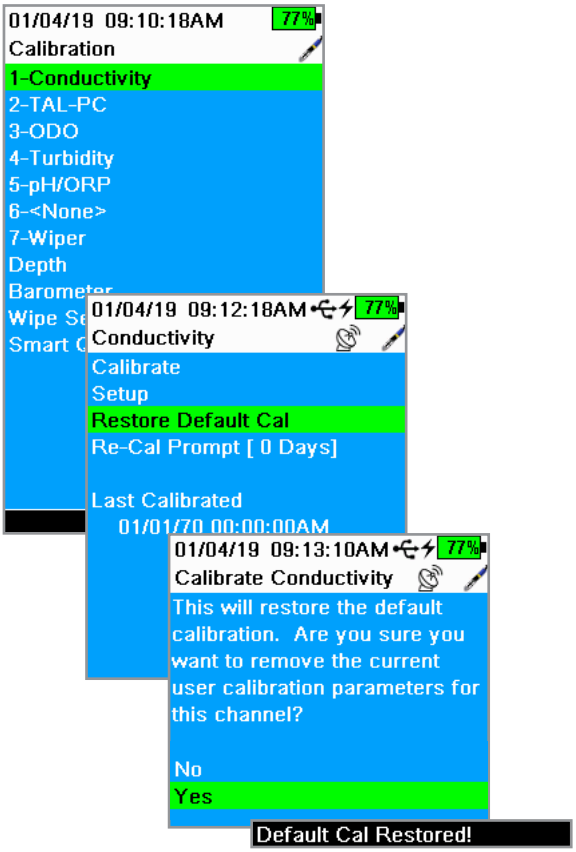
Click the turn-out arrow next to the parameter desired.

Step 3

Click the Factory Reset Calibration button.

Step 4

Type any desired notes into the pop-up window and then click the Yes button to confirm the action.



Performing a Factory Reset Calibration in the Handheld:

Step 1

Click the Calibration button.

Step 2

Select the desired parameter.

Step 3

Select Restore Default Cal.

Step 4

Select Yes. A message will be shown on the bottom of the screen to confirm that the action was successful.

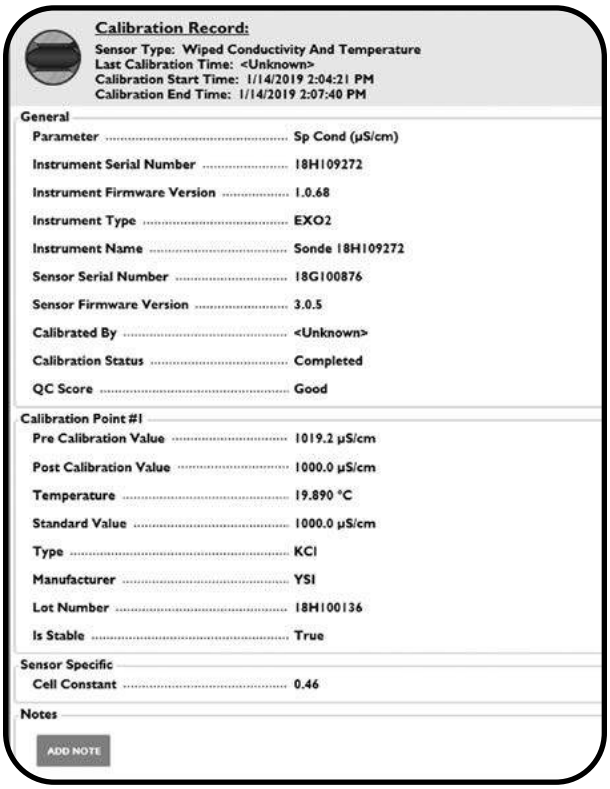
4.3 Calibration
Calibration Report

The Calibration Report is a record of the calibration for an EXO sensor. The report contains quality assurance information including date and time of calibration, date of previous calibration, sensor firmware version, type of calibration performed, standard used, and QC score.

Calibration Reports are saved in the KorEXO Software database on the computer or the EXO Handheld that was used during calibration (not on the sonde or the sensors). All reports can be accessed and viewed through the Calibration Records menu in KorEXO Software.

Sample Reports:

1-point calibration of specific conductance on EXO conductivity/temperature probe



Calibration Record:
Sensor Type: Wiped Conductivity And Temperature
Last Calibration Time: <Unknown>
Calibration Start Time: 1/14/2019 2:04:21 PM
Calibration End Time: 1/14/2019 2:07:40 PM

General

Parameter	Sp Cond (µS/cm)
Instrument Serial Number	18H109272
Instrument Firmware Version	1.0.68
Instrument Type	EXO2
Instrument Name	Sonde 18H109272
Sensor Serial Number	18G100876
Sensor Firmware Version	3.0.5
Calibrated By	<Unknown>
Calibration Status	Completed
QC Score	Good

Calibration Point #1

Pre Calibration Value	1019.2 µS/cm
Post Calibration Value	1000.0 µS/cm
Temperature	19.890 °C
Standard Value	1000.0 µS/cm
Type	KCl
Manufacturer	YSI
Lot Number	18H100136
Is Stable	True

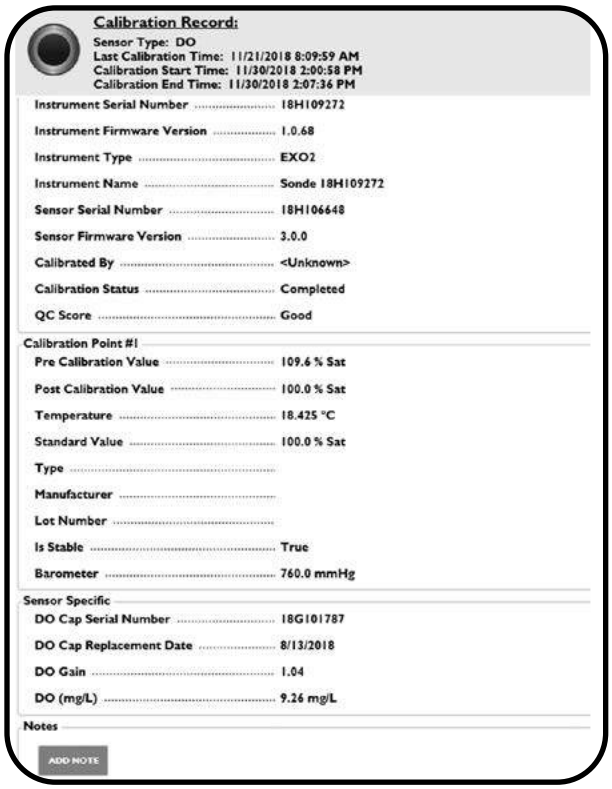
Sensor Specific

Cell Constant	0.46

Notes

ADD NOTE

1-point calibration of percent saturation on EXO optical dissolved oxygen probe



Calibration Record:
Sensor Type: DO
Last Calibration Time: 11/21/2018 8:09:59 AM
Calibration Start Time: 11/30/2018 2:00:58 PM
Calibration End Time: 11/30/2018 2:07:36 PM

Instrument Serial Number	18H109272
Instrument Firmware Version	1.0.68
Instrument Type	EXO2
Instrument Name	Sonde 18H109272
Sensor Serial Number	18H106648
Sensor Firmware Version	3.0.0
Calibrated By	<Unknown>
Calibration Status	Completed
QC Score	Good

Calibration Point #1

Pre Calibration Value	109.6 % Sat
Post Calibration Value	100.0 % Sat
Temperature	18.425 °C
Standard Value	100.0 % Sat
Type	
Manufacturer	
Lot Number	
Is Stable	True
Barometer	760.0 mmHg

Sensor Specific

DO Cap Serial Number	18G101787
DO Cap Replacement Date	8/13/2018
DO Gain	1.04
DO (mg/L)	9.26 mg/L

Notes

ADD NOTE

Additional Post-Calibration Info

ODO Gain: The ODO gain is a diagnostic value recorded on the Calibration Report and used for advanced diagnostic purposes. The nominal value is 1, and accurate calibrations of the DO sensor will only slightly deviate from this number.

Cell Constant: The cell constant is the current value of the conductivity and is a function of the factory original cell constant and the most recent user calibration. The cell constant will drift over time based on the sensor's electrodes, and the cell constant can be used to track drift.

Slope: The slope for the pH sensor is the mV per decade (pH unit) where 59 is the typical value. Slope allows the user to track drift away from 59 to determine the life/aging of the sensor module.

Change mV: The change millivolts is the mV change between either 4 and 7 or 7 and 10 calibration values for the pH sensor. It is the mV deviation away from the middle calibration point number.

4.4 SmartQC
Overview

SmartQC is a mechanism to normalize different sensors and to assess the current state of individual sensor performance relative to factory-defined performance parameters. Every EXO sensor has an embedded microprocessor which, along with calibration metadata, enables EXO to warn users of calibration errors or when a sensor is unable to be calibrated due to age, fouling, or damage, for example. For any sensor a QC score is presented as red, yellow, or green:

- A **green** SmartQC score means the sensor is calibrated properly and all parameters used to assess its performance state are within factory-defined limits.
- A **yellow** SmartQC score means that the sensor will still perform within factory-defined limits, but that during calibration enough of an adjustment was required to suggest that the sensor is drifting from those limits or may soon require some adjustments, such as a new DO cap. A yellow QC score might also result from variations in calibration standards and operators. One's comfort with a yellow score is case-dependent: for long-term deployments a yellow score is not optimal. For deployments of a couple of weeks or for spot-sampling, a yellow score may be perfectly acceptable, depending upon the sensor in question. This is addressed for individual sensors throughout the EXO Manual.
- A **red** SmartQC score means that the sensor is not performing within factory-specified limits. Also, in some cases a red QC score might mean that a component of the sensor is due to be replaced (such as a DO cap), or the user has defined some other limit, such as the term expired since the most recent calibration. These examples are captured under the term *SoftQC* because they are set by the user in Kor software, and such settings will override a green SmartQC score when using the software.

The way in which EXO assesses the calibration metadata is dependent upon the sensor type, and examples of information used include signal to noise ratio, signal gain, raw millivolts, and cell constants. "Gain" is one of the most common principles applied in the SmartQC system, and one might think of gain as m in the linear relationship y = *m*x +b where x is the real-time parameter result computed from a particular factory setting and y is the same parameter but modified and computed from a setting as defined by the user's calibration.

For example suppose that during a calibration the %ODO saturation is calculated from the factory settings to be 92%. This would be *x*. This same setting may be calculated to be 97% during the user's calibration, and this would be *y*. The gain, or *m*, would be calculated to be 1.054, and in this specific example that would be reported in the calibration worksheet as the *ODO Gain*.

In an ideal world where gains are calculated, *m* would be 1 and b would be zero, meaning that there has been no change at all in the sensor's performance since it left the factory. For most sensors this simple relationship can be applied, and gain and offsets are the primary drivers of the QC score (the ranges for them are proprietary, however). Other sensors have more complex sets of coefficients that are used, and factory-to-user calibration outputs are defined by more complex polynomial relationships.

Though proprietary limits and algorithms are used in calculation of the QC scores, much of the metadata that are used (such as millivolts, slopes, or gain factors) are visible to the user in the calibration worksheets. Sometimes these metadata are of more value to the user than the actual QC score, and users can assess whether and how they should use these metadata to build their own SOPs and acceptance criteria. This is readily achieved since each calibration worksheet shows not only the QC score for that calibration event but also the metadata and an audit trail for sensor calibration and performance throughout a sensor's lifetime.

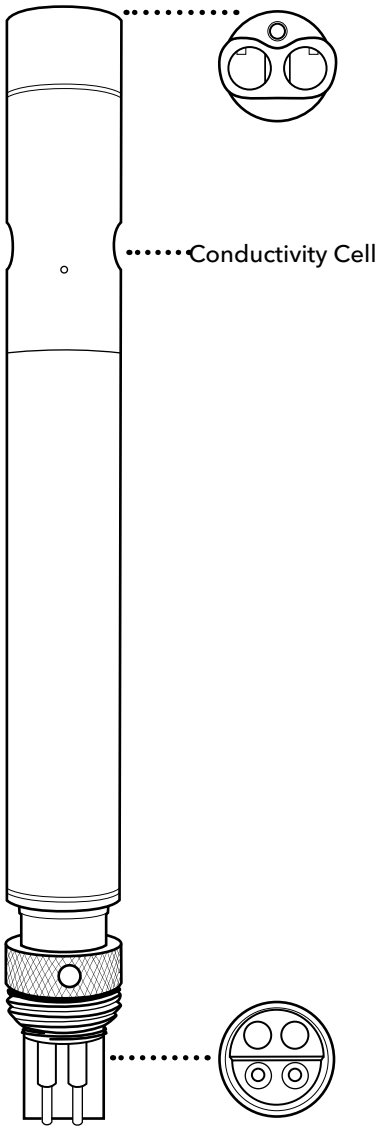
In this manual each individual sensor is described, and the descriptions of calibration for each sensor include recommendations regarding the interpretation and steps to take based upon green, yellow, or red QC scores.

4.5 Conductivity / Temperature

Sensor Overview

The EXO combination conductivity and temperature sensor should be installed in nearly all sonde applications. Not only will this sensor provide the most accurate and fastest response temperature data, but it will also provide the best data for the use in temperature compensation for the other EXO probes. The conductivity data is used to calculate salinity, non-linear function (nLF) conductivity, specific conductance, and total dissolved solids, and compensate for changes in density of water (as a function of temperature and salinity) in depth calculations if a depth sensor is installed.

(continued)



599870-01

Specifications

Conductivity

Default Units	microSiemens/centimeter
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Range	0 to 200 mS/cm
Accuracy	0-100 mS/cm: ±0.5% of reading or 0.001 mS/cm, whichever is greater; 100-200 mS/cm: ±1% of reading
Response	T63<2 sec
Resolution	0.0001 to 0.01 mS/cm range-dependent
Sensor Type	4-electrode nickel cell

Temperature

Default Units	°Celsius
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Accuracy	-5 to 35°C: ±0.01°C 35 to 50°C: ±0.05°C
Response	T63<1 sec
Resolution	0.001°C
Sensor Type	Thermistor

Temperature Thermistor

The temperature sensor uses a highly stable and aged thermistor with extremely low-drift characteristics. The thermistor's resistance changes with temperature. The measured resistance is then converted to temperature using an algorithm. The temperature sensor receives a multi-point NIST traceable wet calibration and the accuracy specification of 0.01˚C is valid for expected life of the probe. No calibration or maintenance of the temperature sensor is required, but accuracy checks can be conducted against a NIST-traceable temperature probe supplied by the user.

Conductivity Electrodes

The conductivity sensor uses four internal, pure-nickel electrodes to measure solution conductance. Two of the electrodes are current driven, and two are used to measure the voltage drop. The measured voltage drop is then converted into a conductance value in milliSiemens (millimhos). To convert this value to a conductivity value in milliSiemens per cm (mS/cm), the conductance is multiplied by the cell constant that has units of reciprocal cm (cm^{-1}). The cell constant for the conductivity cell is approximately 5.1/cm ±10%. For most applications, the cell constant is automatically determined (or confirmed) with each deployment of the system when the calibration procedure is followed.

Temperature Compensation

EXO sensors have internal thermistors for quality assurance purposes. Turbidity uses the internal thermistor for temperature compensation, while all other EXO sensors reference the C/T probe for temperature compensation. To display and log temperature, a C/T probe must be installed in an EXO sonde. Thermistor readings are logged in the sonde's raw data–viewable in KorEXO software–but are not included in data exported to Excel.

Conductivity = This is a measurement of water conductance from the drive and sense electrodes on the conductivity electrode. The output is in mS/cm or µS/cm. Note that the conductivity of solutions of ionic species is highly dependent on temperature, and the conductivity output is NOT compensated for temperature.

Specific Conductivity = When Specific Conductance is selected, the sonde uses the temperature and raw conductivity values associated with each determination to generate a specific conductance value compensated to 25°C by default. Both the Temperature Coefficient and reference temperature can be adjusted in the advanced sensor menu under calibration.

nLF Conductivity = The non-linear function (nLF) is defined by the ISO 7888 standard and is applicable for the temperature compensation of electrolytic conductivity of natural waters. This convention is typically used in German markets.

Salinity = Salinity is determined automatically from the sonde conductivity and temperature readings according to algorithms found in Standard Methods for the Examination of Water and Wastewater (ed. 1989). The use of the Practical Salinity Scale results in values that are unitless, since the measurements are carried out in reference to the conductivity of standard seawater at 15 °C.

4.6 Conductivity / Temperature Calibration

Clean the conductivity cell with the supplied soft brush before calibrating *(see Section 5.7)*.
Also, review the basic calibration description in Section 4.2.

This procedure calibrates conductivity, non-linear function (nLF) conductivity, specific conductance, salinity, and total dissolved solids.

A variety of standards are available based on the salinity of your environment. Select the appropriate calibration standard for your deployment environment; we recommend using standards greater than 1 mS/cm (1000 µS/cm) for greatest stability.

Pour conductivity standard into a clean and dry or pre-rinsed EXO calibration cup. YSI recommends filling the calibration cup up to the second marked line to ensure the standard is above the vent holes on the conductivity sensor. Immerse the probe end of the sonde into the solution, gently rotate and/or move the sonde up and down to remove any bubbles from the conductivity cell.

Allow at least one minute for temperature equilibration before proceeding.

In the Calibrate menu, select the Conductivity sensor and then select the parameter you wish to calibrate. These parameters may include conductivity, nLF conductivity, specific conductance, or salinity. Calibrating any one option automatically calibrates the other parameters. After selecting the option of choice (specific conductance is normally recommended), enter the value of the standard used during calibration. Be certain that the units are correct (microsiemens, not millisiemens).

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point.

> **NOTE:** If the data do not stabilize after 40 seconds, gently rotate the sonde or remove/reinstall the cal cup to make sure there are no air bubbles in the conductivity cell.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu.

Rinse the sonde and sensor(s) in tap or purified water and dry.

SmartQC for Conductivity/Temperature Sensors

The SmartQC Score for conductance is based on a gain factor, which is then computed into a cell constant that appears on the calibration worksheet. The gain may drift over time due to aging electrodes or calibration procedures performed on the sensor, and this will ultimately affect the cell constant. An ideal cell constant for the non-wiped conductivity sensor is 5.1/cm ± 10%, and the effects of changes in gain will be evident in changes in that value.

The CT sensor can be evaluated in air when it is new, and as the sensor ages this may be a useful tool for assessing its drift from factory performance. To perform an air check:

1. Clean the sensor thoroughly.
2. Perform a Factory Reset Calibration.
3. Rinse the sensor with DI water and dry it thoroughly.
4. Observe sensor readings in air. They should be very close to zero. While this is a subjective assessment, if the user has an idea of what air readings were when the sensor was new, monitoring this on occasion can provide clues as to whether the sensor is aging out of use.

Guidance on interpretation of the SmartQC score for this sensor is as follows:

Green: Gain is within acceptable limits. Calibration was performed successfully and resulted in a gain within factory specified limits.

Yellow: The gain has drifted a minor amount from factory specified limits. The sensor is still reporting correctly but adjustments may need to be made. If a user calibration results in a yellow QC Score:

1. First, thoroughly clean the sensor and ensure that all debris is removed from the surfaces of the sensor. Refer to Section 5.7 for additional information on how to properly clean the sensor in order to avoid damaging the sensor.
2. Next, perform a Factory Reset Calibration to reset the gain and cell constant to their factory default values. This is described in Section 4.2.
3. Finally, complete another calibration on the sensor using fresh standard.
4. Perform a check of readings in air.

If the QC Score remains yellow, the sensor is still able to be used, but the user should monitor this sensor during calibrations, including looking at the cell constant on the calibration worksheets.

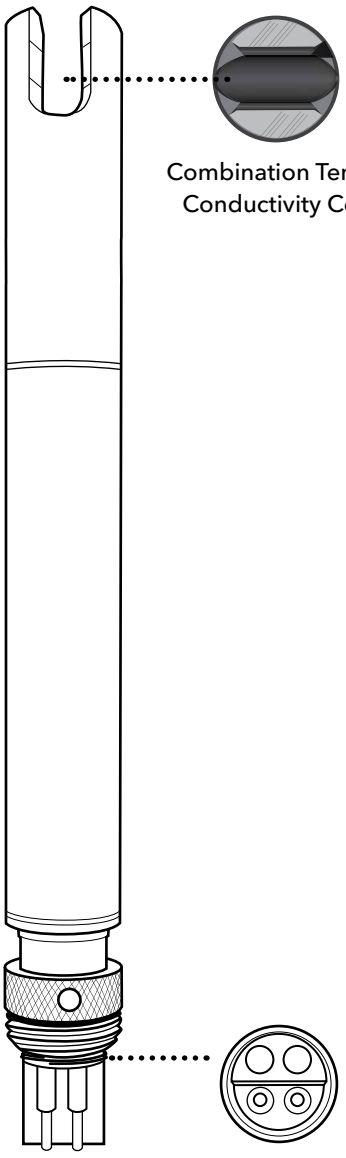
Red: The gain has drifted significantly from the factory specified limits. If the QC Score is red, the sensor may not report correct values. If a user calibration results in a red QC Score:

1. Verify that the standard value used during calibration was entered correctly. If the value was not entered correctly, the resulting QC Score would show a red value due to the gain changing significantly.
2. Thoroughly clean the sensor and ensure that all debris is removed from the surfaces of the sensor. Refer to Section 5.7 for additional information on how to properly clean the sensor in order to avoid damaging the sensor.
3. Perform a Factory Reset Calibration.
4. Complete a calibration using fresh standard.

If the QC Score returns to red after these steps, please contact YSI Technical Support for further assistance.

4.7 Wiped Conductivity / Temperature
Sensor Overview

Biofilms, barnacles, and algal growth are common culprits of poor data quality, clogging up conductivity cells and coating sensor optics. While EXO2's Central Wiper can mechanically remove biofouling from other sensors to maintain data integrity over long deployment periods, in particularly high fouling environments the EXO Wiped C/T sensor provides superior conductivity data by avoiding stagnant readings and reducing the impact of micro-environments.



599827

EXO Wiped C/T Considerations

Sensor performance and specifications are well suited for continuous monitoring applications, where the EXO sonde is installed at a fixed location. For sampling and vertical profiling applications the legacy (599870) Conductivity Temperature probe which has a much faster temperature response should be used.

The Wiped C/T will have a different cell constant than the legacy Conductivity probes. A nominal cell constant of 0.469 +/-0.05 is typical on wiped conductivity.

The EXO central wiper (599090) must have the wiper shaft seal serviced in the past year to use with your new wiped C/T probe. The wiper will work harder grooming the new sensor, therefore if your wiper hasn't had the shaft seal properly maintained there is a chance it could stall mid deployment.

Specifications

Conductivity

Range	0-100,000 µS/cm
Accuracy	±1% of reading or 2 µS/cm w.i.g.

Temperature

Range	-5 to 50°C
Accuracy	±0.2°C
Response Time	T95<30sec

Specific Conductance

Range	0-100,000 µS/cm
Accuracy	±1% of reading or 2 µS/cm w.i.g.

w.i.g. = whichever is greater

Watch Online
EXO2 Wiped (C/T) Video Quick Start Guide:
https://goo.gl/w67OQU

4.8 Wiped Conductivity / Temperature
Calibration and Deployment

Calibration

A wet calibration of your new conductivity sensor should be completed before initial use. It is recommended that you complete a single point calibration in a standard similar to the conductivity readings that you expect to measure. It is recommended not to use standards below 1,000 µs/cm for fresh water applications as they can become easily contaminated. The temperature sensor cannot be user calibrated. Best practice is to periodically test the performance of the temperature sensor against a NIST traceable thermometer at several reference points.

NOTE: *All EXO sensors should be user calibrated before initial use.*

Deployment Setup

The Wiped C/T sensor is optimized for continuous monitoring where a variety of environmental fouling conditions would affect the performance of the sensor without wiping. Numerous solutions can be employed to mitigate the effects of bio-fouling. These can include the use of copper tape, anti-fouling guards, anti-fouling paints, as well as local techniques developed for site specific challenges. However, none of these options can be directly applied to the conductivity cell of the wiped C/T sensor. Using the central wiper to groom the conductivity cell before readings prevents biofouling-induced drift of the conductivity cell.

The sensor includes a new central wiper brush (599673). A brush's wear and replacement intervals vary greatly based on specific application challenges, but 2-12 months use has been observed. Below are three examples of brush wear that will occur with use. It is recommended the wiper brush be replaced before it reaches level 3 for optimal cleaning. We recommend using a new wiper brush with the initial deployment.

Level 1- New brush, minimal "splay"

Level 2- Moderate splaying, have spare ready

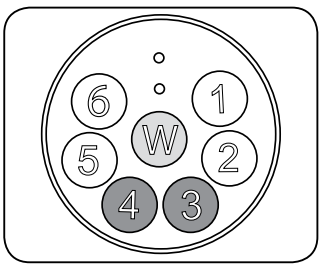
Level 3- Excessive splay, replace to prevent stalling of wiper

NOTICE: It is not recommended using wiped C/T in conjunction with EXO Ammonium, Nitrate, or Chloride electrodes as they are protected with a guard which accelerates the brush splay.

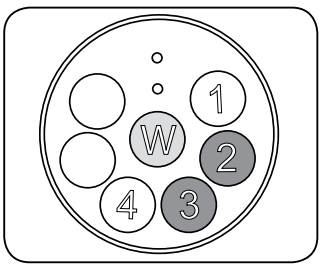
Sensor Installation

A new sensor includes a kit (599831) containing probe alignment o-rings and disposable zip ties. These items are to be used to optimally align the wiped conductivity probe cell with the brush. Refer to the instruction sheet included in the kit for directions and recommendations for applying the spacers. EXO sensors can be installed in any port, however for optimal cleaning avoid installing the Wiped C/T sensor as the first or last sensor in a group. If two conductivity sensors are installed in a single sonde, the temperature from the sensor with the lower port will be used for temperature compensation of other parameters.

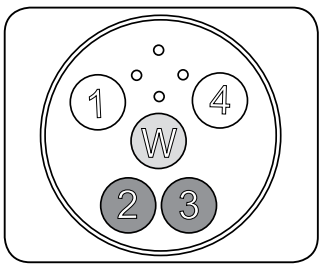
Having the sensor installed towards the middle of an array is optimal. Below are some examples:



EXO2 Optimal Wiped C/T positions: 3 or 4



EXO2 Optimal Wiped C/T positions: 2 or 3



EXO3 Optimal Wiped C/T positions: 2 or 3

NOTICE: When installing a wiped conductivity/temperature sensor in an EXO3 sonde, use ports 2 and 3.

SmartQC for Wiped Conductivity/Temperature Sensors

The SmartQC Score for conductance is based on a gain factor, which is then computed into a cell constant that appears on the calibration worksheet. The gain may drift over time due to aging electrodes or calibration procedures performed on the sensor, and this will ultimately affect the cell constant. An ideal cell constant for the wiped conductivity sensor is 0.469/cm ± 0.05, and the effects of changes in gain will be evident in changes in that value.

Guidance on interpretation of the SmartQC score for this sensor are as follows:

Green: Gain is within acceptable limits. Calibration was performed successfully and resulted in a gain within factory specified limits.

Yellow: The gain has drifted a minor amount from factory specified limits. The sensor is still reporting correctly but adjustments may need to be made. If a user calibration results in a yellow QC Score:

1. First, thoroughly clean the sensor and ensure that all debris is removed from the surfaces of the sensor. Refer to the Sensor Maintenance Section 5.7 of the manual for additional information on how to properly clean the instrument in order to avoid damaging the sensor.
2. Next, perform a Factory Reset Calibration to reset the gain and cell constant to their factory default values.
3. Finally, complete another calibration on the sensor using fresh standard.

If the QC Score remains yellow, the sensor is still able to be used, but the user should monitor this sensor during calibrations, including looking at the cell constant on the calibration worksheets.

Red: The gain has drifted significantly from the factory specified limits. If the QC Score is red, the sensor may not report correct values. If a user calibration results in a red QC Score:

1. Verify that the standard value used during calibration was entered correctly. If the value was not entered correctly, the resulting QC Score would show a red value due to the gain changing significantly.
2. Thoroughly clean the sensor and ensure that all debris is removed from the surfaces of the sensor. Refer to Section 5.7 for additional information on how to properly clean the sensor in order to avoid damaging the sensor.
3. Perform a Factory Reset Calibration.
4. Complete a calibration using fresh standard.

If the QC Score returns to red after these steps, please contact YSI Technical Support for further assistance.

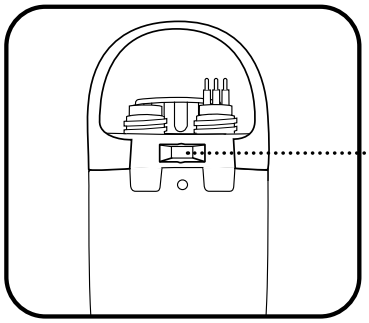
4.9 Depth and Level

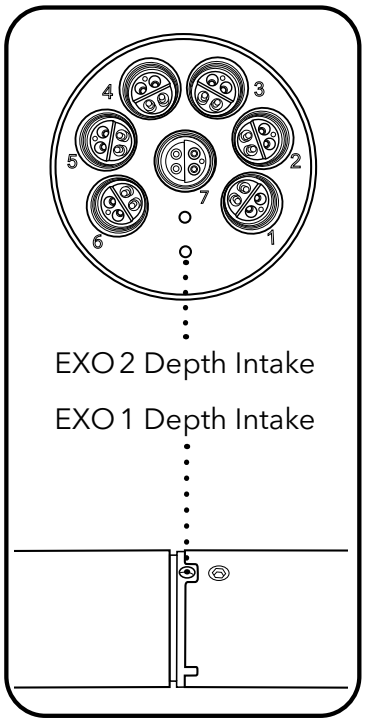
Sensor Overview

EXO measures depth of water with a non-vented strain gauge. (See Section 6 if your sonde is equipped with vented level.) A differential strain gauge transducer measures pressure with one side of the transducer exposed to the water and the other side exposed to a vacuum. We calculate depth from the pressure exerted by the water column minus atmospheric pressure. Factors influencing depth measurement include barometric pressure, water density, and temperature. Calibration in the atmosphere "zeros" the sensor with respect to the local barometric pressure. A change in barometric pressure will result in a zero shift unless the transducer is recalibrated to the new pressure.

EXO sondes have intake openings to allow water to act on the strain gauge. The EXO1 intake is located in the yellow section between the battery compartment and label of the sonde. The EXO2 intake openings are two small holes on the face of the sonde bulkhead.

Location of Depth Sensor





Depth Sensor Location relative to other water quality sensors (see EXO sonde label)

Depth Sensor Location
27.2 cm (EXO1), 13.9 cm (EXO2)
to WQ Sensors

Depth sensors on the EXO2 sondes are not on center. When deploying the sonde *vertically,* take care to ensure the sonde is redeployed in same position. Often a marker pin inside a PVC pipe is used. In *horizontal* deployments, take care to ensure the redeployments are always in the same orientation. This is especially important for the EXO2 sonde because the depth sensor is off-axis.

To assist with consistent horizontal orientation, the EXO2 sonde has an indentation at the top of the sonde for a marker or positioning pin.

The sonde should be installed with at least 1 cm of water above the intake ports. If a conductivity sensor is installed, the depth will be compensated automatically for changes in the density of water as temperature and salinity change.

Depth Configuration

EXO sondes must be ordered with a specific depth sensor option:

59950x-00 = no depth
59950x-01 = 0-10 m depth
59950x-02 = 0-100 m depth
59950x-03 = 0-250 m depth
59950x-04 = 0-10 m vented level

The depth configuration must be chosen at time of ordering. Once a sonde is shipped with a depth configuration it cannot be changed by the user.

Specifications

Units	PSI, Depth (m, ft, bar)
Temperature	
Operating	-5 to +50°C
Storage	-20 to +80°C
Range	*Shallow:* 0 to 33 ft (10 m) *Medium:* 0 to 328 ft (100 m) *Deep:* 0 to 820 ft (250 m) *Vented:* 0 to 33 ft (10 m)
Accuracy	*Shallow:* ±0.04% FS (±0.013 ft or ±0.004 m) *Medium:* ±0.04% FS (±0.13 ft or ±0.04 m) *Deep:* ±0.04% FS (±0.33 ft or ±0.10 m) *Vented:* ±0.03% FS (±0.010 ft or ±0.003 m)
Response	T63<2 sec
Resolution	0.001 ft (0.001 m)
Sensor Type	Stainless steel strain gauge

4.10 Depth and Level Calibration

NOTE: *This calibration option is available only if your sonde is equipped with an integral depth sensor or a vented level sensor.*

For the calibration, make certain that the depth sensor or vented level sensor is in air and not immersed in any solution. Also, review the basic calibration description in Section 4.2.

In the Calibrate menu, select Depth and then select Calibrate.

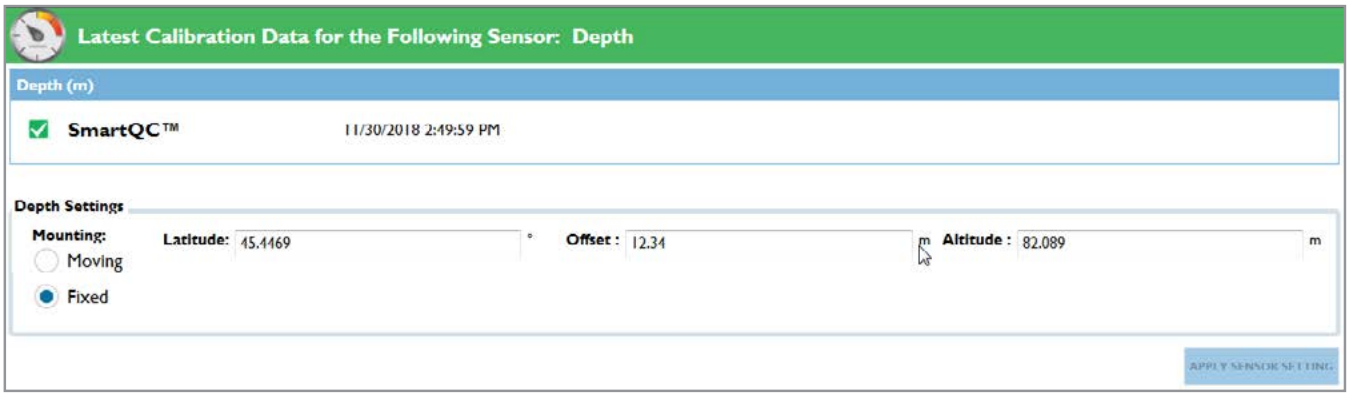
0 is the only acceptable calibration value. An offset may be entered under the Depth sensor settings..

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point. This process zeros the sensor with regard to current barometric pressure.

Click Exit to return to the sensor calibration menu.

For best performance of depth measurements, users should ensure that the orientation of the sonde remains constant while taking readings. This is especially important for vented level measurements. Keep the sonde still and in one position while calibrating.

Advanced



Mounting: Use the Advanced menu to select if a sonde will be mounted in a moving/profiling deployment instead of a fixed location.

Depth Offset: Enter a value in meters (m) to offset the depth at the point of measurement.

Altitude/Latitude: Enter the coordinates for the local altitude (in feet, relative to sea level) and latitude (in degrees) where the sonde is sampling. Latitude values are used in the calculation of depth or level to account for global variations in the gravitational field.

SmartQC for Depth, Non-vented

The SmartQC Score for non-vented depth is based on an expected offset that would be computed by the sensor during calibration.

Green: The offset computed during the calibration is within factory specified limits.

Yellow: The offset computed during the calibration is slightly outside of factory specified limits.

1. If the sensor is being deployed at high altitudes, the computed offset during calibration may be outside of the factory specified limits. The data collected by the depth sensor at higher elevations is not incorrect; simply the offset is outside of normal lower-elevation ranges. At higher elevations, all sensors may experience the yellow QC Score and a green QC score may never be attainable.
2. Ensure that the sensor is free of debris. If there is debris clogging the inlet, use water to clear the inlet. Use care to avoid damaging the thin pressure membrane. Refer to Section 5.5 for additional information on how to properly clean the instrument in order to avoid damaging the sensor.
3. Make sure that the sensor was completely dry before performing the calibration. If needed, use a can of compressed air to dry off the sensor to perform a better calibration. Do NOT stick any tools or utensils inside the pressure sensor vent hole. The sensor membrane is extremely thin and easily punctured.
4. Perform a Factory Reset Calibration to restore the offset to factory calibrated values and then perform another calibration.

If the QC Score is still yellow after performing another calibration, the sensor is still able to be used. The user should continue to monitor the sensor for additional drift away from the factory defaults.

Red: The offset computed during the calibration is significantly outside of factory specified limits.

1. Ensure that the sensor inlet is free of debris. If there is debris clogging the inlet, use water to clear the inlet. Use care to avoid damaging the thin pressure membrane. Refer to Section 5.5 for additional information on how to properly clean the instrument in order to avoid damaging the sensor.
2. Verify that the membrane is not punctured.
3. Perform a Factory Reset Calibration to restore the offset to factory calibrated values and then perform another calibration.

If the QC Score returns to red after the above procedures were performed, please contact YSI Technical Support for further assistance.

SmartQC for Depth, Vented

The SmartQC Score for level is based on an expected offset that would be computed by the sensor during calibration.

Green: The offset computed during the calibration is within factory specified limits.

Yellow: The offset computed during the calibration is slightly outside of factory specified limits.

1. If the sensor is being deployed at high altitudes, the computed offset during calibration may be outside of the factory specified limits. The data collected by the depth sensor at higher elevations is not incorrect; simply the offset is outside of normal lower-elevation ranges. At higher elevations, all sensors may experience the yellow QC Score and a green QC score may never be attainable.
2. Ensure that the sensor is free of debris. If there is debris clogging the inlet, use water to clear the inlet. Use care to avoid damaging the thin pressure membrane. Refer to Section 6.5 for additional information on how to properly clean and care for the instrument.
3. Make sure that the sensor was completely dry before performing the calibration. If needed, use a can of compressed air to dry off the sensor to perform a better calibration. Do NOT stick any tools or utensils inside the pressure sensor vent hole. The sensor membrane is extremely thin and easily punctured.
4. Verify that the vent tube exposed to atmospheric conditions is properly connected to a desiccant canister or connected to a dummy plug to prevent moisture from entering the vent tube. If moisture accumulates in the vent tube, calibrations will not be accurate. Information on how to connect a desiccant container to a vented level sonde can be found in Section 6.3.
5. Perform a Factory Reset Calibration to restore the offset to factory calibrated values and then perform another calibration.

If the QC Score remains yellow after performing another calibration, the sensor is still able to be used. The user should continue to monitor the sensor for additional drift away from the factory defaults.

Red: The offset computed during the calibration is significantly outside of factory specified limits.

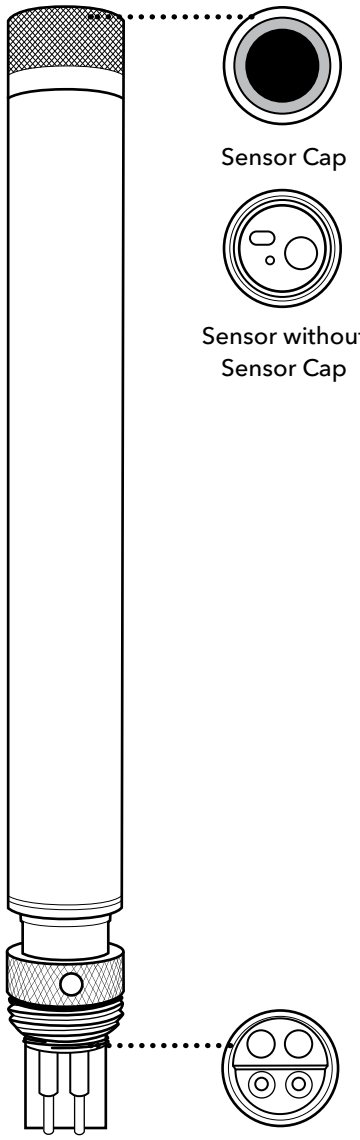
1. Ensure that the sensor inlet is free of debris. If there is debris clogging the inlet, use water to clear the inlet. Use care to avoid damaging the thin pressure membrane. Refer to Section 6.5, for additional information on how to properly clean and care for the instrument.
2. Determine if there is a likelihood that moisture has entered the vent tube. If the desiccant canister is full of water, the vent tube may have significant moisture inside.
3. Verify that the membrane is not punctured.
4. Perform a Factory Reset Calibration to restore the offset to factory calibrated values and then perform another calibration.

If the QC Score returns to red after the above procedures were performed, please contact YSI Technical Support for further assistance.

4.11 Dissolved Oxygen

Sensor Overview

The principle of operation of the EXO optical dissolved oxygen sensor is based on the well-documented concept that dissolved oxygen quenches both the intensity and the lifetime of the luminescence associated with a carefully chosen chemical dye. The EXO DO sensor operates by shining a blue light of the proper wavelength on this luminescent dye which is immobilized in a matrix and formed into a disk. The blue light causes the immobilized dye to luminesce and the lifetime of this dye luminescence is measured via a photodiode in the probe. To increase the accuracy and stability of the technique, the dye is also irradiated with red light during part of the measurement cycle to act as a reference in the determination of the luminescence lifetime.



599100-01;
599110 sensor cap

When there is no oxygen present, the lifetime of the signal is maximal; as oxygen is introduced to the membrane surface of the sensor, the lifetime becomes shorter. Thus, the lifetime of the luminescence is inversely proportional to the amount of oxygen present and the relationship between the oxygen pressure outside the sensor and the lifetime can be quantified by the Stern-Volmer equation: **((Tzero/T) – 1) versus O_2 pressure**

For most lifetime-based optical DO sensors, this Stern-Volmer relationship is not strictly linear (particularly at higher oxygen pressures) and the data must be processed using analysis by polynomial non-linear regression. Fortunately, the non-linearity does not change significantly with time so that, as long as each sensor is characterized with regard to its response to changing oxygen pressure, the curvature in the relationship does not affect the ability of the sensor to accurately measure oxygen for an extended period of time.

(continued)

Specifications

Units	% Saturation, mg/L
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Range	0 to 500% air sat. 0 to 50 mg/L
Accuracy	0-200%: ±1% reading or 1% air sat., whichever is greater; 200-500%: ±5% reading 0-20 mg/L: ±1% of reading or 0.1 mg/L; 20-50 mg/L: ±5% reading
Response	T63<5 sec
Resolution	0.1% air sat. 0.01 mg/L
Sensor Type	Optical, luminescence lifetime

Variables that Affect DO Measurements

Variables that could affect dissolved oxygen measurements include temperature, salinity, and barometric pressure. Temperature and salinity are compensated for during instrument calibration and field use with the use of additional sensors and/or instrument software settings. Barometric pressure relates to the pressure of oxygen in the calibration environment, and barometric pressure changes due to a change in altitude or local weather. Generally the effect of barometric pressure is overcome by proper sensor calibration to a standard pressure. However, if the user measures dissolved oxygen in something besides percent saturation, then the EXO DO sensor can store a local barometric reading put into the KorEXO software (DO % local) or the EXO handheld can take a live barometric reading with its internal barometer (ODO % EU).

ODO % Sat = Raw DO reading corrected with temperature and local barometric pressure at the time of calibration: (local mmHg / 760 mmHg) x 100 = %Sat

ODO % Local = Raw DO reading corrected with temperature and % Sat output fixed to 100% regardless of barometric pressure entry. (The entered local barometric pressure is used by KorEXO software for mg/L calculations.)

ODO % EU = ODO % Sat reading corrected with live barometric reading (available only on EXO Handheld). Fixes the % Sat output to 100%, and conforms to British and EU standards.

4.12 Dissolved Oxygen
Calibration

First review the basic calibration description in Section 4.2.

ODO % sat and ODO % local – 1-point

Place the sonde with sensor into either water-saturated air or air-saturated water:
(a) Water-saturated air: Ensure there are no water droplets on the DO sensor or the thermistor. Place into a calibration cup containing about 1/8 inch of water that is vented by loosening the threads. (Do not seal the cup to the sonde.) Wait 10-15 minutes before proceeding to allow the temperature and oxygen pressure to equilibrate. Keep out of direct sunlight.
(b) Air-saturated water: Place into a container of water which has been continuously sparged with an aquarium pump and air stone for one hour. Wait approximately 5 minutes before proceeding to allow the temperature and oxygen pressure to equilibrate.

In the Calibrate menu, select ODO, then select ODO % sat or ODO % local. Calibrating in ODO % sat automatically calibrates ODO mg/L and ODO % local and vice versa.

Enter the current barometric pressure in mm of Hg (Inches of Hg x 25.4 = mm Hg).

NOTE: *Laboratory barometer readings are usually "true" (uncorrected) values of air pressure and can be used "as is" for oxygen calibration. Weather service readings are usually not "true", i.e., they are corrected to sea level, and therefore cannot be used until they are "uncorrected".* An approximate formula for this "uncorrection" (where the BP readings MUST be in mm Hg) is:
True BP = [Corrected BP] – [2.5 * (Local Altitude in ft above sea level/100)]

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu.

mg/L – 1-point

Place the sonde with sensor in a container which contains a known concentration of dissolved oxygen in mg/L and that is within ±10% of air saturation as determined by one of the following methods:

- Winkler titration
- Aerating the solution and assuming that it is saturated
- Measurement with another instrument

NOTE: *Carrying out DO mg/L calibrations at values outside the range of ±10 % of air saturation is likely to compromise the accuracy specification of the EXO sensor. For highest accuracy, calibrate in % saturation.*

In the Calibrate menu, select ODO, then select ODO mg/L. Calibrating in ODO mg/L automatically calibrates ODO % sat and vice versa.

Enter the known mg/L concentration for the standard value. Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point. Click Complete.

Rinse the sonde and sensor(s) in tap or purified water and dry.

ODO % sat, ODO % local or mg/L – 2-point (or zero point)

Normally it is not necessary to perform a 2-point calibration for the DO sensor, and the procedure is not recommended unless (a) you are certain that the sensor does not meet your accuracy requirements at low DO levels and (b) you are operating under conditions where you are certain to be able to generate a medium which is truly oxygen-free.

For ODO % sat or ODO % local, calibrate your sonde at zero oxygen and in water-saturated air or air-saturated water. For ODO mg/L, calibrate your sonde at zero oxygen and a known concentration of oxygen within ±10% of air-saturation. The key to performing a 2-point calibration is to make certain that your zero-oxygen medium is truly oxygen-free:

- If you use nitrogen gas for the zero-point calibration, make certain that the vessel you use has a small exit port to prevent back diffusion of air and that you have completely purged the vessel before confirming the calibration.
- If you use sodium sulfite solution for the zero-point calibration, prepare the solution at a concentration of approximately 2 g/L at least two hours prior to use and keep it sealed in a bottle which does not allow diffusion of oxygen through the sides of the container. Transfer the sodium sulfite solution rapidly from its container to the calibration cup, fill the cup as full as possible with solution to minimize head space, and seal the cup to the sonde to prevent diffusion of air into the vessel.

Place the sonde with DO and temperature sensors in the zero-oxygen medium.

In the Calibrate menu, select ODO, then select either ODO % sat, ODO % local or ODO mg/L.

Select Zero from the Standard Value drop-down window.

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point.

- If you used sodium sulfite solution as your zero calibration medium, you must thoroughly remove all traces of the reagent from the probes and wiper prior to proceeding to the second point. We recommend that the second calibration point be in air-saturated water if you use sodium sulfite solution.

Next place the sensors in the medium containing a known oxygen pressure or concentration and wait at least 10 minutes for temperature equilibration. Click Add Another Cal Point. Then enter either the barometer reading in mm Hg (for ODO %) or the actual concentration of oxygen as determined from a Winkler titration (for ODO mg/L), for instance. Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu.

NOTE: *Carrying out DO mg/L calibrations at values outside the range of ±10 % of air saturation is likely to compromise the accuracy specification of the EXO sensor. For highest accuracy, calibrate in % saturation.*

Rinse the sonde and sensor(s) in tap or purified water and dry.

SmartQC for Optical Dissolved Oxygen Sensors

Dissolved Oxygen (DO) calculations are derived from polynomial equations based on the K1-K7 coefficients that are provided with each new Dissolved Oxygen sensor cap. Each sensor has been thoroughly tested during the production process to generate these unique calibration coefficients. Calibration of the probe essentially changes these coefficients. The DO SmartQC score is based on a gain factor, which relates to the magnitude of coefficient change. The gain may drift as the sensor gets older and the optics begin to fade and may also be affected by the degradation of or damage to the unique material that is on the face of the sensor. If a zero-DO calibration is performed, SmartQC also calculates a zero-DO coefficient change.

Green: Gain is within acceptable limits. Calibration was performed successfully and resulted in a gain within factory specified limit.

Yellow: The gain or zero-DO calibration coefficient has drifted a minor amount from the factory specified limits. The sensor is still reporting correctly but adjustments may need to be made. If a user calibration results in a yellow QC Score:

1. Thoroughly clean the sensor and ensure that all debris is removed from the surfaces of the sensor. Refer to the Section 5.9 of the manual for additional information on how to properly clean the instrument in order to avoid damaging the sensor.
2. Ensure that proper calibration procedures were followed. Typical errors include not allowing enough time for the calibration chamber to come to equilibrium with the atmosphere or the chamber was not of adequate humidity. Time to equilibrate to an air-saturated water chamber may also not have been adequate. It is recommended to allow between 10-15 minutes for equilibration.
3. Check the lens cap for scratches. If there are scratches, the resulting gain after calibration may change because the amount of membrane remaining on the lens cap has changed.
4. If a new lens cap was installed,
   a. ensure that the new calibration coefficients were entered into the sensor using either the handheld or KorEXO software. The software will calibrate the sensor and also compute the QC Score based on the old lens cap coefficients if the values are not changed after installation of the new lens cap.
   b. perform a Factory Reset Calibration before performing a calibration to revert the gain and zero-DO coefficient back to factory defaults and
5. If a zero-DO calibration resulted in a yellow QC Score, it is recommended to create a new zero-DO solution. Depending upon the method used (sparging with nitrogen or sodium sulfite), either ensure that the proper amount of sodium sulfite is fully mixed into the water, or ensure that the gas purge chamber has an adequate amount of time to purge all oxygen from the water.
6. Sometimes low-quality nitrogen tanks are contaminated with trace amounts of oxygen—check the certificate with your nitrogen source to assure its purity.

If the QC Score returns to yellow, the sensor is still able to be used but the user should monitor this sensor during calibrations for any further drift.

Red: The gain or zero-DO calibration coefficient has drifted significantly from the factory specified limits. If the QC Score is red, the sensor may not report correct values. If a user calibration results in a red QC Score:

1. Throroughly clean the sensor and ensure that all debris is removed from the surfaces of the sensor. Occasionally, thin films from sediment may affix to the lens cap surface and will affect readings and calibrations. Refer to the Section 5.9 of the manual for additional information on how to properly clean in order to avoid damaging the sensor cap.
2. Ensure that proper calibration procedures were followed. Gross errors can cause the gain to change significantly from factory default values. Errors in calibration include sealing the calibration cup to the sonde completely, allowing the calibration setup to equilibrate in the sun, or not properly saturating the air environment with water.
3. Inspect the lens caps for coating loss on the sensor window. If the sensor cap has excessive coating loss to the point that calibration is being affected, replace the sensor lens cap. Re-enter the calibration coefficients, execute a Factory Reset Calibration and perform a calibration on the newly installed sensor lens cap.
4. Verify that proper calibration coefficients were entered if the sensor lens cap was replaced.
5. If a zero-DO calibration was performed, perform a Factory Reset Calibration and redo the 2-point calibration procedure. Allow for ample time for the sensor to equilibrate to both zero and 100% saturation values.

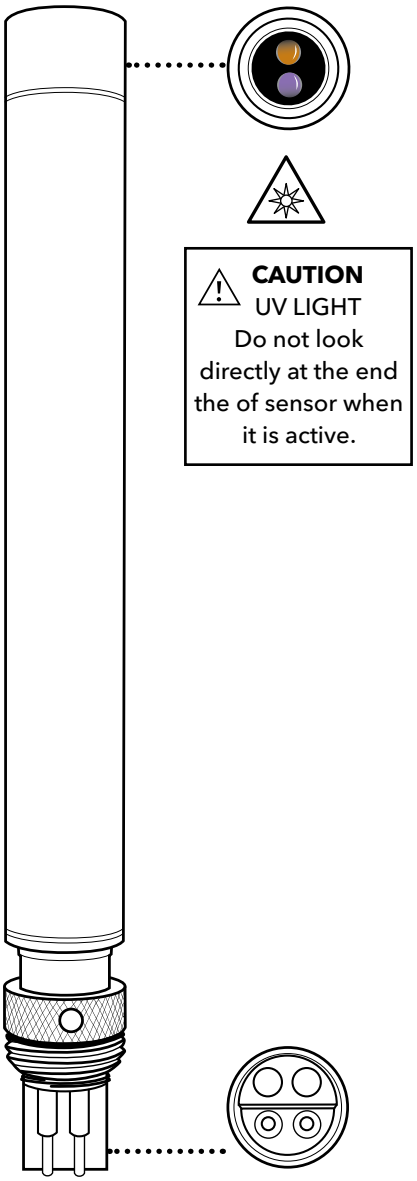
If the QC Score returns to red after the above steps were attempted, please contact YSI Technical Support for further assistance.

4.13 fDOM
Sensor Overview

The EXO fDOM (Fluorescent Dissolved Organic Matter) sensor detects the fluorescent component of DOM (Dissolved Organic Matter) when exposed to near-ultraviolet (UV) light.

Colored Dissolved Organic Matter

Users might wish to quantify *colored* dissolved organic matter (CDOM) in order to determine the amount of light which is absorbed by stained water and thus is not available for photosynthesis. In most cases, fDOM can be used as a surrogate for CDOM.



599104-01

Quinine Sulfate

A surrogate for fDOM is quinine sulfate, which, in acid solution, fluoresces similarly to dissolved organic matter. The units of fDOM are quinine sulfate units (QSUs) where 1 QSU = 1 ppb quinine sulfate and thus quinine sulfate is really an indirect surrogate for the desired CDOM parameter.

The EXO fDOM sensor shows virtually perfect linearity (R^2=1.0000) on serial dilution of a colorless solution of quinine sulfate. However, on serial dilution of stained water field samples, the sensor shows some underlinearity. The point of underlinearity in field samples varies and is affected by the UV absorbance of the DOM in the water. Testing shows that underlinearity can occur at fDOM concentrations as low as 50 QSU. This factor means that a field sample with an fDOM reading of 140 QSU will contain significantly more than double the fDOM of a sample that reads 70 QSU. This effect—good linearity in colorless quinine sulfate solution, but underlinearity in stained field samples—is also exhibited by other commercially available fDOM sensors and thus the performance of the EXO sensor is likely to be equivalent or better than the competition while providing the advantages of easy integration into a multiparameter package and automatic mechanical cleaning when used in monitoring studies with an EXO2 sonde.

Specifications

Units	Quinine Sulfate Units (QSU), ppb
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Range	0 to 300 ppb QSU
Response	T63<2 sec
Resolution	0.01 ppb QSU
Sensor Type	Optical, fluorescence
Linearity	R^2>0.999 for serial dilution of 300 ppb Quinine Sulfate solution
Detection Limit	0.07 ppb QSU
Optics: Excitation	365±5 nm
Emission	480±40 nm

4.14 fDOM Calibration Standards

Quinine Sulfate Solution for fDOM Sensor

⚠ **WARNING:** Before using a quinine sulfate reagent (solid or solution) or sulfuric acid reagent, read the safety instructions provided by the supplier. Take extra precautions when making dilutions of concentrated sulfuric acid, as this reagent is particularly dangerous. Remember that only trained personnel should handle chemicals.

Preparation

Use the following procedure to prepare a 300 µg/L solution of quinine sulfate (300 QSU) that can be used to calibrate the EXO fDOM sensor for field use:

1. Purchase solid quinine sulfate dihydrate (CAS# 6119-70-6) with a high purity (>99%).
2. Purchase 0.1 N (0.05 M) sulfuric acid (CAS# 7664-93-3), to avoid the hazards of diluting concentrated sulfuric acid to make this reagent.
3. Weigh 0.100 g of solid quinine sulfate dihydrate and quantitatively transfer the solid to a 100-mL volumetric flask. Dissolve the solid in about 50 mL of 0.05 M (0.1 N) sulfuric acid (H_2SO_4), dilute the solution to the mark of the volumetric flask with additional 0.05 M sulfuric acid, and mix well by repeated inversion. This solution is 1000 ppm in quinine sulfate (0.1%).
4. Transfer 0.3 mL of the 1000 ppm solution to a 1000 mL volumetric and then fill the flask to the top graduation with 0.05 M sulfuric acid. Mix well to obtain a solution of 300 µg/L (300 QSU or 100 RFU).
5. Store the concentrated standard solution in a darkened glass bottle in a refrigerator to retard decomposition. The dilute standard prepared in the previous step should be used within 5 days of preparation and should be discarded immediately after exposure to EXO's metal components.

Degradation of quinine fluorescence by copper and chloride

NOTICE: Exposure of the quinine sulfate solution to any copper-based component of the EXO sonde and sensors (primarily the wiper assembly) will begin to degrade the solution significantly within minutes. Quinine fluorescence is also degraded by the presence of chloride or halide ions, found in estuarine or seawater, conductivity standards, and Zobell solution. Thus, clean your sensors thoroughly and perform your calibration as quickly as possible on immersion of the sensors into the quinine sulfate solution. Discard the used standard. When quinine sulfate standards are required in the future, perform another dilution of the concentrated solution.

Effect of temperature on fluorescence

The intensity of the fluorescence of many dyes shows an inverse relationship with temperature. This effect must be accounted for when calibrating the EXO fDOM sensor with quinine sulfate solution. Enter the QSU or RFU value from the table below that corresponds to the temperature of the standard.

Temp (˚C)	RFU	QSU	Temp (˚C)	RFU	QSU
30	96.4	289.2	18	101.8	305.4
28	97.3	291.9	16	102.7	308.1
26	98.2	294.6	14	103.6	310.8
24	99.1	297.3	12	104.6	313.8
22	100	300	10	105.5	316.5
20	100.9	302.7	8	106.4	319.2

4.15 fDOM Calibration

Review the basic calibration description in Section 4.2.
Before calibrating, be certain that the sensing window is clean (cleaning instructions, Section 5.6).

This procedure calibrates fDOM RFU or fDOM QSU/ppb. If the user has both units selected, then this procedure must be performed twice, once for each unit, to completely calibrate the parameter.

For 2-point calibrations, the first standard must be clear water (0 µg/L). The second standard should be a 300 µg/L quinine sulfate solution. For detailed instructions for mixing this solution, see Section 4.14.

> **NOTICE:** Do not leave sensors in quinine sulfate solution for a long time. A chemical reaction occurs with the copper on the sonde (wiper assembly, sonde bulkhead, copper tape) that degrades the solution and causes it to drift. Also, start with very clean sensors, as the presence of chloride and halide ions (from estuarine or seawater, conductivity standards, and Zobell solution) can compromise QS fluorescence.

QSU – 1- or 2-point

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water.

In the Calibrate menu, select fDOM, then select QSU/ppb. Select either a 1- or 2-point calibration. Enter 0 for first standard value and 300 µg/L for second standard value.

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point.

Remove the central wiper from the EXO2 sonde before proceeding to the next step.

Next place the sensors in the correct amount of 300 µg/L quinine sulfate standard in the calibration cup. Click Add Another Cal Point in the software. Observe the Pre Calibration Value readings and the Data Stability. While stabilizing, verify that no air bubbles reside on the sensing face of the sensor. If there are bubbles, gently shake or move the sensor to dislodge. When data are Stable, click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

RFU – 1- or 2-point

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water.

In the Calibrate menu, select fDOM, then select RFU. Select either a 1- or 2-point calibration. Enter 0 for first standard value and 100 RFU for second standard value.

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, and when they are Stable, click Apply to accept this calibration point.

Remove the central wiper from the EXO2 sonde before proceeding to the next step.

Next place the sensors in the 300 µg/L quinine sulfate standard in the calibration cup. Click Add Another Cal Point in the software. Observe the Pre Calibration Value readings and the Data Stability. While stabilizing, verify that no air bubbles reside on the sensing face of the sensor. If there are bubbles, gently shake or move the sensor to dislodge. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu. Rinse the sonde in tap or purified water and dry the sonde. Discard the used standard.

SmartQC for fDOM Sensors (RFU or QSU)

The SmartQC Score for fDOM is based on a gain factor and an offset factor. Both of these values may change as the sensor and the optics age.

Green: Gain and offset are within acceptable limits. Calibration was performed successfully and results are within factory specified limits.

Yellow: The sensor gain or offset is slightly outside of calibration limits.

1. Perform a Factory Reset Calibration and complete a recalibration.
    a. If performing a 1-point calibration, use fresh, clear water.
    b. If performing a 2-point calibration, use fresh, clear water and freshly made quinine sulfate solution.
2. Ensure that the standard value was entered correctly. Calibration of fDOM is temperature-dependent; make sure the appropriate value from the table in Section 4.14 was entered during calibration for either RFU or QSU.
3. Ensure that the sensor is free of contamination. Refer to Section 5.6 for additional information on how to properly clean the sensor in order to avoid damage.

If the QC Score returns to yellow, the sensor is still able to be used, but the user should monitor this sensor during calibrations for any further drift.

Red: The sensor gain or offset are significantly outside of factory specified limits. Follow the same three steps described above for a Yellow QC Score.

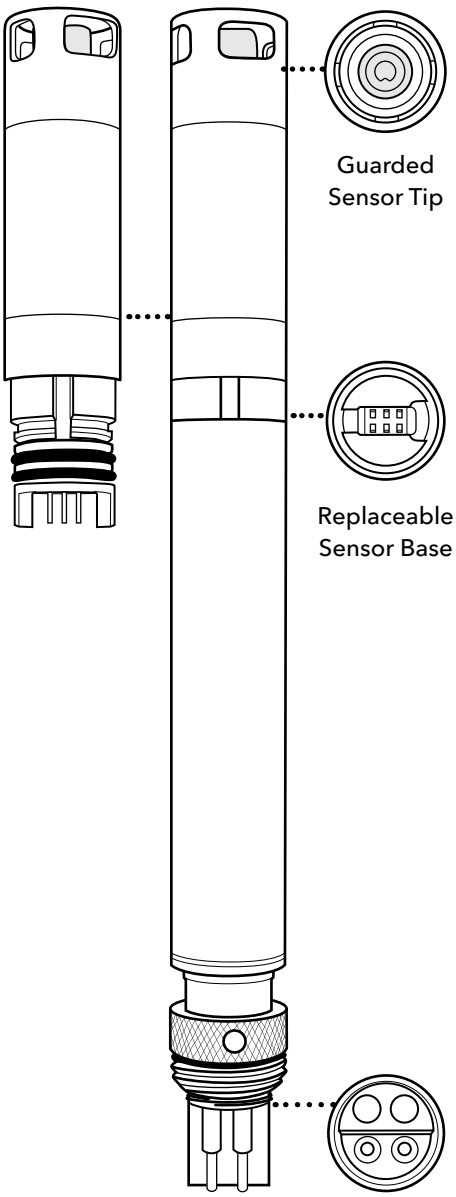
If the QC Score remains red, please contact YSI Technical Support for further assistance.

4.16 ISEs: Ammonium, Nitrate, & Chloride
Sensors Overview

NOTE: *Ammonium, nitrate, and chloride ion-selective electrodes (ISEs) should be used in freshwater applications only at depths of less than 55 feet (17 meters) and less than 25 psi.*

The ammonium and nitrate sensors use a silver/silver chloride wire electrode in a custom filling solution. The internal solution is separated from the sample medium by a polymer membrane, which selectively interacts with ammonium or nitrate ions. When the sensor is immersed in water, a potential is established across the membrane that depends on the relative amounts of ions in the sample and the internal solution. This potential is read relative to the Ag/AgCl reference electrode.

(continued)



599709, 599710, 599711;
599743-01, 599744-01, 599745-01 modules

Specifications

Ammonium - NH_4

Units	mg/L-N, millivolts
Temperature *Operating* *Storage*	 0 to 30˚C 0 to 30°C
Depth	0 to <55 ft (0 to <17 m)
Range	0 to 200 mg/L-N
Accuracy	±10% of reading or ±2 mg/L-N, whichever is greater
Response	T63<30 sec
Resolution	0.01 mg/L
Sensor Type	Ion-selective electrode
Conductivity	<1500 µS/cm

Nitrate - NO_3

Units	mg/L-N, millivolts
Temperature *Operating* *Storage*	 0 to 30˚C 0 to 30°C
Depth	0 to <55 ft (0 to <17 m)
Range	0 to 200 mg/L-N
Accuracy	±10% of reading or ±2 mg/L-N, whichever is greater
Response	T63<30 sec
Resolution	0.01 mg/L
Sensor Type	Ion-selective electrode
Conductivity	<1500 µS/cm

(Specs. continued)

Specifications *(continued)*

Chloride - Cl

Units	mg/L-Cl, millivolts
Temperature *Operating* *Storage*	 0 to 30˚C 0 to 30°C
Depth	0 to <55 ft (0 to <17 m)
Range	0 to 18000 mg/L-Cl
Accuracy	±15% of reading or ±5 mg/L-Cl, whichever is greater
Response	T63<30 sec
Resolution	0.01 mg/L
Sensor Type	Ion-selective electrode
Salinity	30 psu

NOTE: *Qualification testing for chloride was performed in a stirred calibration solution. Due to the solid state nature of the chloride ISE, the sensor exhibits moderate flow dependence. Mitigation can be achieved by stirring during calibration.*

The chloride sensor uses a solid-state membrane attached to a conductive wire. This sensor operates in a similar fashion to the ammonium and nitrate sensors.

For all ISEs, the linear relationship between the logarithm of the ammonium, nitrate or chloride activity and the observed voltage, as predicted by the Nernst equation, is the basis for the determination.

Ammonium is calculated from the pH, salinity, and temperature readings. If a pH sensor is not in use, the instrument will assume the sample is neutral (pH 7) for the calculation. If a conductivity sensor (salinity) is not in use, the instrument will use the salinity correction value entered in the ammonium sensor calibration screen for the calculation.

Replaceable Sensor Module

The EXO ammonium, chloride, and nitrate sensors have a unique design that incorporates a user-replaceable sensor tip (module) and a reusable sensor base that houses the processing electronics, memory, and wet-mate connector. This allows users to reduce the costs associated with these sensors by only replacing the relatively inexpensive module periodically and not the more costly base.

The connection of the module to the sensor base is designed for one connection only and the procedure must be conducted in an indoor and dry environment. Once installed the module cannot be removed until you are prepared to replace it with a new module.
See Section 5.14 for detailed instructions.

The typical life expectancy of an ISE sensor is three to six months, depending on use.

Precautions

- ISEs are intended for sampling purposes and **must** be calibrated frequently due to sensor drift.
- ISEs can be used in long-term deployments for qualitative trends. Use with an EXO wiper will deform the brush over time and may require more frequent brush replacement. The brush deformation may intensify with the fouling present in the monitored environment.
- ISE sensors only come in guarded configurations. Customers should not remove the plastic guard that protects the ISE membrane.
- For long-term deployments, sensor data should be compared to that of grab samples throughout the monitoring period to note drift.

For a full list of precautions see the end of Section 4.17.

4.17 ISEs: Ammonium, Nitrate, & Chloride
Calibration

This procedure calibrates the EXO ammonium, chloride, or nitrate sensor. The sensors can be calibrated to one, two or three points. The 3-point calibration method assures maximum accuracy when the temperature of the media to be monitored cannot be anticipated; we strongly recommend a 3-point calibration for best performance of ISE sensors. Review the basic calibration description in Section 4.2.

The temperature response of ion-selective electrodes is not as predictable as that of pH sensors. Therefore, be sure to carry out a 3-point calibration the first time you use the sensor. This will provide a default setting for the effect of temperature on your sensor. After this initial calibration, you can use the less time-consuming 2-point and 1-point routines to update the 3-point calibration. However, we strongly recommend a new 3-point calibration after each deployment of 30 days or longer.

Due to the nature of ion-selective electrodes, it is recommended that they be used for sampling purposes for the greatest accuracy. Using an ISE in long-term deployments is possible, but it's important to note that drift occurs over an extended period of time. Collecting grab samples from the site is encouraged to correct for drift. Additionally, sample readings should be taken after sensors have fully stabilized. Calibrating in a continuously stirred solution from 1 to 5 minutes has shown to improve sensor performance. For best performance sensors should be calibrated as close to the expected field conditions as possible.

For more ISE precautions, drift, and accuracy notes please see ISE Precautions at the end of this section.

Calibration Options (Ammonium Example)

1-point

Perform the 1-point option only if you are adjusting a previous calibration. If a 2-point or 3-point calibration has been performed previously, you can adjust the calibration by carrying out a 1-point calibration.

2-point

Perform the 2-point option to calibrate the ammonium sensor using only two calibration standard solutions. In this procedure, the ammonium sensor is calibrated using a 1 mg/L NH_4^+ -N and 100 mg/L NH_4^+ -N calibration standard solutions. A 2-point calibration procedure (as opposed to a 3-point procedure) can save time if the temperature range of the media being monitored is known and stable.

3-point

Perform the 3-point option to calibrate the ammonium sensor using three calibration standard solutions, two at ambient temperature and one at a temperature substantially different from ambient. The 3-point calibration method should be used to assure maximum accuracy when the temperature of the media to be monitored cannot be anticipated. 3-point calibration temperatures should span the range of interest, for example 20°C and 2°C for "cold" and 20°C and 30°C for "hot". The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to place the sensor in the additional calibration standard solution to complete the 3-point procedure. Be certain that the calibration standard solution and sensor are thermally equilibrated prior to proceeding with the calibration. The recommended order of calibration standards is (1) 1 mg/L NH_4^+ -N standard at ambient temperature, (2) 100 mg/L NH_4^+ -N standard at ambient temperature, and (3) 1 mg/L NH_4^+ -N standard at a different temperature (usually lower) than ambient, ±10°C minimum.

- To save time during calibration, chill/heat a sufficient amount of 1 mg/L NH_4^+ -N calibration standard solution prior to the start of calibration.

Ammonium Pre-calibration

Soaking

EXO Ammonium Sensors are shipped in a container that holds a sponge soaked in 100 mg/L ammonium standard solution. Before initial use the sensor membrane needs to be soaked in 100 mg/L ammonium standard solution (YSI part #003843). Most users find it useful to soak the sensors overnight; shorter soaking times may be used if the sensor output is monitored and is fully stabilized.

In addition to initially soaking the sensor, users may also see improved performance if the ammonium sensor is soaked in 100 mg/L solution after field deployments. This process helps remove any interfering ions from the sensor membrane.

After the activation process the sensor should be rinsed thoroughly and the following calibration precautions should be observed.

The ammonium sensor should be calibrated using solutions of known total ammonium-nitrogen content or YSI Standards.

part #003841	1 mg/L
part #003842	10 mg/L
part #003843	100 mg/L

If a two point calibration protocol is used, the temperature of the standards should be as close as possible to that of the environmental medium to be monitored. The recommended calibration procedure is one involving three solutions. Two of the solutions should be at ambient temperature while the third should be at least 10˚C different from ambient temperature. This protocol minimizes the effects of taking readings at temperatures that are significantly different from ambient laboratory temperatures.

Calibration Tip

Exposure to the high ionic content of pH buffers can cause a significant, but temporary, drift in the Ammonium, Nitrate, and Chloride sensors. Therefore, when calibrating the pH/ORP probe, YSI recommends that you use one of the following methods to minimize errors in the subsequent readings:

1. Calibrate pH first, immersing all of the probes in the pH buffers. After calibrating pH, place the probes in 100 mg/L nitrate or ammonium standard or 1000 mg/L chloride standard and monitor the reading. Usually, the reading starts low and may take as long as 30 minutes to reach a stable value. When it does, proceed with calibration of the ISE sensor.

2. When calibrating pH, remove ISE modules from the sonde bulkhead and plug the ports. After pH calibration is complete, replace the ISE sensors and proceed with their calibration with no stabilization delay.

Despite the potential problems with interference when using ISEs, it is important to remember that almost all interfering species produce an artificially high ammonium reading. Thus, if the sonde indicates the presence of only small quantities of ammonium, it is unlikely that the reading is erroneously low because of interference. Unusually high ammonium readings (which could be due to interfering ions) should be confirmed by laboratory analysis after collection of water samples.

Ammonium 3-point

NOTICE: Do not expose electrodes to high-conductivity solutions. Exposure will reduce data quality and response of the sensors. During calibration of other sensors, remove the ISEs to avoid exposing them to conductivity standards, Zobell solution, pH buffer, or any solution with significant conductivity.

In the Calibrate menu, select Ammonium, then select Calibrate.

Pour a sufficient amount of 1 mg/L NH_4^+ -N calibration standard solution at ambient temperature in a clean and dry or pre-rinsed calibration cup. Carefully immerse the sensor end of the sonde into the solution, making sure the sensor's tip is in solution by at least 1 cm. Allow at least 1 minute for temperature equilibration before proceeding.

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point.

Rinse the sensors in deionized water between changes of the calibration solutions. Pour a sufficient amount of 100 mg/L of NH_4^+ -N calibration standard solution at ambient temperature into a clean, dry or pre-rinsed calibration cup and carefully immerse the sensor end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Click Add Another Cal Point in the software. Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point.

Rinse the sensors in deionized water between changes of the calibration solutions. Immerse the sensor end of the sonde in the pre-chilled 1 mg/L NH_4^+ -N calibration standard solution ensuring that the temperature is at least 10°C different than ambient. Allow at least 1 minute for temperature equilibration before proceeding.

Click Add Another Cal Point in the software. Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu

Rinse the sonde in tap or purified water.

Nitrate 3-point

The calibration procedure for nitrate is identical to the procedure for ammonium, except that the calibration standard solution values are in mg/L NO_3^- -N instead of NH4+ -N.

Chloride 3-point

The calibration procedure for chloride is identical to the procedure for ammonium and nitrate, except that the calibration standard solution values are in mg/L Cl^- instead of NH_4^+ -N or NO_3^- -N. YSI recommends that the user employ standards for chloride that are 10 times greater than for ammonium and nitrate and that span the expected deployment conditions. Typical calibration ranges are 10mg/L Cl^- and 1000mg/L Cl^- or 1000mg/L Cl^- and 18000mg/L Cl^-.

Chloride Standard for Chloride Sensor

⚠ **WARNING:** Read and follow all the safety instructions and MSDS documentation supplied with the chemical before proceeding. Remember that only trained personnel should handle hazardous chemicals.

Preparation

Use the following procedure to prepare 10 and 1000 mg/L chloride reagents for the EXO Chloride sensor. (Nitrate and Ammonium standards can be purchased from YSI or other laboratory supply companies.)

10 mg/L Standard

1. Accurately measure 10 mL of the above 1000 mg/L standard solution into a 1000 mL volumetric flask.
2. Add 0.5 grams of anhydrous magnesium sulfate to the flask.
3. Add 500 mL of water, swirl to dissolve the solid reagents, and then dilute to the volumetric mark with water. Mix well by repeated inversion and then transfer the 10 mg/L standard to a storage bottle.
4. Rinse the flask extensively with water prior to its use in the preparation of the 1000 mg/L standard.

1000 mg/L Standard

1. Purchase solid sodium chloride from a supplier.
2. Accurately weigh 1.655 grams of anhydrous sodium chloride and transfer into a 1000 mL volumetric flask.
3. Add 0.5 grams of anhydrous magnesium sulfate to the flask.
4. Add 500 mL of water to the flask, swirl to dissolve all of the reagents. Dilute to the volumetric mark with water. Mix well by repeated inversion and then transfer the 1000 mg/L standard to a storage bottle.

   Alternatively, simply add 0.5 grams of magnesium sulfate to a liter of a 1000 mg/L chloride standard from a certified supplier.

Sensor Drift

The ion-selective electrodes have the greatest tendency to exhibit calibration drift over time. This drift should not be a major issue for sampling studies where the instrument can be frequently calibrated. However, if the sensor is used in longer-term deployments, drift is almost certain to occur. The extent of the drift will vary depending on the age of the probe, the flow rate at the site, and the quality of the water. For all monitoring studies using ion-selective electrodes, the user should acquire a few grab samples during the deployment for analysis in the laboratory or with another sensor that has been recently calibrated.

Sensor Accuracy Specifications

The typical accuracy specification for the sensors (+/-10% of reading or 2 mg/L which ever is greater for ammonium and nitrate and ±15% of reading or 5 mg/L which ever is greater for chloride) refer to sampling applications where only minimal time has elapsed between calibration and field use.

To maintain accuracy specifications for EXO sensor, we recommend that users calibrate sensors in the lab in standards with temperatures as close to the ambient temperature of the field water as possible.

All ion-selective electrodes are subject to the interaction of species with the sensor membrane, which are similar in nature to the analyte. These interfering species thus include other halide ions (fluoride, bromide, and iodide) as well as other anions.

Despite the potential problems with interference when using ISEs, it is important to remember that almost all interfering species produce an artificially high reading. Thus, if the sensor indicates the presence of only small quantities, it is unlikely that the reading is erroneously low because of interference. Unusually high readings (which could be due to interfering ions) should be confirmed by laboratory analysis after collection of water samples.

ISE Precautions

Ion-selective electrodes may not stabilize as rapidly as pH sensors. Be sure to allow plenty of time for the readings to come to their final values during all calibration routines.

Ion-selective electrodes generally drift more than pH sensors. To check for this drift, read the sensor's value in a calibration standard solution at the end of each deployment.

Ammonium and nitrate standards are good growth media for a variety of microorganisms. This growth can significantly reduce the nitrogen content of your standards, an effect that is particularly important for the 1 mg/L solution. It is best to use new standards for each calibration, but if you decide to save your solutions for reuse, we recommend refrigerated storage to minimize the growth of these organisms.

Remember that the ammonium, nitrate, and chloride sensors will take longer to stabilize after exposure to high conductivity solutions such as a pH buffer. To accelerate the recovery process, soak the sensor in 100 mg/L ammonium or nitrate standard solution or 1000 mg/L Cl- standard solution for a few minutes after exposure. In addition, be particularly careful that readings are stable during subsequent calibrations.

Of all the sensors available on the sonde, ion selective electrodes have the greatest tendency to exhibit calibration drift over time. This drift should not be a major problem for sampling studies where the instrument can be frequently calibrated. However, if an ammonium sensor is used in a longer-term deployment study with the sonde, the user should be aware that drift is almost certain to occur. The extent of the drift will vary depending on the age of the probe, the flow rate at the site, and the quality of the water. For all monitoring studies using ion selective electrodes, the user should acquire a few "grab samples" during the course of the deployment for analysis in the laboratory by chemical means or with another ammonium sensor which has been recently calibrated. Remember that the typical accuracy specification for the sensor (+/- 10 % of the reading or 2 mg/L, whichever is larger) refers to sampling applications where only minimal time has elapsed between calibration and field use.

Many users find it useful to swap ISEs after 30 days of deployment with freshly calibrated sensors. On the EXO platform the calibration is retained inside the sensor, so they can be calibrated in the lab and installed in the field.

SmartQC for ISE Sensors

ISE sensor algorithms are derived from three independent coefficients (called J, S, and A) as well as mV, temperature and salinity. J, S, and A are the calibrated coefficients and S specifically is concentration of the analyte being detected by the sensor. S is the coefficient whose gain factor is the basis of SmartQC for these sensors.

Green: Gain and offset are within acceptable limits. Calibration was performed successfully and results are within factory specified limits.

Yellow: The S gain is slightly outside of calibration limits.

1. Perform a Factory Reset Calibration and re-do the calibration.
2. If the sensor had not been properly stored it may be necessary to rehydrate the reference junction, as described in Section 5.13.
3. Pre-calibration soaking is advisable for ISEs, especially if a non-green SmartQC score occurs. Pre-soak in the appropriate calibration solution and attempt again to recalibrate.
4. During calibration, ensure that the standard solutions were thermally equilibrated, meaning that the temperature was stable and not changing during calibration. Sometimes putting the solutions in a water bath can help ensure this.
5. Ensure that the standard value was entered correctly.
6. It is imperative that the sensors, calibration cup, and sonde guard are all very clean when calibrating.
7. Since these modules have a relatively short lifespan, a prior user may have entered an expiration date into the software for when the sensor should be replaced. Check to see if that date is near.
8. Ensure that the sensor is free of debris. Refer to Section 5.13 for additional information on how to properly clean the sensor in order to avoid damage.

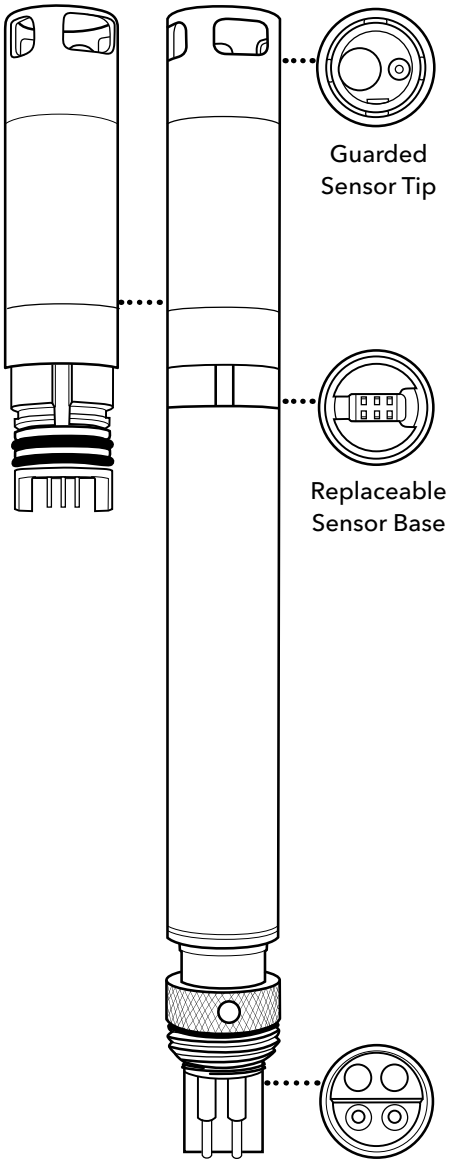
If the QC Score remains yellow, the sensor is still able to be used, but ISE's are the one case where a yellow-scored sensor should not be used for a continuous deployment, because the period of time before it would become red is probably short. It can be used for spot sampling, and should be recalibrated before each day's use.

Red: The S gain is significantly outside of factory specified limits. Follow the same steps described above for a Yellow QC Score. If the QC Score remains red, it is likely time to replace the sensor module. If replacement of the module does not return the sensor to a Green QC score, please contact YSI Technical Support for further assistance.

4.18 pH and ORP
Sensor Overview

Users can choose between a pH sensor or a combination pH/ORP sensor to measure these parameters. pH describes the acid and base characteristics of water. A pH of 7.0 is neutral; values below 7 are acidic; values above 7 are alkaline. ORP designates the oxidizing-reducing potential of a water sample and is useful for water which contains a high concentration of redox-active species, such as the salts of many metals and strong oxidizing (chlorine) and reducing (sulfite ion) agents. However, ORP is a non-specific measurement—the measured potential is reflective of a combination of the effects of all the dissolved species in the medium. Users should be careful not to overinterpret ORP data unless specific information about the site is known.

(continued)



599701, 599702, 599705, 599706;
599795-01, 599795-02, 599797-01,
599797-02 modules

Specifications

pH

Units	pH units
Temperature *Operating* *Storage*	 -5 to +50°C 0 to 60°C
Range	0 to 14 units
Accuracy	±0.1 pH units within ±10°C of calibration temperature; ±0.2 pH units for entire temp range
Response	T63<3 sec
Resolution	0.01 units
Sensor Type	Glass combination electrode

ORP

Units	millivolts
Temperature *Operating* *Storage*	 -5 to +50°C 0 to 60°C
Range	-999 to +999 mV
Accuracy	±20 mV in Redox standard solution
Response	T63<5 sec
Resolution	0.1 mV
Sensor Type	Platinum button

Replaceable Sensor Module

The EXO pH and pH/ORP sensors have a unique design that incorporates a user-replaceable sensor tip (module) and a reusable sensor base that houses the processing electronics, memory, and wet-mate connector. This allows users to reduce the costs associated with pH and pH/ORP sensors by only replacing the relatively inexpensive module periodically and not the more costly base.

The connection of the module to the sensor base is designed for one connection only and the procedure must be conducted in an indoor and dry environment. Once installed the module cannot be removed until you are prepared to replace it with a new module. See Section 5.14 for detailed instructions.

Users must order either a pH or pH/ORP sensor. Once ordered the sensor is *only* compatible with like-model sensor modules. For example, if a pH sensor is purchased initially, then the user must order a replaceable pH sensor module in the future; it cannot be replaced with a pH/ORP module.

Electrodes

EXO measures pH with two electrodes combined in the same probe: one for hydrogen ions and one as a reference. The sensor is a glass bulb filled with a solution of stable pH (usually 7) and the inside of the glass surface experiences constant binding of H^+ ions. The outside of the bulb is exposed to the sample, where the concentration of hydrogen ions varies. The resulting differential creates a potential read by the meter versus the stable potential of the reference.

The ORP of the media is measured by the difference in potential between an electrode which is relatively chemically inert and a reference electrode. The ORP sensor consists of a platinum button found on the tip of the probe. The potential associated with this metal is read versus the Ag/AgCl reference electrode of the combination sensor that utilizes gelled electrolyte. ORP values are presented in millivolts and are not compensated for temperature.

Signal Quality

Signal conditioning electronics within the pH sensor module improve response, increase stability, and reduce proximal interference during calibration. Amplification (buffering) in the sensor head is used to eliminate any issue of humidity in the front-end circuitry and reduce noise.

4.19 pH Calibration

1-point

Select the 1-point option to calibrate the pH probe using one calibration standard.

> **NOTE:** *While a 1-point pH calibration is possible, YSI recommends using a 2 or 3-point calibration for greater accuracy.*

2-point

Select the 2-point option to calibrate the pH probe using two calibration standards. In this procedure, the pH sensor is calibrated with a pH 7 buffer and a pH 10 or pH 4 buffer depending upon your environmental water. A 2-point calibration can save time (versus a 3-point calibration) if the pH of the media to be monitored is known to be either basic or acidic.

3-point

Select the 3-point option to calibrate the pH probe using three calibration standards. In this procedure, the pH sensor is calibrated with a pH 7 buffer and both the pH 10 and the pH 4. The 3-point calibration method assures maximum accuracy when the pH of the media to be monitored cannot be anticipated.

Review the basic calibration description in Section 4.2.

Pour the correct amount of pH buffer in a clean and dry or pre-rinsed calibration cup. Carefully immerse the probe end of the sonde into the solution, making sure the sensor's glass bulb is in solution by at least 1 cm. Allow at least 1 minute for temperature equilibration before proceeding.

In the Calibrate menu, select pH or pH/ORP, then select Calibrate.

> **NOTE:** *Observe the temperature reading above the standard value*. The actual pH value of all buffers varies with temperature. Enter the correct value from the bottle label for your calibration temperature for maximum accuracy. For example, the pH of one manufacturer's pH 7 Buffer is 7.00 at 25˚C, but 7.02 at 20˚C.
> If no temperature sensor is installed, user can manually update temperature by entering a value.

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point. Click Add Another Cal Point in the software.

Rinse the sensor in deionized water. Pour the correct amount of the next pH buffer standard into a clean, dry or pre-rinsed calibration cup, and carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Repeat the calibration procedure and click Apply when the data are stable. Rinse the sensor and pour the next pH buffer, if necessary. Repeat calibration procedure for the third point and click Apply when data are stable.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

Rinse the sonde and sensors in tap or purified water and dry.

SmartQC for pH Sensors

The SmartQC Score for pH is based on both a gain and an offset. The offset calculation is based on the millivolts recorded during sensor calibration.

Green: Gain and offset are within acceptable limits. Calibration was performed successfully and results are within factory specified limits.

Yellow: Either the gain or the offset is slightly outside of factory specified limits.

1. Ensure that all debris is removed from the surfaces of the sensor. Refer to Section 5.12 for information on proper sensor cleaning in order to avoid damaging the sensor.
2. Verify that there are no cracks or visual damage to the glass bulb.
3. A yellow score can result from a contaminated standard; ensure that all buffers are clear (not cloudy) and free of debris, and that the calibration cup was clean.
4. A Factory Reset Calibration should be performed.
5. The electrolyte solution inside the sensor may be partially depleted which causes the millivolt values to drift over the range of calibration. This is not a user-addressable problem, but to prevent it make sure that sensor modules are stored in the same bottle of solution that was shipped with the new modules. Avoid storage of sensor modules in distilled or deionized water.
6. If the sensor is new, make sure that there are no air bubbles in the pH bulb. Sensors actually do have air in the reference solution, but if the sensor is in the upright position, as it should be during calibration, an air bubble should not be in the bulb. If air bubbles are found, shake the sensor gently to encourage electrolyte solution to flow into the bulb and the air to rise to the top (where it will not be visible).
7. Check the delta slope and mV per decade to ensure that the sensor is fine (see "Additional Information" below).

If the QC Score returns to yellow, the sensor (or module) is still able to be used but one should be cautious if a long-term deployment is planned. With a yellow QC score it is more acceptable to use the sensor for discrete sampling because the mV value can be easily monitored under those conditions. In either case, the user should monitor this sensor during calibrations and periodic calibration checks for any further drift. Finally, the sensor could be reconditioned using HCl and a bleach solution (Section 5.12), but persistent yellow QC Scores are a sign that the time to replace the sensor module may be approaching.

Red: The gain or offset is significantly outside of factory specified limits. Follow the same 6 steps described above for a Yellow QC score. If the score remains red then replace the sensor module with a new module, perform a Factory Reset Calibration, and calibrate the new module with fresh buffers.

If the QC Score remains red after the Factory Reset Calibration and recalibration, or after replacement of the module and performing a calibration, please contact YSI Technical Support for further assistance. Further if upon replacement with a new module the QC score is yellow, contact YSI Technical Support.

Additional QC Information for pH

The calibration worksheet provides information that can be useful for assessing performance of the pH modules with age. Two useful parameters shown there are the "delta slope" and the "mV per decade." In general the practice is to not use a pH module where the delta slope is ≥165 mV, and the mV per decade deviates by more than 5 units from an ideal of 59.16. However, these ranges assume a calibration was performed at or near to 25°C. For users who wish to better understand the underlying principles for these guidelines, and perhaps to establish their own acceptance criteria, read on.

The Nernst equation is a well-established relationship that governs pH:

$E = E_o + 2.3RT/\eta F * pH$
Where

E = millivolts output
E_o = a constant associated with the reference electrode
T = temperature of measurement in Kelvin
R = the universal gas constant
ηF = the Faraday constant

In simplified y = mx + b form, the relationship is (mV output) = (slope) x (pH) + (intercept). Using this form note that the term 2.3RT/ηF is the slope, and it is sometimes called the Nernst potential.

The absolute value of the Nernst potential, at 298 K (25°C), is 59.16 mV/pH unit. At standard temperature, then, when one would change the pH from 7 to 8, the mV change is expected to be -59.16. Extrapolating further, from pH 7 to pH 10, the mV change would be

3 * -59.16 = -177.3 mV/pH unit.

Similarly, from pH 7 to pH 4 the change would be +177.3 mV/pH unit.

Returning to the Nernst equation, note that these slopes are temperature-dependent. During calibration the mV values for two standard buffer solutions are experimentally established and used by the sonde's software to calculate the slope and intercept of the plot of mV vs. pH. Once this calibration has been performed, the mV output of the probe in any sample can be converted by the sonde into a pH value, *as long as the calibration and the reading are carried out at the same temperature*.

In reality the temperature is almost never the same in environmental monitoring as it is during calibration. Thus a mechanism must be in place to compensate for temperature, effectively converting the slope and intercept of the plot of pH vs. mV established at the temperature of calibration into a slope and intercept at the temperature of measurement.

This mechanism is already provided by the Nernst equation. The slope of the plot of pH vs. mV is *directly proportional* to the absolute temperature in degrees Kelvin. Thus, if the slope of the plot is experimentally determined to be 59 mV/pH unit at 298 K (25°C), then the slope of the plot at 313 K (40°C) must be (313/298) * 59, or 62 mV/pH unit. At 283 K (10°C), the slope is calculated to be (238/298) * 59, which is 56 mV/pH unit. Determination of the slope of pH vs. mV plots at temperatures different from the calibration temperature is thus straightforward.

How can one apply this information for QC?

First, use the temperature compensation to determine what the slope should be for the calibration that was just performed. A calibration performed at 23°C, for instance, should have a slope of (296/298)*59.16, or 58.76. The calibration worksheet shows "mV per decade" between calibration points, such as from 4 to 7 and 7 to 10.

It is not unusual for the mV per decade to deviate from the ideal predicted by the Nernst equation, but typically it should not deviate more than 4 to 5 mV per decade. In this example, if the mV per decade is 56.51, that would be acceptable to most users. If it were instead 53.43, that could be cause for concern.

Another valuable piece of information on the calibration worksheet is in the "Delta slope," which is the change in mV per decade across the range being measured. As stated above, in an ideal scenario at standard temperature, the "delta slope" going from pH 7 to pH 4 would be +177.3, and going from pH 7 to pH 10 it would be -177.3. If, as in our example here, the calibration was performed at 23°C, and therefore the a slope of 58.75 were calculated, then the delta slope from pH 7 to pH 4 would be 3 * 58.75 = 176.25, and the delta slope from pH 7 to pH 10 would be -176.25.

In general it is advisable that the delta slope should not deviate more than about 12-15 from the ideal. So a delta slope for pH 7 to pH 4 of 161 would be considered unacceptable to most users in the present example.

In practice, people don't usually do these calculations, but rather apply a rule of thumb that states, for a laboratory-based calibration where temperature is often near 25°C, the delta slope should always be ≥165.

With a better understanding of the Nernst equation, however, users can monitor the changes in the mV per decade and delta slope, and look for big changes from prior calibration worksheets. These changes, even when the SmartQC score is green, can be useful indicators of changes in the performance of the pH module with age.

4.20 ORP Calibration

Review the basic calibration description in Section 4.2.

Pour the correct amount of standard with a known oxidation reduction potential value (we recommend Zobell solution) in a clean and dry or pre-rinsed calibration cup. Carefully immerse the probe end of the sonde into the solution.

In the Calibrate menu, select pH/ORP, then select ORP to Calibrate.

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point.

> **NOTICE:** Do not leave sensors in Zobell solution for a long time. A chemical reaction occurs with the copper on the sonde (sonde bulkhead, central wiper assembly, copper tape). While the reaction does not impact calibration, it will degrade the sonde materials over time. Discard the used standard.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu.

Rinse the sonde in tap or purified water and dry the sonde.

Effect of temperature on ORP

The oxidation reduction potential value shows an inverse relationship with temperature. This effect must be accounted for when calibrating the EXO ORP sensor with an ORP standard. YSI recommends using Zobell solution for calibration, but other standards may be used. Refer to the table included with your ORP standard instrutions for the mV value that corresponds to the temperature of the standard.

SmartQC for ORP Sensors

The SmartQC Score for ORP is based on an offset from 0 mV.

Green: Offset is within acceptable limits. Calibration was performed successfully and results are within factory specified limits.

Yellow: The sensor offset is slightly outside of factory specified limits.

1. Perform a Factory Reset Calibration. Complete a recalibration using freshly-prepared Zobell solution. Incorrect mixing of the Zobell solution can cause errors in calibration.
2. The electrolyte solution in the sensor may be partially depleted causing shifts to the millivolt readings. This is not a user-addressable problem, but to prevent it make sure that sensor modules are stored in the same bottle of solution that was shipped with the new modules. Avoid storage of sensor modules in distilled or deionized water.
3. ORP calibration is temperature- dependent so make sure that the correct standard value was entered, using the instructions that came with the Zobell solution.
4. Ensure that the sensor is free of debris. Refer to Section 5.12 for information on proper sensor cleaning in order to avoid damaging the sensor.

If the QC Score returns to yellow, the sensor is still able to be used, but the user should monitor this sensor during calibrations for any further drift. Consideration should be made to eventually replacing the pH/ORP sensor module.

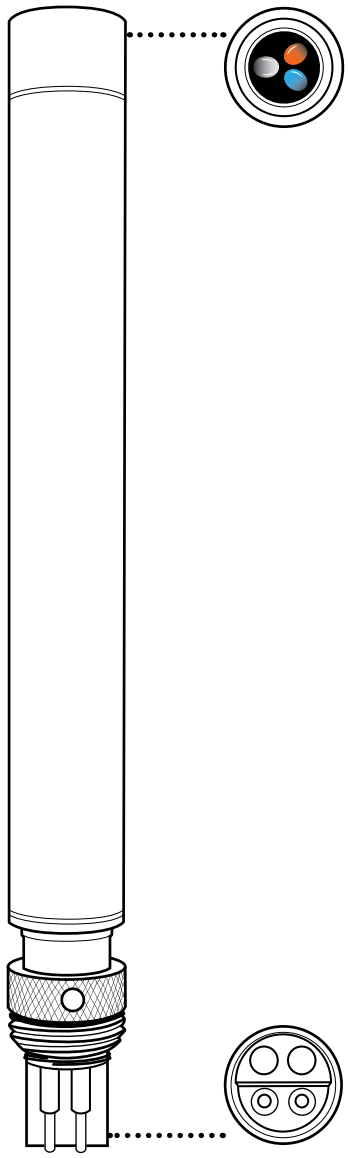
Red: The sensor offset is significantly outside of factory specified limits. Follow the same four steps described above for a Yellow QC Score.

If the QC Score remains red after the Factory Reset Calibration and recalibration, or after replacement of the module and performing a calibration, please contact YSI Technical Support for further assistance.

4.21 Total Algae
Sensor Overview

The Total Algae (TAL) sensors are dual-channel fluorescence sensors. The "channels" are for chlorophyll and phycocyanin (TAL-PC), or chlorophyll and phycoerythrin (TAL-PE), which are measured in the water. Each sensor thus yields two data sets: for TAL-PC, one results from a blue-emitting LED that excites the chlorophyll *a* (chl) molecule and the second results from an orange excitation beam that excites the phycocyanin (PC) accessory pigment. The TAL-PE sensor is similar, also having the chlorophyll channel, but rather than an orange-emitting LED there is a slightly blue-shifted beam that excites phycoerythrin (PE).

(continued)



599102-01 (TAL-PC)
599103-01 (TAL-PE)

Specifications

Units	
Chlorophyll	RFU, µg/L Chl
PC	RFU, µg/L PC
PE	RFU, µg/L PE
Temperature	
Operating	-5 to +50°C
Storage	-20 to +80°C
Range	*Chl:* 0-100 RFU, 0-400 µg/L Chl*; *PC:* 0-100 RFU, 0-100 µg/L*; *PE:* 0-100 RFU, 0-280 µg/L*
Response	T63<2 sec
Resolution	*Chl:* 0.01 RFU, 0.01 µg/L Chl; *PC:* 0.01 RFU, 0.01 µg/L; *PE:* 0.01 RFU, 0.01 µg/L
Sensor Type	Optical, fluorescence
Linearity	*Chl:* R^2>0.999 for serial dilution of Rhodamine WT solution from 0-400 µg/L Chl equivalents *PC:* R^2>0.999 for serial dilution of Rhodamine WT solution from 0-100 µg/L PC equivalents; *PE:* R^2>0.999 for serial dilution of Rhodamine WT solution from 0-280 µg/L PE equivalents
Optics: Chl Excitation	470±15 nm
PC Excitation	590±15 nm
PE Excitation	525±15 nm
Emission	685±20 nm

*Pigment concentration ranges of algae sensors were determined in monocultures of specific algae species. This range will vary depending on algae assemblage and environmental conditions. The best accuracy of pigment measurements can be obtained by user-built correlations between RFU and pigment concentrations measured by an independent method, and using samples from the site or sites of interest with representative algal populations.

Total Algae Sensor Units

The TAL sensors generate data in RFU or µg/L of pigment (chl, PC or PE) units, with RFU as the default. When using either RFU or µg/L, the sensor's response is highly linear: a reading of 50 of either unit represents twice as much fluorescence detected as a reading of 25, for example, if the temperature is constant.

However, users are advised to use default RFU, which stands for Relative Fluorescence Units. RFU is used to set sensor output relative to a stable secondary standard, rhodamine WT dye, which normalizes the sensor's output on a 0-100% scale. RFU calibration allows for the best comparisons of data from sensor to sensor, and also enables users to monitor for sensor drift and edaphic factors such as biofouling or declining sensor optical performance over time as the LEDs age. Another reason to use RFU is the excellent linearity once the channels are calibrated with Rhodamine WT, which translates to optimized accuracy of measurements.

The µg/L output generates an estimate of pigment concentration that is based upon correlations we built between sensor outputs and extracted pigments from laboratory-grown blue-green algae. Synonymous with parts per billion (ppb), µg/L is still in common use by regulatory agencies, but has the drawback that it is very dependent upon the composition of the algal population, the time of day, the physiological health of the algae, and a number of other environmental factors. So if two populations of algae yield a reading of 50 µg/L of chlorophyll, it does not mean that those populations are equivalent in the number of cells, for instance. Further, since algal populations can regulate their intracellular pigment concentrations, the µg/L of pigment per cell changes with season, time of day, and population dynamics. Thus the challenge with the µg/L unit is user expectations: it should not be expected that µg/L will necessarily correlate well with pigment extractions that customers perform themselves, and it should not be expected that a doubling of µg/L necessarily represents a doubling of the algal population.

RFU is likewise affected by these dynamics: a doubling of RFU does not necessarily mean there has been an exact doubling of an algal population. But it is generally more clear to users that an RFU is detecting a change in relative fluorescence signal, which can occur for a number of reasons in situ.

In any case, many users are required for regulatory compliance to deliver data in µg/L, and in waters where the algal populations are fairly predictable or stable from year to year, with respect to species compositions, good correlations can be built. So users are advised to assess whether the pigment concentration delivered by the sensor is reasonable and acceptable for the algal populations and environment with which they work.

That assessment should start with calibration of both RFU and µg/L channels with rhodamine WT, as described in the next section. Next, with samples collected from the site of interest, measure both RFU and µg/L with the sensor(s). Observing careful handling and preservation of the samples, as soon as possible extract the pigments from the samples, using standardized or preferred methods to determine pigment µg/L in each sample. The extraction data may be used to assess how RFU and µg/L delivered by the sensor compare with the extracted µg/L of pigment that would be predicted by the sensor. Ideally this would be done with a dilution series of the original sample or at the very least multiple samples. The user's requirements for how well µg/L delivered by the sonde must correlate with their own extraction data will determine whether the µg/L output should be used for reporting.

Measuring cells/mL with EXO TAL Sensors

Similar to µg/L, some users have a requirement to report cell/mL data for blue-green alga monitoring, even though in reality these measurements vary widely from algal population to algal population in situ. Within KorEXO 2.0 and later software versions, there is the capability to have the sonde deliver this unit for the PC and PE channels, based upon user-applied correlations.

When selecting the TAL sensor in the Calibration module of the software, there is a "TAL-PC Phycocyanin Settings" window (or TAL-PE if that is the sensor in use). There are two radio buttons that appear when that window is opened:

- Use legacy cells/mL relationship
- Build my own cells/mL relationship

The first option was designed for users that were accustomed to this unit in our legacy 6-Series sondes, and who want their EXO data to tightly match the cells/mL data generated by these older sondes. The algorithm applied to "match" these outputs across sonde platforms is proprietary, and it is highly advisable that when using this unit at some point users actually test the validity of the outputs for their applications. This can be done by collecting grab samples and comparing actual cells/mL using microscopy or plating as appropriate.

A better method would be to use the second option of building one's own cells/mL relationship. This makes a module appear wherein users can enter an RFU measurement alongside a corresponding cells/mL measurement that has been made for the exact same sample, using microscopy or whatever method the user prefers. The software will derive the relationship between the columns entered by the user and will apply that equation to all subsequent measurements to deliver the cells/mL unit in the sonde's output.

From time to time and place to place, the validity of this correlation can be tested, verified, or validated by collecting grab samples and comparing in vitro measurements of cells/mL with the in situ values delivered by the sonde.

In all cases, proper calibration of the sensor with Rhodamine WT is necessary for the most reliable outputs, and for comparison of data from sensor to sensor.

4.22 Total Algae
Calibration

For best performance assure that the sensor face is clean prior to calibration. We advise that new sensors should be calibrated before use, and calibration checks and the user's own tolerance of drift should be used to determine when recalibration is necessary.

Users will prepare their own calibration standards. Rhodamine WT is a secondary standard (the actual pigments would be primary standards). It is used because of its stability and affordability. The units that the sensor delivers are in either RFU (recommended) or µg/L pigment equivalent units. We strongly recommend using RFU, but in either case Table A below must be used to derive the calibration values that the user will enter during the process outlined below. Use of this table requires a temperature measurement, and the best way to do this is to have an EXO conductivity/temperature sensor on the sonde bulkhead during calibration. In general fluorescence is inversely related with temperature, and this effect will be accounted for to optimize the accuracy of your calibration by using Table A.

Table A. Temperature-compensated standard solution values for TAL sensors.

	Chlorophyll 0.625 mg/L Rhodamine		Phycocyanin 0.625 mg/L Rhodamine		Phycoerythrin 0.025 mg/L Rhodamine	
Solution Temperature (˚C)	Chl RFU	µg/L chlorophyll	PC RFU	µg/L phycocyanin	PE RFU	µg/L phycoerythrin
30	14.0	56.5	11.4	11.4	37.3	104.0
28	14.6	58.7	13.1	13.1	39.1	109.0
26	15.2	61.3	14.1	14.1	41.0	115.0
24	15.8	63.5	15.0	15.0	43.0	120.0
22	16.4	66	16.0	16.0	45.0	126.0
20	17.0	68.4	17.1	17.1	47.0	132.0
18	17.6	70.8	17.5	17.5	49.2	138.0
16	18.3	73.5	19.1	19.1	51.4	144.0
14	18.9	76	20.1	20.1	53.6	150.0
12	19.5	78.6	21.2	21.2	55.9	157.0
10	20.2	81.2	22.2	22.2	58.2	163.0
8	20.8	83.8	22.6	22.6	60.6	170.0

Steps 1-3 below describe a standard two point calibration performed with Kor EXO 2.0 software. Calibration can also be performed using the EXO Handheld, the main differences simply being the references to windows. In some cases users may prefer to perform a re-zeroing of the sensor, sometimes referred to as a "one point calibration," and that is described later in this section.

Step 1: Prepare Rhodamine WT Dye Solution

Purchase Rhodamine WT as a 2.5% solution to follow the procedure below. Note that there are many types of Rhodamine—make sure Rhodamine WT is selected. If a 2.5% solution cannot be obtained commercially, prepare it from a solid or liquid solution to a 2.5% final concentration, or adjust the dilutions below accordingly. Kingscote Chemicals (Miamisburg, OH, 1-800-394-0678) has historically had a 2.5% solution (item #106023) that works well with this procedure. It should be stored in the refrigerator when not in use.

1. **For any TAL sensor calibration, prepare a 125 mg/L solution of Rhodamine WT**. Transfer 5.0 mL of the 2.5% Rhodamine WT solution into a 1000 mL volumetric flask. Fill the flask to the volumetric mark with deionized or distilled water and mix well to produce a solution that is approximately 125 mg/L of Rhodamine WT. Transfer to a storage bottle and retain it for future use.

   *This solution can be stored in the refrigerator (4°C). Its degradation will depend upon light exposure and repeated warming cycles, but solutions used 1-2 times a year can be stored for up to two years. Users should implement their own procedures to safeguard against degradation.

2. **For calibration of any chlorophyll channel (on either the TAL-PC or the TAL-PE sensor) and the TAL-PC phycocyanin channel, prepare a 0.625 mg/L solution of Rhodamine WT.** Transfer 5.0 mL of the 125 mg/L solution prepared in step one into a 1000 mL volumetric flask. Fill the flask to the volumetric mark with deionized or distilled water. Mix well to obtain a solution that is 0.625 mg/L of Rhodamine WT. Use this solution within 24 hours of preparation and discard it after use.

3. **If using a TAL-PE sensor, additionally prepare a 0.025 mg/L solution of Rhodamine WT for calibration of the phycoerythrin channel.** Transfer 0.2 mL of the 125 mg/L solution prepared in step one into a 1000 mL volumetric flask. Fill the flask to the volumetric mark with deionized or distilled water. Mix well to obtain a solution that is 0.025 mg/L of Rhodamine WT. Use this solution within 24 hours of preparation and discard it after use.

Step 2: Select the pigment and channel to be calibrated.

In the Kor software or on the handheld, select the channel you want to calibrate (chl, PC, or PE) and the units you intend to use (RFU or µg/L).

Note that each channel of the sensor must be calibrated independently. Calibration of the chlorophyll channel does not set the calibration for the PC channel or the PE channel. Likewise, even just for the chlorophyll channel, calibration of RFU does not automatically calibrate the µg/L units. Calibration must be performed for each channel of interest, each unit of interest, and each calibration point (zero and the second point). It is thus possible that Step 3 below will be performed up to 8 times total, if one wants reading for all units from all channels. This is cut in half if only RFU are used, which is YSI's recommendation.

Step 3: Perform a two-point calibration.

Step 3a: Calibration at zero.

The zero point is always calibrated first. Place the sonde, loaded with a TAL and an EXO temperature sensor, into a clean calibration cup containing clean water. It is not required that this be deionized or even distilled water; it must be free of any particles that might fluoresce and interfere with the calibration process. Thus distilled water is typically what users prefer to have that assurance.

The software or handheld will show a graph while the sensor is stabilizing, and the temperature will also be shown. Temperature is not needed for the zero point; the user must enter a "Standard Value" of 0. When the Data Stability indicates "Stable", click to "Apply" the calibration. Next select "Add Another Cal Point" and proceed to Step 3b.

Step 3b: Calibration with Rhodamine WT

The same basic procedure will be followed, but using either Kor software or the EXO handheld will require that users enter the temperature-compensated standard value for the calibration solution. In all cases, the reading from the EXO temperature sensor is the most reliable to use, and the value for the standard can be derived from the Table A provided above.

As an example, assume that you will calibrate the chlorophyll RFU channel, and that the temperature measured in the 0.625 mg/L rhodamine WT solution is 22°C. This temperature will show up on the calibration screens using the KorEXO software, and can be seen on the handheld's dashboard screen as well. The first standard value entered during calibration will be 0, since that standard will be water (see Step 3 below). The second standard value will be 16.4, as derived from Table A using a temperature of 22°C. Alternatively, if you intend to use the µg/L unit, the second standard value would be 66 for this example. Using the same 0.625 mg/L rhodamine WT solution to calibrate the PC channel will yield a second standard value of 16.0 RFU or 16 µg/L. You will enter these values when you perform the calibration.

Upon entering the Table A-derived value, wait for the sensor to show "Stable" and then click on "Apply". Now choose "Complete Calibration" and then "Exit."

Note that throughout this process users had options to "Redo a cal point" or to "View Calibration Worksheet." So for any channel and a given unit of interest, a point can be redone at any time without having to exit out to the beginning of the process.

However, to now calibrate other units for either the same or different pigment channels, this process must be started again at Step 2.

Re-zeroing the TAL Sensor.

Oftentimes users will perform a "cal check" in water to assess if the sensor has drifted beyond an acceptable limit defined by that user. When drift has occurred ideally a two-point calibration should be performed. However, when there isn't an opportunity to prepare the rhodamine solutions and perform a two-point calibration, or if users are mainly interested in accuracy at the lower end of the sensor's range, they may choose to re-zero the sensor.

Historically referred to as a "single-point calibration," doing a calibration with water only resets the zero value, called here "re-zeroing" the sensor. The main advantage of doing this is speed, and users should be aware that re-zeroing the sensor does not reset the second point entered during the most recent two-point calibration. The consequence is that drift error will be alleviated at and near zero, but more error can accumulate in the measurement the farther away from zero the measured value is. The amount of that error can be different from sensor to sensor, and use case to use case. It is dependent upon how much that second point may drift, which is not always equivalent to how much the zero point drifts.

For many users, especially those with sites where pigment is rarely detected and values are at or near zero most of the time, the far-from-zero accumulation of error is a non-issue. For others, a single point calibration may not be acceptable. A single-point calibration is an option in the software and is performed exactly the same way as the two- point calibration, using water as the standard and waiting for the value to stabilize before applying it. Rather than adding a second calibration point, the user would exit after the water calibration.

SmartQC for TAL Sensors

The SmartQC Score for any TAL sensor is based on an offset from 0 RFU, and a gain factor. Each individual channel (Chl, PC, PE) has a unique offset and gain factor. It is possible to have a green SmartQC score for calibration of one channel, but a yellow or red SmartQC score for the second channel. In this case the TAL sensor Soft QC that is shown in Kor Software will appear as the worst QC score (yellow or red), and one must look at the individual channels to investigate where the issue is. Thus the steps outlined here are for each channel, and for each unit calibrated within that channel.

Green: Gain and offset are within acceptable limits. Calibration was performed successfully and results are within factory specified limits.

Yellow: The sensor gain or offset is slightly outside of calibration limits.

1. Perform a Factory Reset Calibration and complete a recalibration.
    a. If performing a 1-point calibration, use fresh, clear water.
    b. If performing a 2-point calibration, use fresh, clear water and freshly made Rhodamine WT solution.
2. Ensure that the standard value was entered correctly. Calibration of TAL channels is temperature-dependent; make sure the appropriate value from the table in Section 4.22 was entered during calibration for either RFU or µg/L.
3. Ensure that the sensor is free of debris. Refer to Section 5.6 for additional information on how to properly clean the sensor in order to avoid damage.

If the QC Score returns to yellow, the sensor is still able to be used, but the user should monitor this sensor during calibrations for any further drift.

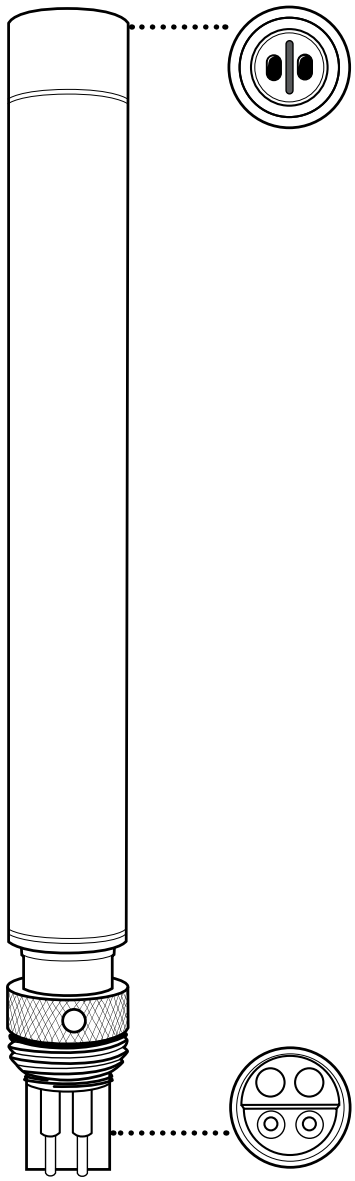
Red: The sensor gain or offset are significantly outside of factory specified limits. Follow the same three steps described above for a Yellow QC Score.

If the QC Score remains red, please contact YSI Technical Support for further assistance.

4.23 Turbidity
Sensor Overview

Turbidity is the indirect measurement of the suspended solid concentration in water and is typically determined by shining a light beam into the sample solution and then measuring the light that is scattered off of the suspended particles. Turbidity is an important water quality parameter and is a fundamental tool for monitoring environmental changes due to events like weather-induced runoff or illicit discharges. The source of the suspended solids varies (examples include silt, clay, sand, algae, and organic matter) but all particles will impact light transmittance and result in a turbidity signal.

(continued)



599101-01

Specifications

Default Units	FNU
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Range	0 to 4000 FNU
Accuracy	0-999 FNU: 0.3 FNU or ±2% of reading, whichever is greater; 1000-4000 FNU: ±5% of reading[2]
Response	T63<2 sec
Resolution	0-999 FNU: 0.01 FNU 1000-4000 FNU: 0.1 FNU
Sensor Type	Optical, 90° scatter
Optics: Excitation	 860±15 nm

1 *ASTM D7315-07a "Test Method for Determination of Turbidity Above 1 Turbidity Unit (TU) in Static Mode."*

2 *Performance based on 3-point calibration done with YSI AMCO-AEPA standards of 0, 124, and 1010 FNU. The same type of standard must be used for all calibration points.*

The EXO Turbidity sensor employs a near-infrared light source and has been characterized as a nephelometric near-IR, non-ratiometric sensor in accordance with ASTM Method D7315-07a.[1] This method calls for this sensor type to report values in formazin nephelometric units (FNU), which is the default calibration unit for the EXO sensor. Users are able to change calibration units to nephelometric turbidity units (NTU).

Turbidity is one of the most misunderstood measurements in environmental monitoring. In reality the turbidity sensor is not much different from other optical sensors: differences in outcomes with different standards, sensors and environments can be a result of differing optical components and geometries, and the impact of different environmental factors upon the measurement technologies themselves. Thus like many optical measurements, where a light beam is passing through a sample in an environment of changing temperature, etc., turbidity is best monitored with consistent use of standards, technology platforms, and practices to compare outcomes for scientific conclusions.

Among the many factors that can impact turbidity measurements, users should be aware of three over which they have some control. These are the use of recommended YSI standards, preventing fouling, and using sound and consistent calibration practices.

Turbidity Standards

Turbidity sensors of many types, from many manufacturers, are often calibrated with formazin. Considered the "gold standard" for turbidity calibration there is the perception that all turbidity sensors will read consistently in formazin. In practice this has led to the belief that two different sensors of different types (design or manufacturer, for instance), if calibrated in formazin, would yield the same FNU when used to measure a sample. When sensors are of the same fundamental design, using the same type of light source and with detection of scattering at the same angles of incident light, this is more likely to be true, especially if measuring an actual formazin solution. However, with field samples this rule does not always hold; different manufacturer's sensors calibrated with the same formazin solutions can yield slightly different readings from the same field samples. There can be a number of reasons for this, including how the raw data are post-processed.

Due to the challenges of preparation and disposal of formazin, polymer-based standards are now preferred as turbidity standards. As with formazin, it is the case that field readings will vary between different models of turbidity sensors even when they are calibrated with the same standards. This is true of the popular AMCO-AEPA standards upon which YSI's standards solutions are based, and which were used to determine the Specifications shown below.

Further, if YSI sensors are calibrated with the non-YSI standard AMCO-AEPA solutions, sensor specifications may differ from those shown in the Specification table, and thereby turbidity measurements may differ. For the best consistency, EXO users should use the YSI-labeled turbidity standards throughout the lifetime of their sensors, and use the FNU values on the labels of these standards during calibration.

While formazin can be used to calibrate YSI's EXO turbidity sensors, the specifications were determined with YSI-labeled AMCO-AEPA turbidity standards, and the factory-defined limits for the SmartQC tool were also determined with YSI standards.

Preventing Fouling

Turbidity measurements are vulnerable to both biofouling and non-biological fouling. This is because of the high sensitivity and resolution of measurements, which can be affected by any changes to the sensor face that light must pass through. Any obstruction of that light path will affect measurements, and even bubbles on the sensor's face can affect measurements. Low-range measurements (e.g. <100 FNU) are especially susceptible to these effects.

As such it is imperative in continuous monitoring applications that antifouling tools be employed. The central wiper on the EXO 2, 2^{S}, and 3 sondes is highly effective in combating fouling during continuous monitoring, and can be aided by strategies like C-spray and copper tape on the sensors. Even during spot-sampling applications such as with EXO 1 it is very important that users pay attention to the sensor faces so that they are not trapping bubbles during measurements.

Calibration Practices

The following section describes in detail how to calibrate EXO turbidity sensors. Before calibrating, be certain that the probe is very clean and free of debris. Solid particles, particularly those carried over from past deployments, will contaminate the standards and can cause either calibration errors and thereby errors in measurement.

The cleaning instructions in Section 5.6 should be helpful for preventing contamination, but another recommendation we make is to have a sonde guard and a calibration cup devoted solely to turbidity calibration.

Finally, never calibrate turbidity *without* the sonde guard. If one is using the copper antifouling guard for a deployment, then that is the guard that should be used during turbidity calibration (don't use the standard black guard).

4.24 Turbidity
Calibration

Tools and Practices

YSI Turbidity standards that are based upon AMCO-AEPA polymer are the basis of SmartQC and EXO turbidity sensor specifications, and therefore should be used for turbidity sensor calibration. Gallon bottles are available as follows:

Item No.	Description
608000	0 FNU
607200	12.4 FNU
607300	124 FNU
607400	1010 FNU

Standards should be selected based upon the range in which one is expected to work. For low-turbidity waters, one might use 0 and 12.4 for a two-point calibration. If turbidities might exceed the lower ranges 0 and 124 should be used for a two-point calibration (not 0 and 1010 for reasons described below), and 0, 124 and 1010 for a three-point calibration. There is not a calibration standard beyond 1010 FNU at this time.

The FNU of each bottle can change with production batches, and as such the label of the bottle should always be checked for the FNU that should be entered into the software or handheld during calibration.

In some cases it may be acceptable to use deionized or distilled water rather than YSI's 0 FNU standard. Beware, however, that distilled water from some sources has been shown to not be 0 FNU. Calibration with a non-zero standard can cause negative readings when the sensor is used in waters that actually are clear. Non-zero readings also can occur if the calibration equipment (e.g. sonde guard, calibration cup) is not sufficiently clean.

Some users will have a preference, if not a requirement, for use of formazin standards. Examples may be formazin prepared according to *Standard Methods for the Treatment of Water and Wastewater* (Section 2130 B), or Hach StablCal™ of various NTUs. These standards are acceptable for a two-point calibration. However, users who anticipate working in higher turbidities and who choose to use a formazin standard for the third point may see yellow SmartQC scores during that calibration. The sensor can still be used, but since the algorithms for calibration were developed with YSI's polymer beads there may be less perfect alignment of the gain factors when using formazin.

Note also that if doing a three-point calibration, one should not use formazin for the second point, and polymer for the third point. Rather, one should only use the polymer for all points of a three point calibration (or water for 0 FNU and polymer for the second and third points), or formazin for all three points.

In all cases, due to the non-linear response of turbidity sensors and YSI's proprietary algorithms for post-processing of the data, the points of a two or three point calibration must be within the limits outlined here:

First Point	> 0 and ≤1 FNU
Second Point	>5 and ≤200 FNU
Third Point	>400 and ≤4200 FNU

The second calibration point, whether one is using formazin or YSI's polymer, should not be out of the 5-200 FNU range. If one tries to use a standard that is in the 400-4200 FNU range for the second calibration point, accuracy cannot be assured and often a yellow QC score will result.

Performing a 2-point calibration

Pour the 0 FNU standard (or deionized or distilled water) into the clean calibration cup and immerse the probe end of the sonde into the standard. The sonde should have the sonde guard on, and if one will deploy with the copper antifouling guard that is likewise the guard that should be used during calibration. Pay careful attention while submersing the sensors to not trap bubbles on the face of the turbidity sensor(s).

In either KorEXO Software or the handheld's Calibration menu, select Turbidity to calibrate.

Enter 0.0 (or some offset value between 0.0 and 1.0) as the first calibration value. While the sensor is still stabilizing one may wipe the sensors (using the button in the software or menu option on the handheld) to remove any bubbles. When the data are Stable, select the option to "Apply calibration" for this point.

It is advised at this point that the sensors, sonde guard, and calibration cup be rinsed with a small amount of the standard that will be used for the second calibration point. Discard this rinse, adn then fill the cup with the second calibration standard. Click Add Another Cal Point in the software.

Place the sensors into the second calibration standard, adn follow the same steps to wipe and obtain a stable reading. Use the value on the label of the YSI standard bottle for the FNU of the second calibration point.

When the data are Stable, select the option to "Apply calibration" for this point. Select the option to complete the calibration and observe the SmartQC score in the calibration worksheet. In KorEXO Software, color indicators will also make the QC score apparent.

Rinse the sonde with water and discard all used turbidity standards.

Performing a 3-point calibration

The steps for a three-point calibration are the same as describe above, but note that:

- The first point must always be 0 FNU, followed by the second standard (5-200 FNU) and then third (400-4200 FNU).
- Always use the same type of standard for the two non-zero points. Both must be YSI polymer, or both must be formazin.
- It is critically important, between the second and third calibration points, to rinse the sensors, sonde guard, and calibration cup with water, blot them dry with a lint-free material, and then do a rinse (at least once) with the standard for the third calibration point.

SmartQC for Turbidity Sensors

The turbidity response is nonlinear across the sensor's range, and a proprietary algorithm that employs up to five terms is used during calibration and for generation of the SmartQC score. Three of those terms are the actual calibration points, and those calibration points must read within an absolute range set within the sensor (this is slightly different than the concept of an offset that is used for SmartQC on most sensors). Two of the terms are calculated from the ratios of the calibration points, and likewise must be within an absolute range set within the sensor. The result is that the SmartQC calculation for turbidity is slightly different depending upon whether one does a 1, 2, or 3 point calibration. Since each individual term used by the algorithm must fall within an absolute range SmartQC is most reliable when the YSI standards, upon which these algorithms were built, are used.

Green: A Green SmartQC score means that the point for a single-point calibration is within the specified range. For a two-point calibration a Green SmartQC score means that both calibration points, as well as the slope between them, is within the specified range for each term. For a three-point calibration a Green SmartQC score means that all three calibration points, as well as the slope between the first two points and the slope between the second two points, are within the specified ranges for each term.

Yellow: A Yellow SmartQC score can result if any one of the five terms of interest is outside of the factory-specified range. In the case of a Yellow SmartQC score check the following:

1. Perform a Factory Reset Calibration and re-do the calibration.
2. If a two-point calibration was performed, make sure that the second point is between 5-200 FNU. If the second point was the 1010 FNU standard rather than the 124 FNU standard, for instance, a Yellow QC score might result.
3. If a three point calibration was performed with formazin, make sure that each calibration point was within the specified ranges of 0-1 FNU, 5-200 FNU, and 400-4200 FNU.
4. If a three point calibration was performed with YSI's polymer standards, make sure the correct values from the bottles were entered during calibration. For example, make sure the EXO values, and not the 6-Series values, were entered from the label
5. Make sure you are using YSI's polymer standards. Difficulties in calibration may occur if AMCO-AEPA standards that were not produced for YSI instruments are used. These will not have a YSI label on them.
6. It is imperative that the sensors, calibration cup, and sonde guard are all very clean when calibrating turbidity.
7. Customers who use the 12.4 NTU standard to calibrate will often see a yellow QC score, even with a perfect calibration.

Red: Any of the five terms of interest may be outside of the factory-set specifications. Follow the same steps described above for a Yellow QC Score. If the QC Score remains red, please contact YSI Technical Support for further assistance.

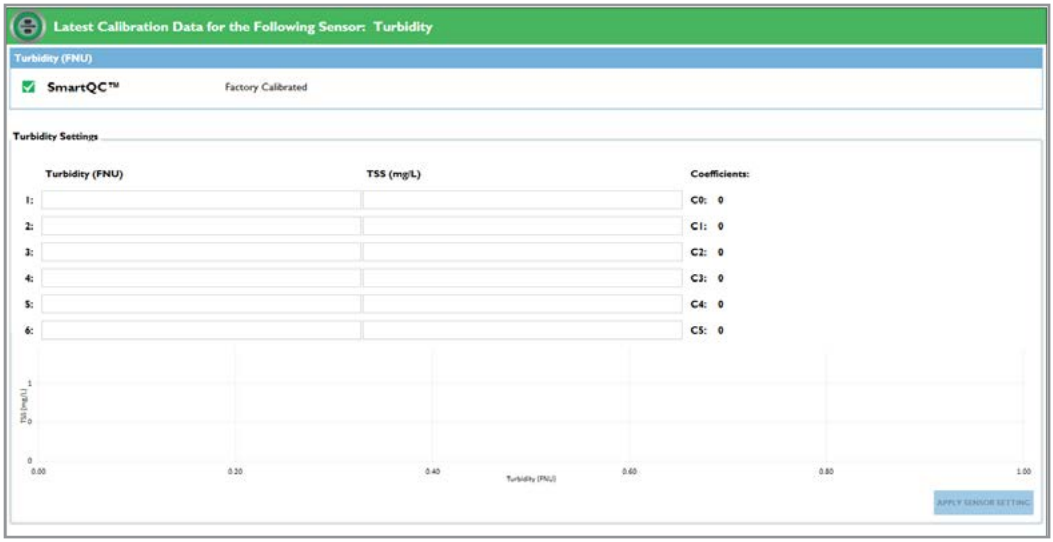
4.25 Total Suspended Solids
Calculation

Please follow the process below to calculate TSS.

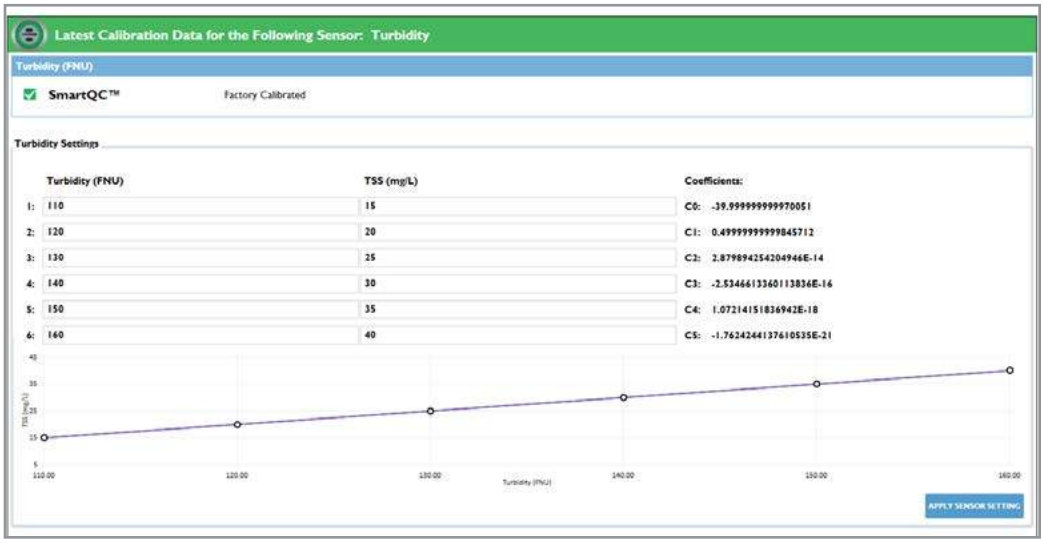
NOTE: *This process cannot be performed via the EXO handheld. It must be done using KorEXO Software.*

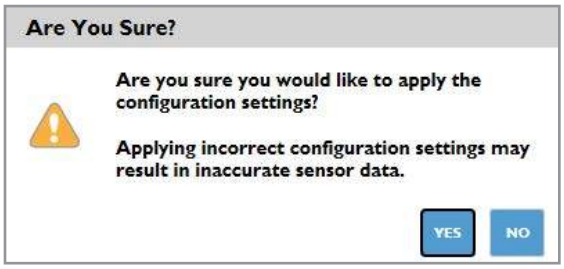
Step 1
Make sure the turbidity probe is installed in the sonde.

Step 2
In KorEXO Software, connect to the sonde, and navigate to Instruments and Sensors>Turbidity. The correlation table appears under the Turbidity Settings header.



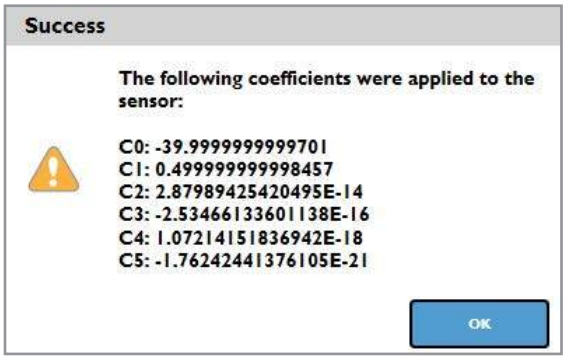
Step 3
Type in the turbidity NTU/FNU values and the corresponding TSS values obtained through lab analysis into the table. The coefficients will automatically calculate and a graph will be generated as additional values are added. Click Apply Sensor Setting.





Step 4

The message below will be displayed, asking for confirmation that the settings should be applied. Click Yes.



Step 5

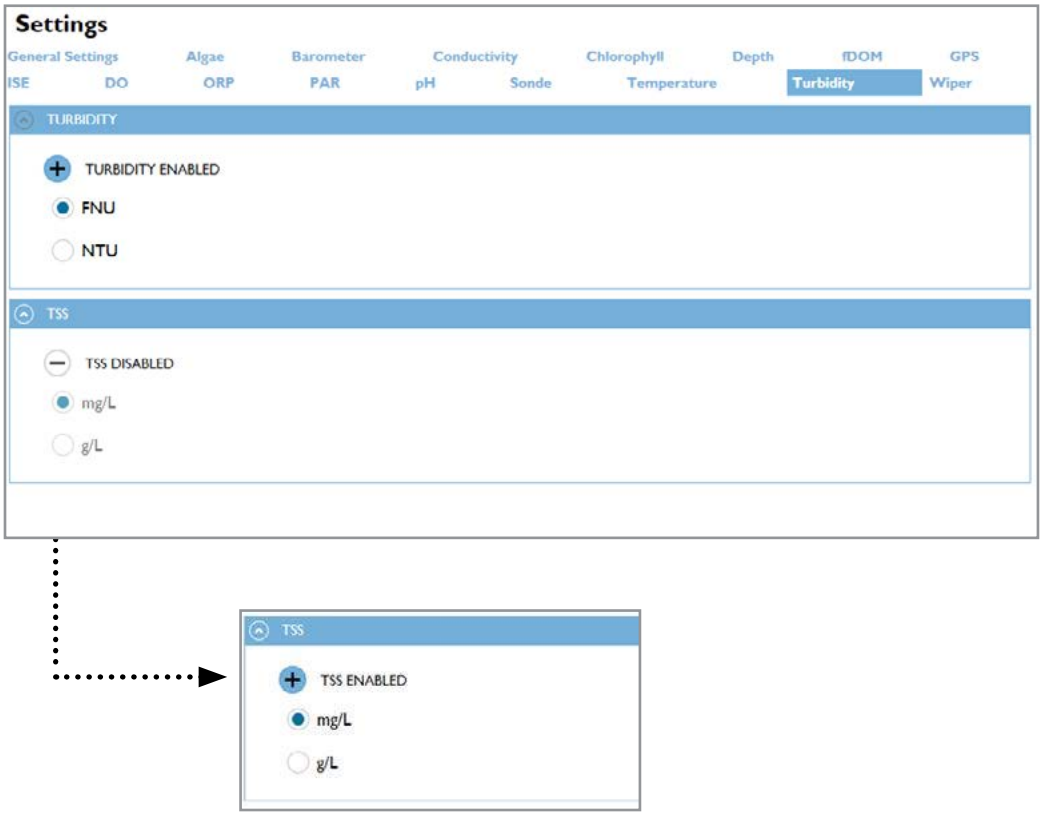
A message box appears which states that the coefficients have been successfully applied to the sensor. The coefficients are also displayed.

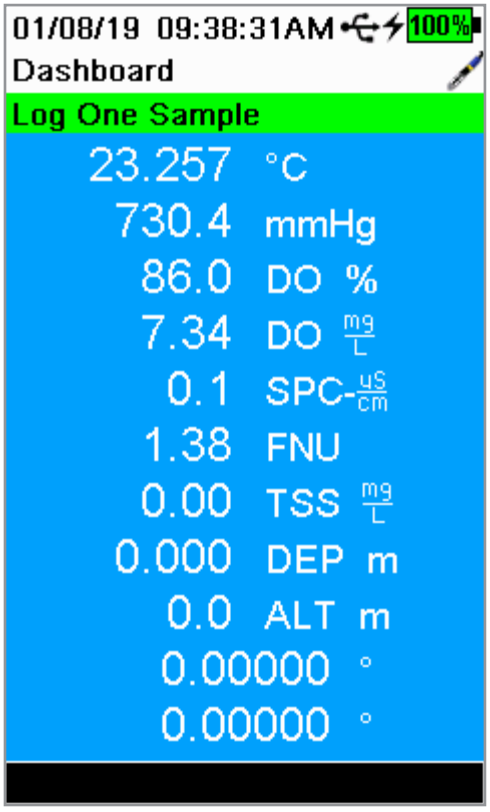
Step 6

TSS values will now be displayed on the Dashboard based on the values entered via KorEXO and saved to the turbidity probe.

Step 7

If the TSS parameter is not displayed on the Dashboard, go to File>Settings>Turbidity, and click the "-" sign next to TSS Disabled to activate the TSS parameter. A "+" sign will appear and TSS Enabled will be displayed. Click Save and return to the Dashboard.





Step 8

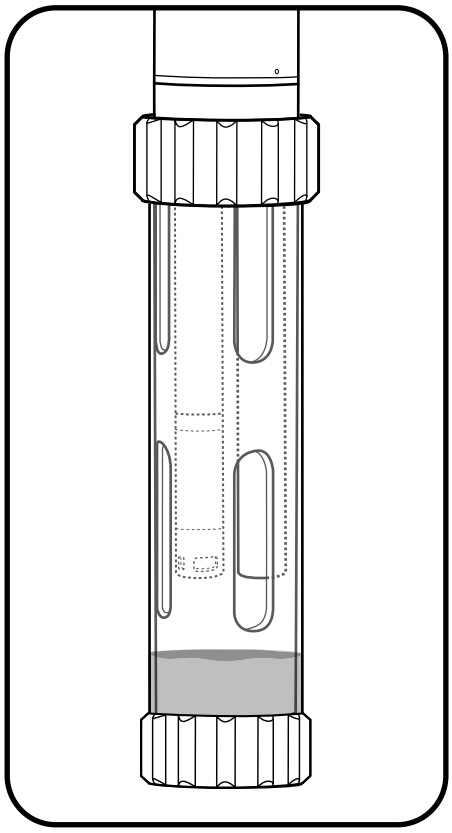
The units to display TSS will need to be activated separately in the EXO handheld. To add the TSS parameter to the handheld, navigate to Handheld> Display>Units>Turbidity>TSS and choose which unit to display. Click "Esc" to return to the live data dashboard. TSS will be displayed.

If you wish to view the TSS coefficients in the handheld, navigate to Calibration>Turbidity>Setup and the TSS coefficients will be displayed.

Section 5
Maintenance

5.1 Sonde
Storage

Proper sonde storage helps to ensure proper sonde operation. To keep sondes in their best working order, users must follow these instructions. This section will identify storage as "long-term" or "short-term." Long-term denotes storage during times of long inactivity (over winter, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.).



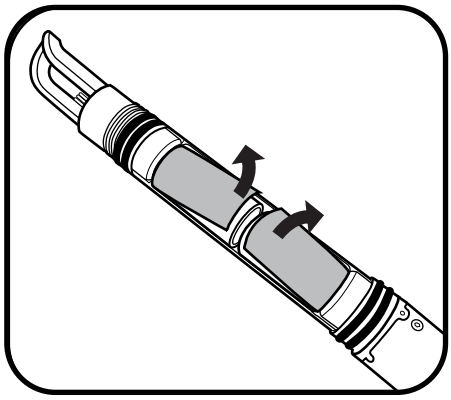
1 Short-term storage

For interim storage, users should keep sensors moist, but not submerged; submersion during storage may produce sensor drift. Users should aim for a storage environment of water-saturated air (100% humidity) for the sensors.

Place approximately 0.5 in (1 cm) of water (deionized, distilled, tap, or environmental) in the bottom of the calibration cup. Then place the sonde with all of its sensors into the cup and close it tightly to prevent evaporation. Users can also use a moist sponge to create a humid environment.

Ensure that unused sensor ports are properly protected with port plugs. The sonde itself should be stored in dry air.

To protect the cable connector, either leave the cable installed on the connector, or install the port plug. This is especially important for sondes with level; users should always keep the cable connector of vented sondes dry. (See Section 6.5)



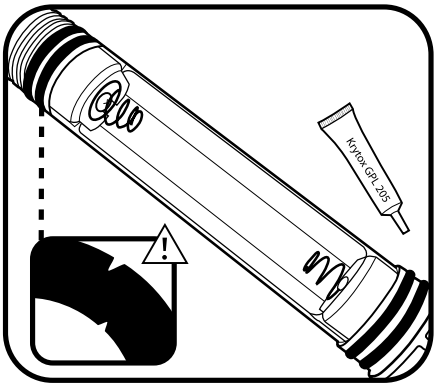
2 Long-term storage

Store all removed sensors according to the specific instructions in their sensor storage section. Plug all open ports, and store the sonde according the above instructions for short-term sonde storage.

NOTICE: Always remove batteries from sondes during long periods of inactivity to prevent potentially harmful battery leaks.

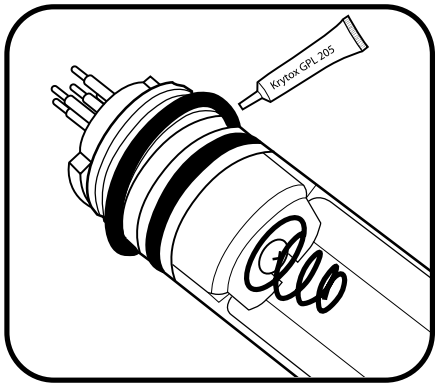
5.2 Sonde
Maintenance

Like all precision equipment, EXO sondes work most reliably when users maintain them properly. A proper inspection and cleaning can prevent several issues, including leaks. When performing general maintenance on the sonde, also check this manual's depth and connector sections. Use only the recommended materials to service instruments. Each sonde comes with a maintenance kit, including proper lubricants and replacement o-rings. Users can order replacement o-ring kits (599680 or 599681) or tool kit (599594) from the manufacturer or an authorized distributor.



1 Inspect and service o-rings

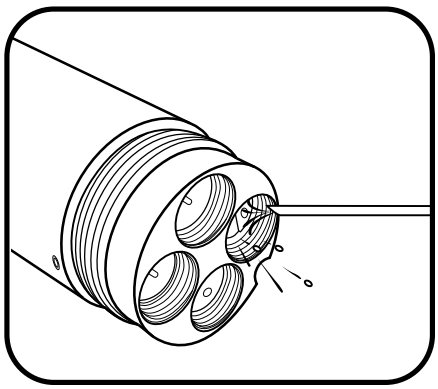
User-serviceable o-rings are located in the EXO sonde battery compartments. Perform a thorough visual inspection of o-rings each time they are exposed. Carefully look for grit, hair, etc. on the o-ring and mating surfaces and wipe away any contamination with a lint-free cloth. Without removing them from their grooves, *lightly* grease each o-ring with Krytox. Replace any damaged o-rings.



2 Replace o-rings

If the above inspection reveals a damaged (split, cracked, or misshapen) o-ring, remove it. Wipe the groove clean with alcohol and a lint-free cloth. Grease the o-ring by drawing it between your *lightly* greased thumb and index fingers. Place the o-ring in its groove, being careful to not roll or twist it, and lightly grease the surface. Inspect the o-ring for contamination.

NOTICE: Do not apply excess grease to the o-rings. This can cause contamination and seal failure.



3 Inspect, clean, and grease ports

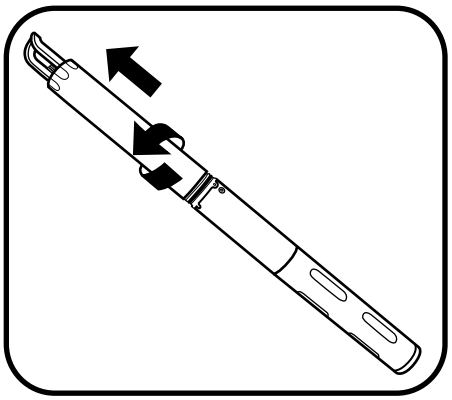
Visually inspect each port for contamination (grit, hair, etc.). Should the user detect contamination, remove it with a blast of compressed air. When the port's rubber appears dry, lightly grease the sensor connector before insertion.

NOTICE: Never insert solid objects into the sonde ports. This could permanently damage the connectors.

5.3 Sonde

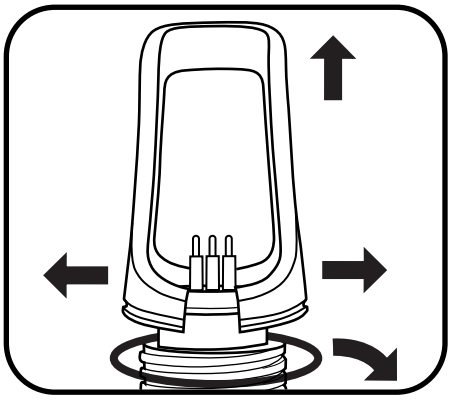
Replace EXO1 Sonde Bail

Sonde bails provide users with a handle for convenient transport and an attachment point for cable strain reliefs. If an EXO1 bail breaks due to impact or standard wear and tear throughout the life of the sonde, a user can easily replace it. We also recommend attaching the cable's strain relief mechanism to the bail.



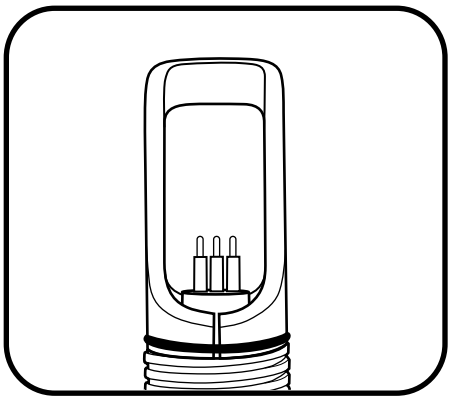
1 Remove battery cover

Twist the battery cover counterclockwise until free. Then slide off the battery cover.



2 Remove bail

Spread the sides of the bail away from the connector, pull the bail over the posts on top of the sonde, and remove the o-ring from its groove and discard.



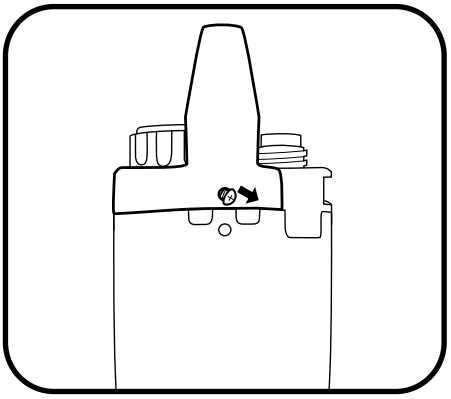
3 Install new bail

Install a new o-ring in the groove at the base of the bail. Then carefully spread the bail open and seat its sockets over the posts around the connector.

5.4 Sonde

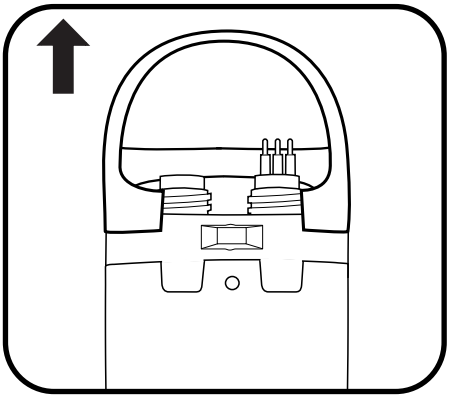
Replace EXO2 and EXO3 Sonde Bail

Sonde bails provide users with a handle for convenient transport and an attachment point for cable strain reliefs. If an EXO2 or EXO3 bail breaks due to impact or standard wear and tear throughout the life of the sonde, a user can easily replace it. We also recommend attaching the cable's strain relief mechanism to the bail.

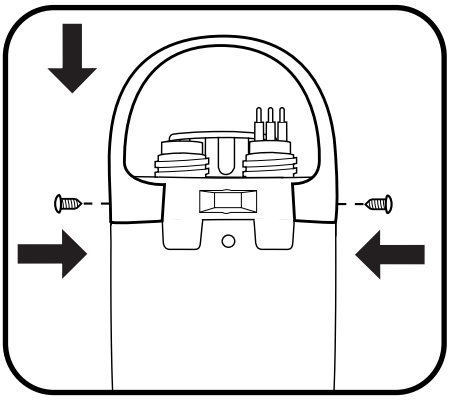


1 Remove bail

Use a small screwdriver to remove two screws on the sides of the bail.



Once screws are removed, lift the bail off the sonde.



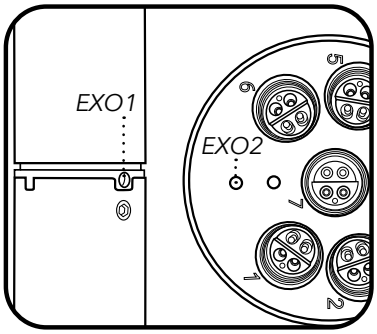
2 Install new bail

Place the new bail onto the sonde, aligning holes for the screws. With one side of the bail aligned, push on the other side to snap it into place. Use a small screwdriver to insert two screws on the sides of the bail. Tighten until snug.

5.5 Depth and Level Sensor

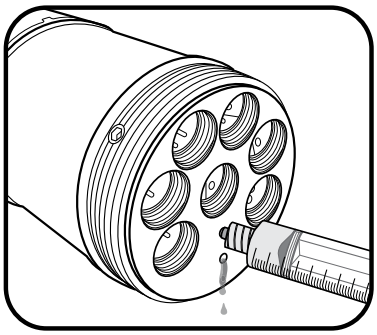
Maintenance and Storage

EXO depth and level sensors access the water through small holes (ports) located in the sonde body or bulkhead. Although users cannot access them directly, proper storage and maintenance will help to ensure reliable operation. Depth sensors can be stored dry, in water-saturated air, or submerged in clean water. However, be sure that the water does not contain solutions that are corrosive. This can cause damage to the sensor's strain gauge.



1 Locate depth ports

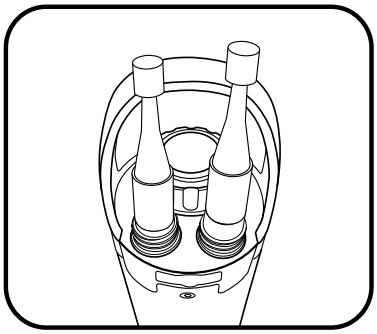
The two EXO1 depth ports are located in the yellow-plastic section between the bulkhead tube (labeled area) and the blue plastic battery cover. The EXO2 / EXO3 depth ports are located on the metal bulkhead face itself, in the largest open area between ports.



2 Clean depth ports

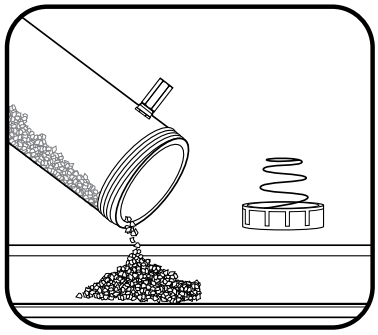
Although users cannot directly access the depth/level sensors, they should periodically clean them with the syringe included in the EXO tool kit (599594). Fill the syringe with clean water and gently force water through one of the ports. Ensure that water flows from the other hole. Continue flushing the port until the water comes out clean.

NOTICE: Do not insert objects in the depth ports, as this may cause damage to the transducer not covered under the warranty.



3 Level sensor storage

Users can store these sensors either dry or submerged in clean water. However, regardless of storage method or length, ensure the vent tube remains dry. Always attach the port plug to the cable connector, or leave the cable installed with a cap over the desiccant's vent.



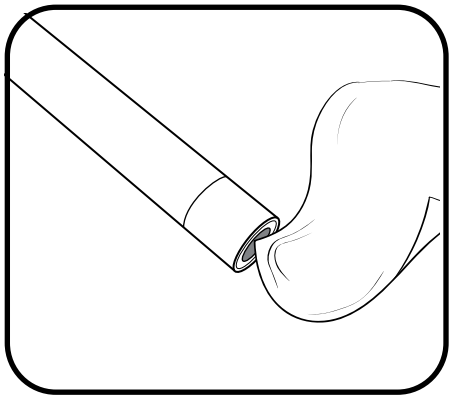
4 Level desiccant maintenance

Active desiccant is blue; saturated desiccant is pink. When the desiccant closest to the sonde begins to turn pink, you should replace (YSI 6108), or regenerate (YSI 6109) the desiccant cartridge. To regenerate desiccant, remove it from the cartridge and heat it for one hour at 200°C (about 400°F); then cool it in an airtight container before refilling. Also heat the felt filters at 100°C (about 200°F) for 30 minutes. The desiccant will turn blue following a successful recharge.

5.6 Standard Optical Sensors

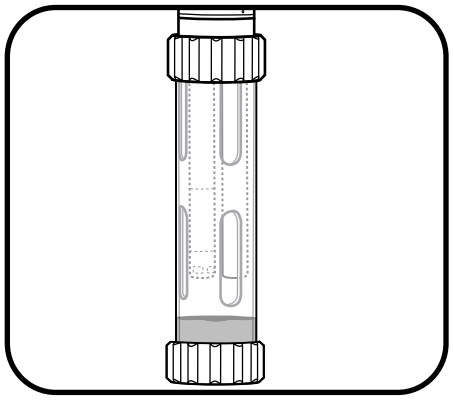
Maintenance and Storage

Standard optical sensors include Turbidity, Total Algae, and fDOM sensors; these optical sensors are very low maintenance. This section identifies storage as "long-term" or "short-term." Long-term denotes storage during times of long inactivity (over winter, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.). Maintain connectors as instructed in Section 5.17.



1 Clean sensing window

Turbidity, Total Algae, and fDOM require minimal maintenance. Users should periodically inspect the optical surface at the tip of the sensor and wipe it clean with a non-abrasive, lint-free cloth if necessary. As much as possible, prevent scratches and damage to the sensing window.



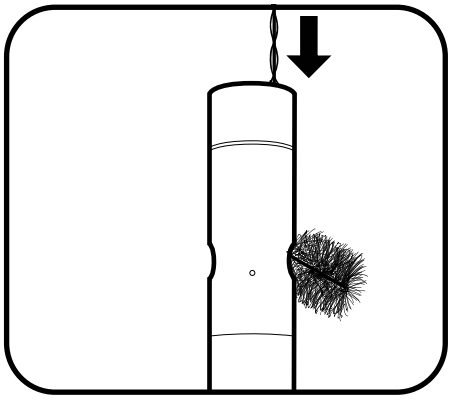
2 Long- and short-term storage

Turbidity, Total Algae, and fDOM require minimal precautions. Users can either remove the sensors or leave them installed in the sonde for long- and short-term storage. If left installed on the sonde, follow guidelines for sonde storage. If users remove them from the sonde, the sensors may be stored in dry air in their shipping cap (to protect against physical damage).

NOTICE: Do not store any sensor in quinine sulfate solution.

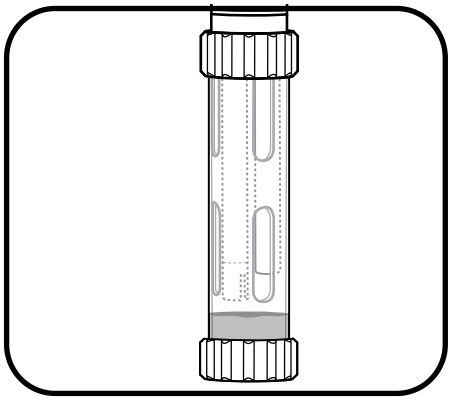
5.7 Conductivity/Temp Sensor
Maintenance and Storage

EXO conductivity and temperature (CT) sensors require little maintenance or special attention for storage. As much as possible, prevent impact to the sensor's exposed thermistor. This section will identify storage as "long-term" or "short-term." Long-term denotes storage during times of long inactivity (over-wintering, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.). Maintain connectors as instructed in Section 5.17.



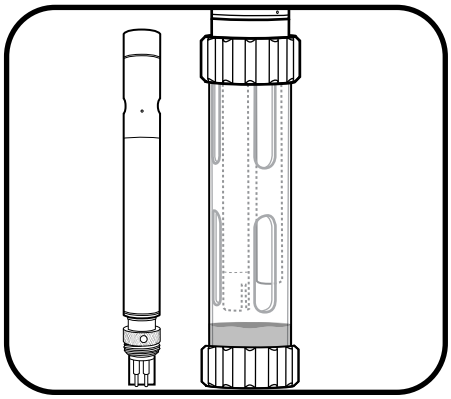
1 Clean electrode channels

The only parts of the CT sensor that require special maintenance are the channels leading to the internal electrodes. Dip the sensor's cleaning brush (included in the sonde maintenance kit) in clean water, insert at top of channels, and sweep the channels 15-20 times. If deposits have formed on the electrodes, use a mild solution of dish soap and water to brush the channels. If necessary, soak in white vinegar to aid cleaning. Rinse the channels with clean water following the sweepings or soak.



2 Short-term storage

When in regular field use, the sensor should remain installed on the sonde in an environment of water-saturated air. Place approximately 0.5 in (1 cm) of any water (deionized, distilled, tap, or environmental) in the bottom of the calibration cup. Insert the sonde and sensor into the cup and screw it on tightly to prevent evaporation. (More information in "Short-Term Sonde Storage" Section 5.1.)



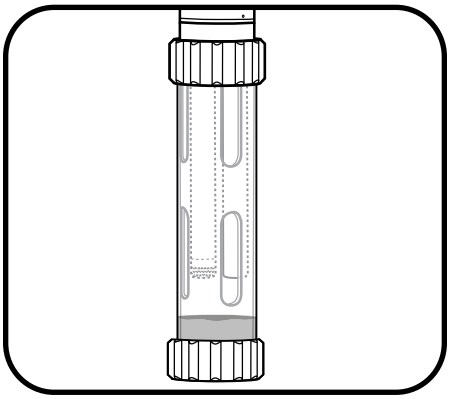
3 Long-term storage

Store the sensors either dry or wet, installed on the sonde or detached. However, before storage, perform the recommended maintenance (above) to ensure the sensor is in good working order for the next deployment season. If the sensor is submerged for storage, ensure that the liquid is not corrosive.

5.8 Dissolved Oxygen Sensor

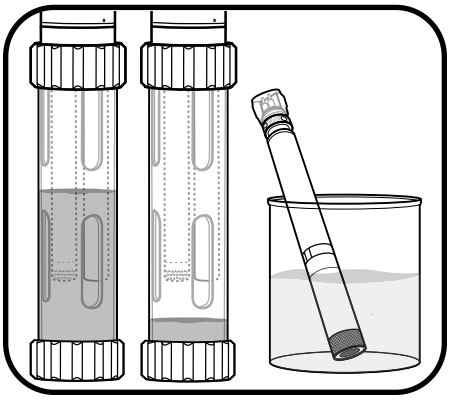
Storage

EXO DO sensors require separate storage instructions from other optical sensors due to their sensing membranes. This section will identify storage as “long-term” or “short-term.” Long-term denotes storage during times of long inactivity (over winter, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.).



1 Short-term storage

When in regular field use, the ODO sensor should remain installed on the sonde. Place approximately 0.5 in (1 cm) of any water (deionized, distilled, tap, or environmental) in the bottom of the calibration cup. Insert the sonde and sensor into the cup and screw it on tightly to prevent evaporation. (More information in “Short-Term Sonde Storage” Section 5.1.)



2 Long-term storage

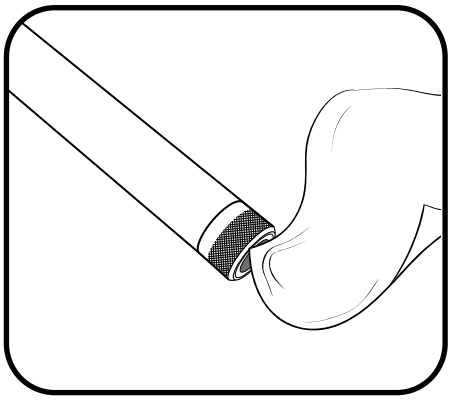
Leave the sensor installed in the sonde, and submerge it in clean water in the calibration cup. Screw the cup on tightly to prevent evaporation. Users may also store the ODO sensor by itself in two ways. One, submerge the sensing end of the sensor in a container of water; occasionally check the level of the water to ensure that it does not evaporate. Two, store the sensor in water-saturated air.

We do not recommend storing the sensor with the connector end unmated or exposed. If unmated, cover with plastic connector cap.

5.9 Dissolved Oxygen Sensor

Maintenance and Rehydration

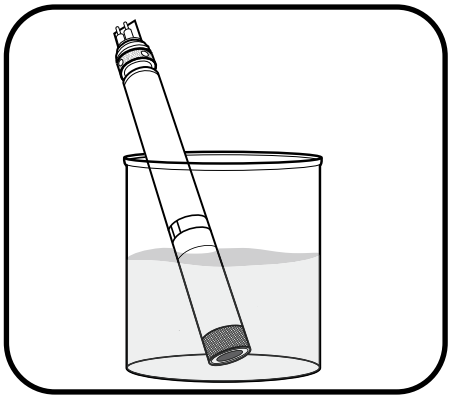
EXO optical Dissolved Oxygen (DO) sensors require unique maintenance instructions due to their sensing membranes. Users should routinely perform these steps in order to achieve the highest levels of sensor accuracy. DO sensor caps have a typical life of 12 months. After this point, users should replace the DO membrane cap. As caps age, accuracy may be reduced, ambient light rejection suffers, and response times can be affected. Maintain connectors as instructed in Section 5.17.



1 DO membrane maintenance

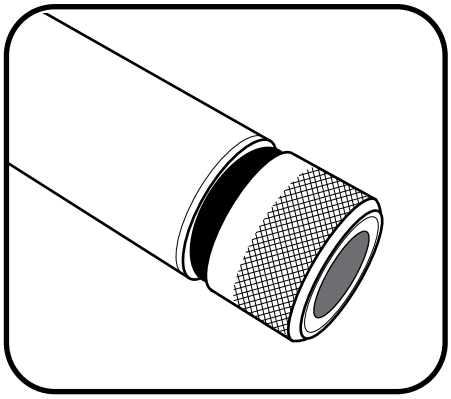
Users should periodically inspect the optical surface at the tip of the sensor and wipe it clean with a non-abrasive, lint-free cloth if necessary. Never use organic solvents to clean an EXO DO sensor.

As much as possible, prevent scratches and damage to the sapphire sensing window. Avoid getting fingerprints on the window. If necessary, wash with warm water and dish soap and rinse with DI water.



2 Sensor rehydration

Users should always store DO sensors in a moist or wet environment in order to prevent sensor drift. However, should DO sensors be left in dry air for longer than eight hours, they must be rehydrated. To rehydrate, soak the DO sensor cap in warm (room temperature) tap water for approximately 24 hours. Following this soak, calibrate the sensor and store it in a moist environment.



3 Sensor cap replacement

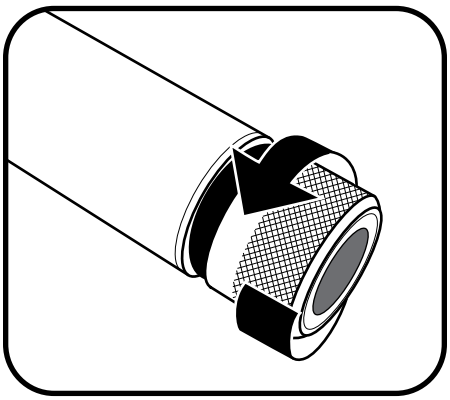
DO sensor caps have a typical life of 12 months. After this point, users should replace the DO membrane cap. To replace this cap, follow the directions in the "Sensor Cap Replacement" section found on the next page.

5.10 Dissolved Oxygen Sensor

Sensor Cap Replacement

Follow these instructions to replace the sensor cap on an EXO optical dissolved oxygen sensor once the previous cap has exhausted its usable life (typically about one year). The DO sensor cap (599110-01) is shipped in a humidified container, and should be stored in a 100% humid environment.

NOTE: *Keep the instruction sheet shipped with the DO sensor cap as it contains the unique coefficients required for calibration.* If the sensor cap dries completely, follow instructions to rehydrate it.



1 Remove current sensor cap

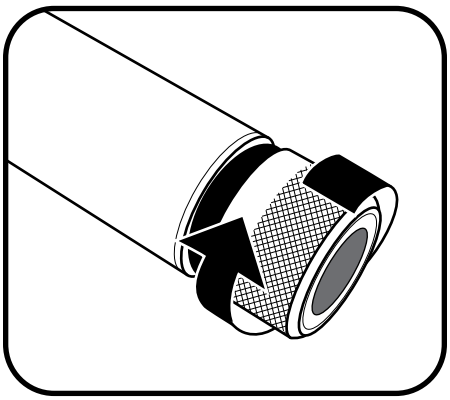
Rotate the sensor cap with your fingers counterclockwise until free.

If possible, do not use any tools during this process. However, should the cap be immovable after use, carefully twist the sensor cap with pliers until it breaks loose.

NOTICE: Do not use pliers on the sensor body, and take great care not to damage the sensor threads.

2 Replace o-ring

Without using tools, remove the previous o-ring (pinch the o-ring out, then roll it upwards over the threads) and discard it. Visually inspect the new o-ring for nicks, tears, contaminants, or particles; discard damaged o-rings. Without twisting it, carefully install the new o-ring over the threads and into its groove, then apply a thin coat of Krytox lubricant to the o-ring only.



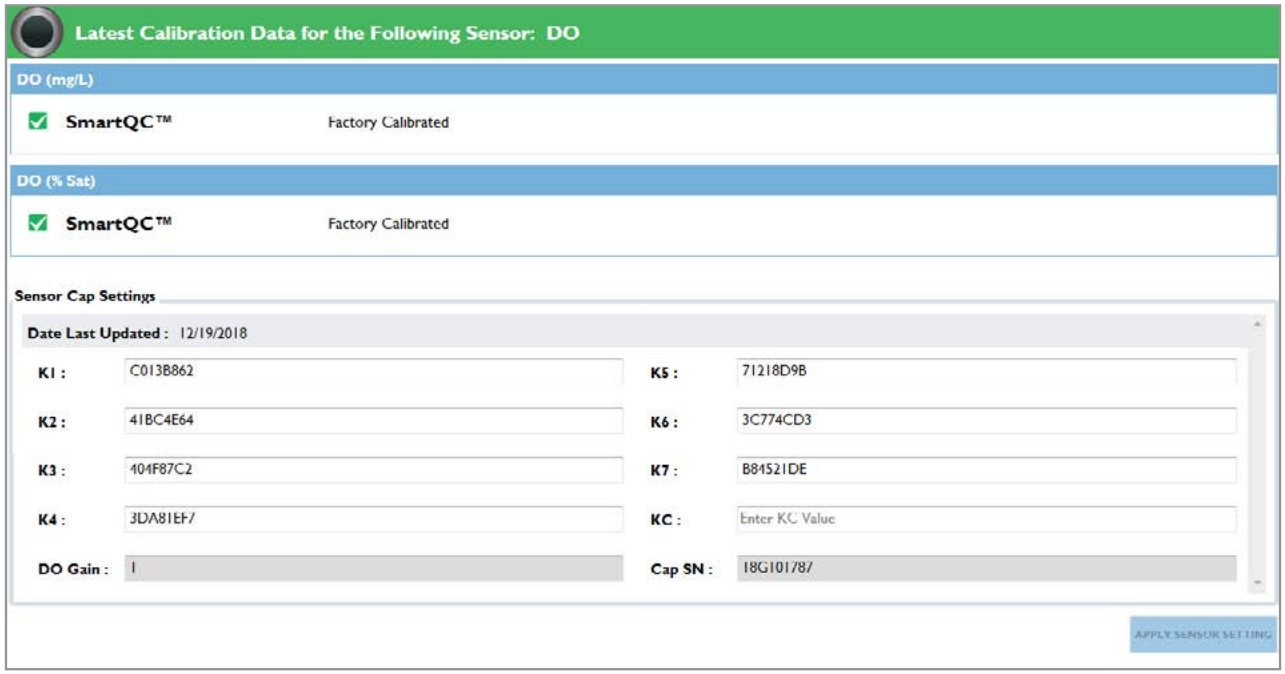
3 Install new sensor cap

After the o-ring is installed and lubricated, wipe the clear window at the end of the sensor with a lint-free cloth until clean. Then dry the inside cavity of the sensor cap with a lint-free cloth. With a clockwise motion, thread the new sensor cap onto the sensor until it is finger-tight. The o-ring should now be compressed between the sensor cap and sensor, and not pinched. If pinched, remove and discard the o-ring and repeat procedure.

NOTICE: Do not over-tighten the sensor cap. Do not use any tools for the installation process.

4 Configure sonde for new cap

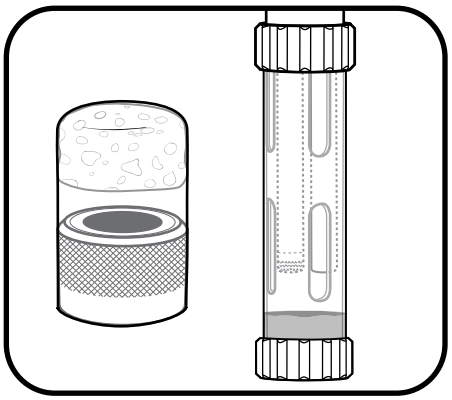
Connect the sonde to KorEXO and navigate to the Instrument and Sensors tab. Select the ODO sensor.



In the DO screen, enter the unique membrane cap coefficients found on the instruction sheet shipped with the DO sensor cap. Click Apply Sensor Settings to save the changes.

NOTE: *Calibration coefficients are associated with specific individual sensor caps. They cannot be used for other ODO sensors.*

Although measures are taken at the factory to ensure this, please check that the serial number with the calibration coefficients on the instruction sheet matches the serial number engraved on the outside of the sensor cap.



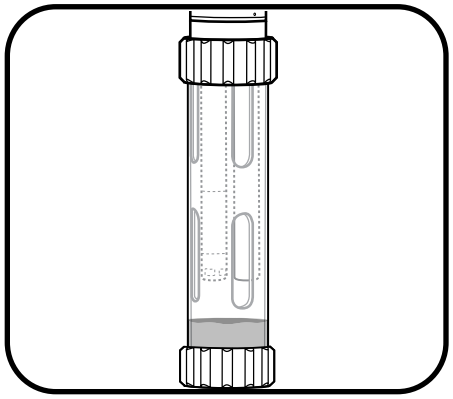
5 Store sensor cap

The sensor cap is shipped in a humidified container, and should be consistently stored in a 100% humid environment. Prior to installation, ensure the cap's container remains moist. Once the sensor cap is installed on the sensor, maintain this environment by placing approximately 0.5 in (1 cm) of water (deionized, distilled, tap, or environmental) in the bottom of the calibration cup and screw it tightly onto the sonde to prevent evaporation. You may also store the sensor by submerging the cap end in water.

NOTICE: If pH sensor is also installed, do not submerge it in *distilled* water.

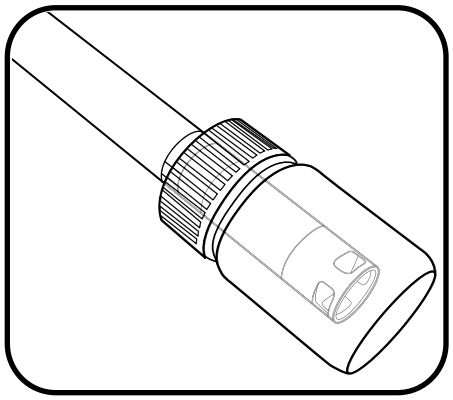
5.11 pH and pH/ORP Sensors
Storage and Rehydration

pH and pH/ORP sensors have two specific storage requirements: they should not be stored in distilled or deionized water and their reference electrode junction should never dry out. This section will identify storage as "long-term" or "short-term." Long-term denotes storage during times of long inactivity (over-wintering, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.).



1 Short-term storage

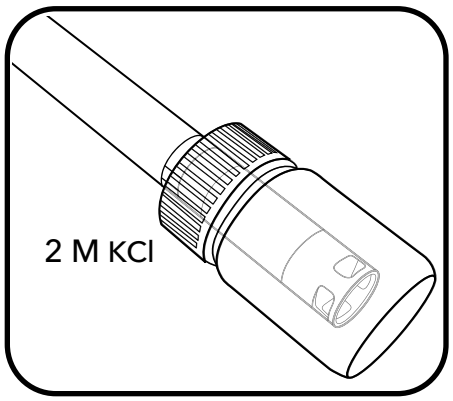
When in regular field use, the sensor should remain installed on the sonde in an environment of water-saturated air. Place approximately 0.5 in (1 cm) of any water (deionized, distilled, tap, or environmental) in the bottom of the calibration cup. Insert the sonde and sensor into the cup and screw it on tightly to prevent evaporation. (More information in "Short-Term Sonde Storage" Section 5.1.)



2 Long-term storage

Remove the sensor from the sonde and insert its sensing end into the bottle that the sensor was shipped in. Install the bottle's o-ring and cap then tighten. This bottle contains a 2 molar solution of pH 4 buffer. If this solution is unavailable, users may store the sensor in tap water.

NOTICE: Do not store the pH or pH/ORP sensor in Zobell solution, DI or distilled water.

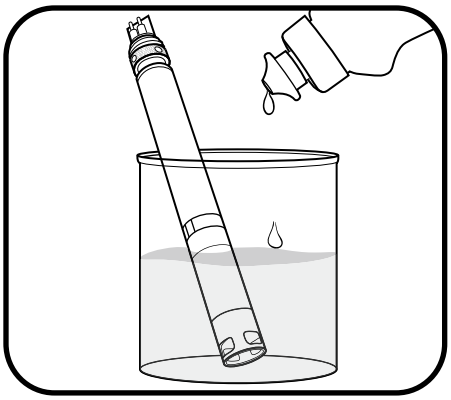


3 Rehydrate reference junction

If the pH sensor has been allowed to dry, soak the sensor for several hours (preferably overnight) in a 2 molar (2 M) solution of potassium chloride (KCl). In order to create a 2 M KCl solution, dissolve 74.6 g of KCl in 500 mL of distilled or deionized water. If KCl is unavailable, a tap water or pH 4 buffer soak may restore function. If the sensor is irreparably damaged, users must replace the sensor module.

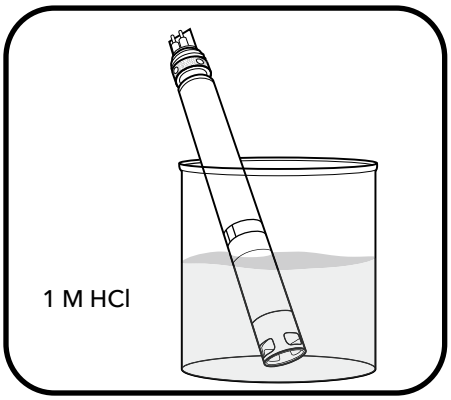
5.12 pH and pH/ORP Sensors
Maintenance

pH and pH/ORP sensors will require occasional maintenance to clear contamination from the sensing elements. These contaminants can slow the sensor's response time. Clean the sensors whenever deposits, biofouling, or other contamination appear on the glass, or when the sensor's response time slows perceptibly. Remove the sensor from the sonde before performing the following cleaning steps. Do not attempt to physically scrub or swab the glass bulbs. The bulbs are very fragile and will break if pressed with sufficient force. Maintain connectors as instructed in Section 5.17. Replace depleted sensor module as instructed in Section 5.14.



1 Soak in dishwashing liquid solution

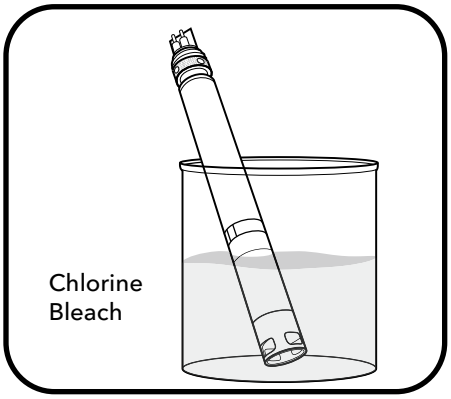
Soak the sensor for 10-15 minutes in a solution of clean tap water and a few drops of dishwashing liquid. Following the soak, rinse the sensor with clean water and inspect. If contaminants remain or response time does not improve, continue to the HCl soak.



2 Soak in HCl solution

Soak the sensor for 30-60 minutes in one molar (1 M) hydrochloric acid (HCl). This reagent can be purchased from most distributors. Following the HCl soak, rinse the sensor in clean tap water and allow it to soak for an hour in clean water. Stir the water occasionally. Then, rinse the sensor again in tap water and test response time. If response time does not improve or you suspect biological contamination of the reference junction, continue to the next soak. If HCl is not available, soak in white vinegar.

⚠ **WARNING:** Follow the HCl manufacturer's instructions carefully to avoid personal harm.

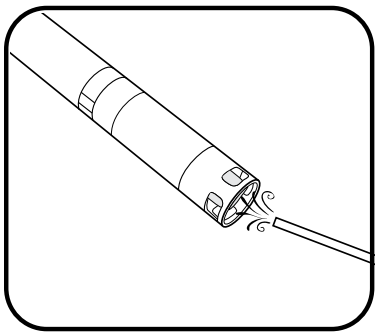


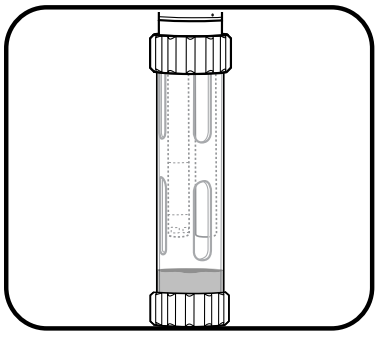
3 Soak in chlorine bleach solution

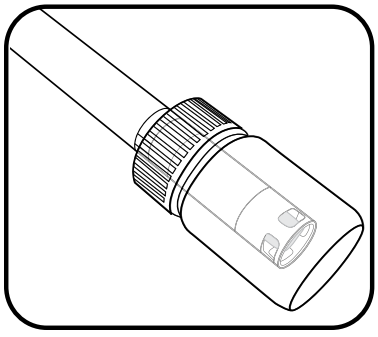
Soak the sensor for approximately one hour in a 1:1 dilution of chlorine bleach and tap water. Following the soak, rinse the sensor in clean tap water and allow it to soak for at least one hour in clean water (longer if possible). Then, rinse the sensor again in tap water and test response time.

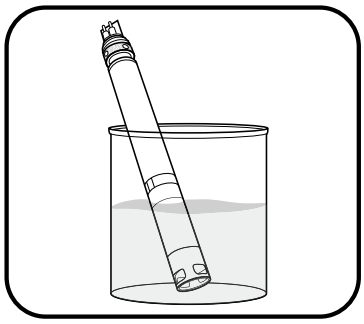
5.13 ISE Sensors
Maintenance and Storage

EXO ammonium, nitrate, and chloride sensors utilize ion-selective electrodes (ISEs) to monitor these parameters. One key requirement of storage, short or long-term, for these sensors is that their reference electrode junctions should never dry out. This section will identify storage as "long-term" or "short-term." Long-term denotes storage during times of long inactivity (over-wintering, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.) Replace depleted sensor module as instructed in Section 5.14.









1 Sensor maintenance

Ammonium or Nitrate sensor: When deposits, biofouling, or other contamination appear on the membrane, users should *gently* remove them with a fine jet of deionized water or rinsing in alcohol followed by soaking in the high standard calibration solution. Gently dab dry with a lint-free tissue.

Chloride sensor: When deposits, biofouling, or other contamination appear on the membrane, users should *gently* remove them by washing with alcohol and/or gently polishing with fine emery paper in a circular motion to remove deposits or discoloration, then thoroughly washing with deionized water to remove any debris.

NOTICE: The ion-selective membranes are very fragile. Do not use coarse materials (e.g. paper towels) to clean the membranes, as these could permanently damage the sensor. The exception is fine emery paper for the chloride sensor, noted above.

2 Short-term storage

When in regular field use, the sensor should remain installed on the sonde in an environment of water-saturated air. Place approximately 0.5 in (1 cm) of any water (deionized, distilled, tap, or environmental) in the bottom of the calibration cup. Insert the sonde and sensor into the cup and screw it on tightly to prevent evaporation. (More information in "Short-Term Sonde Storage" Section 5.1.)

3 Long-term storage

Users should remove the sensors from the sonde and place them in their storage bottle (installed on sensor during shipping) with a small amount of tap water or calibration standard. The sensors should not be immersed in water.

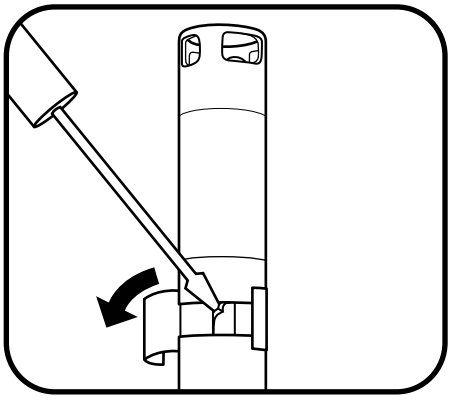
NOTICE: Do not store the ISE sensors in conductivity standard, pH buffer, salt water, or any solution with significant conductivity.

4 Rehydrate reference junction

If an ISE sensor has been allowed to dry, soak the sensor for several hours (preferably overnight) in the sensor's high-calibration solution. If the sensor is irreparably damaged, users must replace the sensor module.

5.14 Sensor Module Replacement

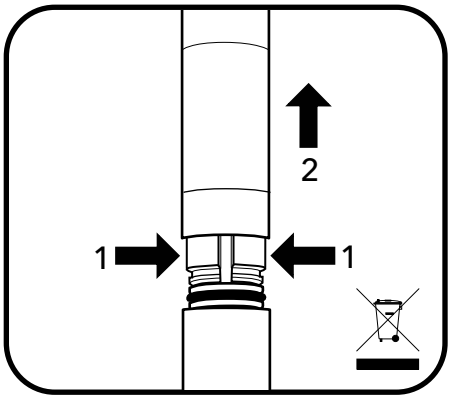
EXO pH, pH/ORP, ammonium, nitrate, and chloride sensors feature replaceable sensor modules (#599795, 599797, 599743-01, 599744-01, 599745-01) due to the electrolyte-depleting characteristics necessary to make such measurements. We recommend that users replace these modules as necessary–typically 12 to 18 months for pH and ORP and three to six months for ISEs, when stored properly. Working life will depend on the conditions of the deployment environment. Perform this procedure in a clean, dry laboratory environment.



1 Remove old sticker and plug

Peel off and discard the old sticker that covers the junction of the sensor body and the module. Then, with a small, flat-blade screwdriver, remove the small rubber plug from the gap in the hard plastic ring at the base of the sensor module.

⚠ **CAUTION:** Always exercise extra care when using sharp or potentially harmful instruments.

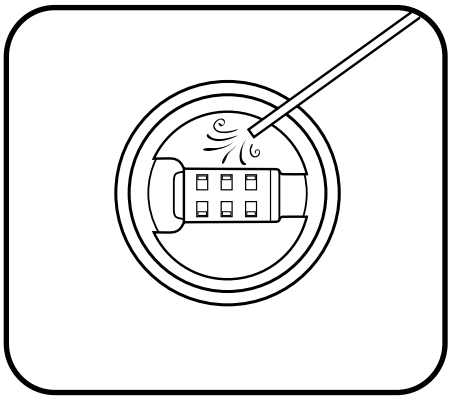


2 Remove and discard old sensor module

To remove, perform two motions simultaneously.

1. With your fingers, squeeze the sensor module's hard plastic ring so that it compresses the gap left by the rubber plug.
2. Steadily pull the sensor module straight back from the sensor body, rocking slightly if necessary.

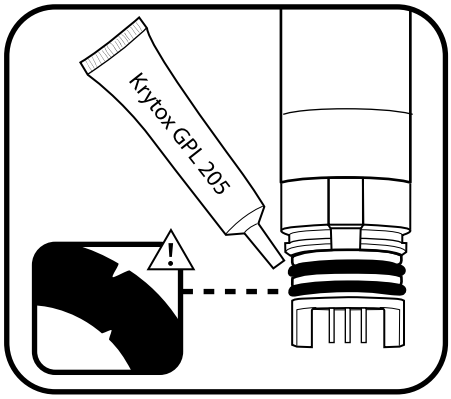
NOTICE: The act of removing the old sensor module renders the o-rings on the module unusable. To prevent catastrophic leaks, do not attempt to reinstall a module with damaged o-rings. Discard the module and the old o-rings according to your organization's guidelines, or return it to manufacturer for recycling.



3 Inspect and service connector cavity

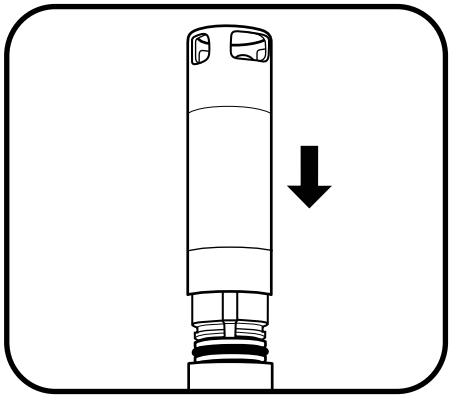
Inspect the connector cavity of the probe body for debris or moisture.

If detected, remove it with a lint-free cloth or a gentle blast of compressed air.



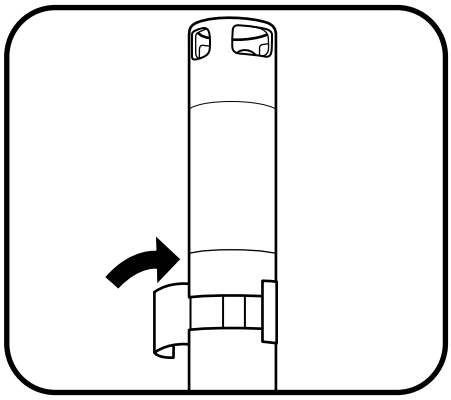
4 Inspect and service new sensor module's o-rings

Ensure that the two o-rings are not nicked or torn and have no contaminants or particles on them. If the user detects damage, carefully replace them with the extras included in the sensor module kit. Then apply a thin coat of Krytox® lubricant to each o-ring. If a user removes a sensor module that is in good working order, replace the o-rings before use.



5 Insert new sensor module

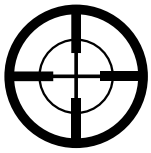
Align the prongs on the base of the module with the slots in the sensor body. The sensor module is keyed to insert in only one orientation. Once the module is aligned, press it firmly into position until it clicks. Wipe away any excess grease from the assembled components.



6 Apply new sticker

Wrap the junction of the sensor module and the body with the new sticker included in the sensor module kit. This sticker helps keep the sensor module junction clean and retains the rubber plug throughout deployment.

On the sticker, use a permanent marker to write the date the replacement module was installed, as a reminder.

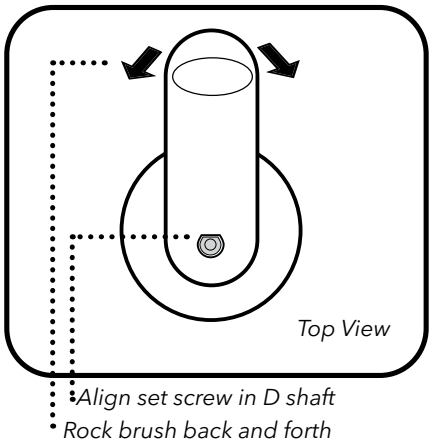


7 Re-calibrate the sensor

Using KorEXO software, calibrate the sensor following each sensor module replacement. After calibration, the sensor is ready for field use.

5.15 EXO Central Wiper
Maintenance and Storage

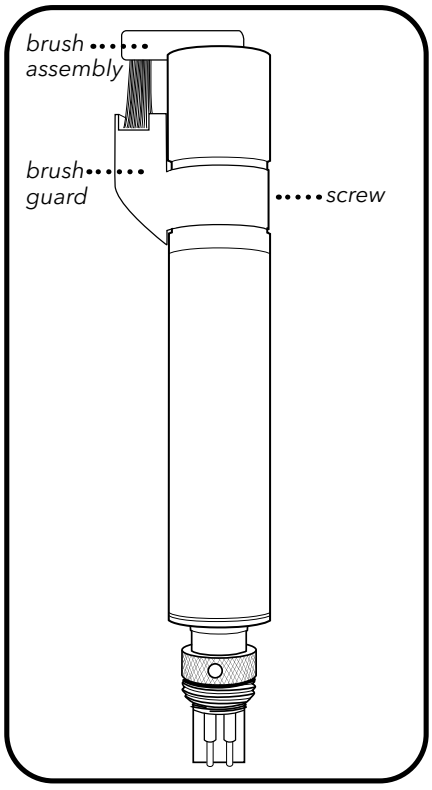
Follow these instructions to replace the wiper brush assembly or brush guard component on the central wiper.
We recommend changing the brush between deployments to avoid sediment carryover, which can compromise calibration and data collection. For long- and short-term storage, the wiper requires minimal precautions. Users can either remove the wiper or leave it installed in the sonde. If left installed on the sonde, follow guidelines for sonde storage. If users remove it from the sonde, the wiper may be stored in dry air in its shipping cap to protect against physical damage.



1 Replace wiper brush

Loosen set screw with a 0.050 inch Allen wrench. Remove old brush assembly and clean any residue from wiper shaft and wiper end cap.
Install new brush assembly, gently pressing the wiper arm down against the shoulder on the wiper shaft.

Tighten set screw to a torque of 4 inch-pounds. While tightening, gently and slowly rock the brush to ensure a tight fit against the D shaft.
Check snugness of wiper by gently rocking 5 degrees in either direction.



2 Replace brush guard

In KorEXO software, go to Run > Dashboard. Click the Wipe Sensors button to ensure proper wiper park position.

Mark the position of the old guard with a marker.

Loosen the #6 screw with a 7/64 inch Allen wrench, remove the old guard and clean any residue from motor housing.

Remove the cover on adhesive strip on the inside of the new brush guard.

Carefully install the new brush guard in same position as old guard—with brush centered in well. Tighten screw until snug, but do not overtighten. (The adhesive helps to hold the guard in place.)

If necessary, calibrate the position of the new wiper in the KorEXO Calibrate menu.

NOTE: *The adhesive on the guard strap, which facilitates installation, may make it difficult to re-position the wiper guard after it's been installed. Take caution to mark the position of the old guard before removing it and install the new one in the same location. Confirm that the new guard is aligned with the 4-pin connector at the bottom of the probe as shown, and properly centered between ports 1 and 6 after the wiper has been installed in the sonde.*

Central Wiper O-Ring Replacement

In order to minimize the chance of water infiltration, YSI recommends annual replacement of the wiper shaft o-rings inside the EXO Central Wiper. This replacement must be performed by a YSI Authorized Service Center. EXO Authorized Service Centers are located in the United States and around the world. Please refer to the YSI website (**YSI.com/Repair**) for your nearest Authorized Service Center.

SmartQC for the Central Wiper

The central wiper has a QC score based on the expected voltage of the sensor when seated in the central wiper housing.

Green: The voltage when the wiper is seated in its housing is within the factory specified limits.

Yellow: The voltage when the wiper is seated in its housing is slightly outside of the factory specified limits.

1. Perform a Factory Reset Calibration.
2. Calibrate the central wiper so that it seats itself in the correct location.
3. Perform a series of wipes on the sonde to ensure that the wiper continues to reseat itself in the correct location after each wipe. Do not manually adjust the central wiper. The wiper calibration will associate a voltage to a location. Manually moving the wiper will negate the calibration. To perform a sensor wipe:
    a. In KorEXO: On Live Data screen, click the "Start Wiping" button
    b. On the Handheld: Click "Calibration" button, select "Wipe Sensors".

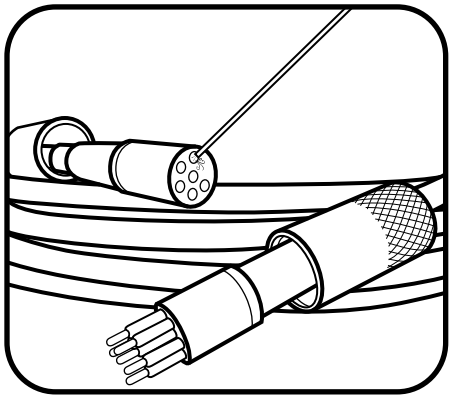
If the central wiper continues to show a yellow QC Score after recalibration, it is still able to be used and will wipe all of the sensors properly. However, the wiper may be nearing its time to be serviced in the factory.

Red: The voltage when the wiper is seated in its housing is significantly outside of the factory specified limits. Perform the same three steps described above for a Yellow QC score.

If the QC Score returns to red after the above procedures when performed, please contact YSI Technical Support for further assistance. It will possibly be recommended that the wiper should be returned to the factory for maintenance.

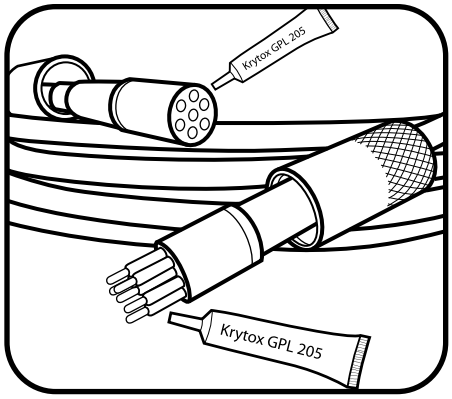
5.16 EXO Field Cable
Maintenance and Storage

EXO field cables are rugged and provide years of reliable service when properly maintained. As with all field cables, they are most vulnerable at their connectors. Take extra caution to protect the connectors from debris and physical harm.



1 Inspect and clean cables

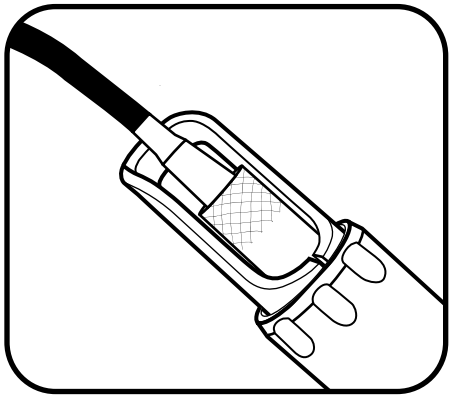
Inspect the cable's connectors for contamination and remove any detected debris with a blast of compressed air. Periodically inspect the cable for nicks and tears to ensure best performance.



2 Lubricate cable connectors

To maintain the cable assembly, users should also apply a thin coat of Krytox grease to both ends when they appear dried out.

NOTICE: It is better to apply too little grease than too much. Too much grease can encourage contamination.



3 Cable storage

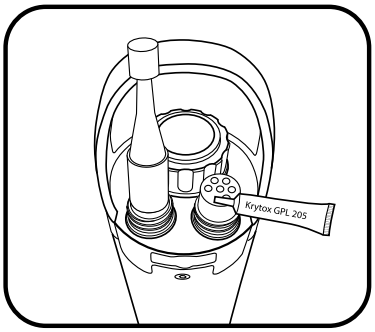
Users should leave the cable installed on the sonde to protect the connectors. If necessary users may remove it from the sonde, but extra care should be taken to protect the connectors. Store the cable in a safe location free from direct sunlight.

If the cable is vented, ensure the storage cap is affixed to the desiccant inlet. Store vented cables in a bag containing desiccant.

5.17 Connectors
Maintenance and Storage

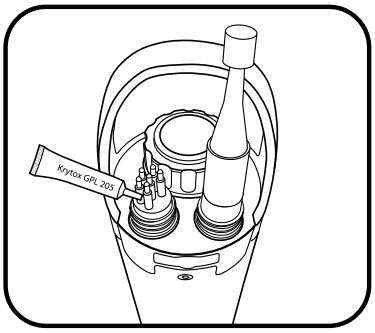
EXO sondes utilize wet-mate connectors that greatly reduce problems associated with traditional underwater connectors. However these connectors must be properly maintained to reap the full benefit of this design. Following these instructions will minimize most potential issues.

Never stick any foreign object into a female connector. Use only Krytox grease to lubricate the mating surfaces of the connectors.



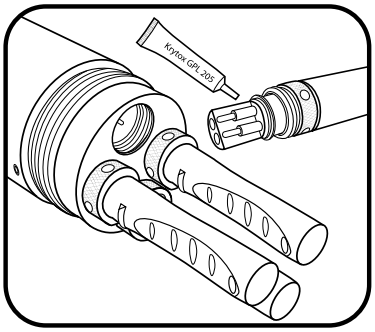
1 Female 6-pin connectors

These connectors are located on field cables, the EXO2 accessory connector, and the EXO Handheld. Periodically inspect the connectors for signs of contamination. If you detect debris, remove it with a gentle blast of compressed air. Prior to initial installation, or when dry, apply a light coat of Krytox grease to the flat rubber mating surface on top of the connector. When not in use, always install the connector's plug.



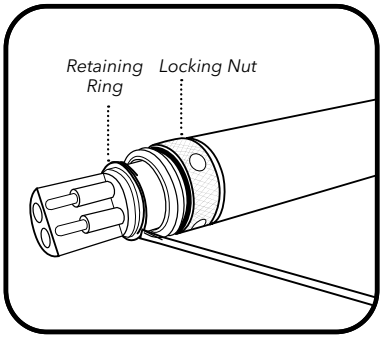
2 Male 6-pin connectors

These connectors are located on field cables and topside sonde connectors. Periodically inspect the connectors for signs of contamination. If you detect debris, carefully remove it. Prior to initial installation, or when dry, apply a light coat of Krytox grease to the rubber mating surfaces of the connector (including the rubber portions of the pins). When not in use, always install the connector's plug.



3 Sensor connectors (4-pin)

These connectors are located on sonde bulkheads (sockets) and sensors. Periodically inspect the female portions of these hermaphroditic connectors and the entire socket for contamination, and remove any debris with a gentle blast of compressed air. Prior to initial installation, or when dry, apply a light coat of Krytox grease to the rubber area of the sensor's connector.



4 Replace locking nut

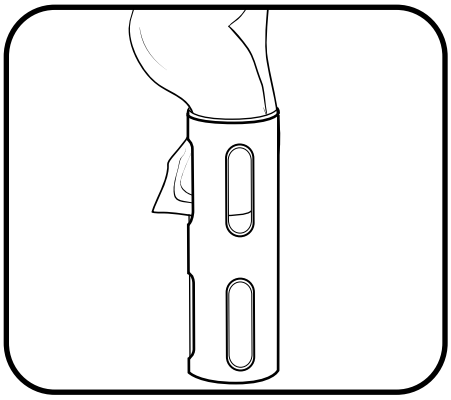
If the locking nut near the sensor connector wears out, users can replace it with 599668 (sensor) or 599669 (EXO central wiper).

First remove the retaining ring by inserting the tip of a small, flat-blade screwdriver under the lip of the ring and pry upward. Pull ring out of groove. Slide off locking nut and replace with new locking nut. Install new retaining ring by prying up one edge with screwdriver and fitting it into groove. Use the screwdriver to follow the diameter of the ring around the groove to seat it fully.

⚠ **CAUTION:** Wear eye protection when servicing the retaining ring.

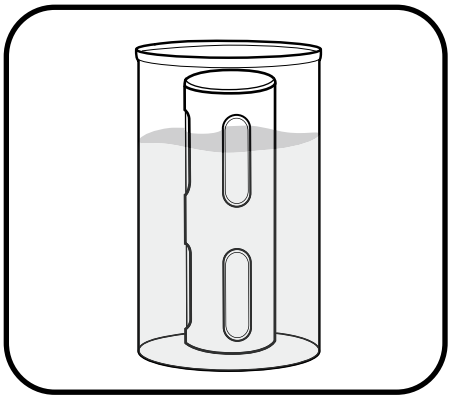
5.18 Antifouling Equipment
Maintenance

Many components on EXO sondes are made of an anti-fouling copper-alloy material that discourages the growth of aquatic organisms. However, longer deployment intervals and highly productive waters can result in biofouling of any equipment, so periodic cleaning may be required.



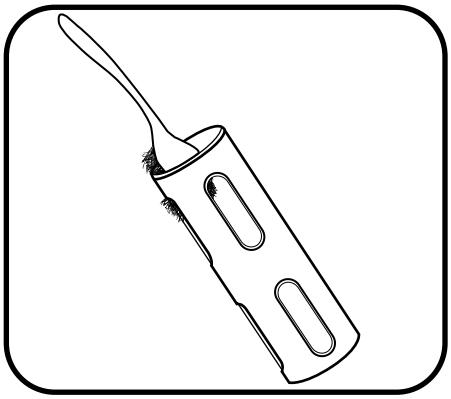
1 Remove minimal biofouling

Remove the antifouling sonde guard from the sonde. If the guard is covered in a thin layer of slime or filaments, wipe away the biofouling with a cloth soaked in clean water and a few drops of a dishwashing liquid that contains a degreaser. Rinse the guard with clean water and inspect.



2 Soak to remove heavy biofouling

Remove the antifouling sonde guard from the sonde. If the guard is covered in a thick layer of filaments or barnacles, soak the guard for 10-15 minutes in a solution of clean water and a few drops of a dishwashing liquid that contains a degreaser. Following the soak, rinse the guard with clean water and inspect.



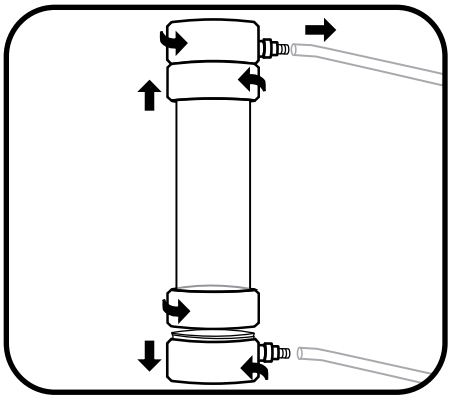
3 Scrub to remove heavy biofouling

If biofouling remains, use a small plastic scrub brush or plastic scraper to gently scrub the biofouling off the guard. Then wipe the guard with a wet, soapy cloth and rinse.

NOTICE: Do not sand or polish the inside of the guard bottom, as this may affect turbidity readings. (The guard bottom has a black coating that will eventually wear off.)

5.19 Flow Cell
Maintenance

There are two versions of the EXO flow cell: EXO1 flow cell (599080) and EXO2 / EXO3 flow cell (599201). Flow rate of the flow cell is typically between 100 mL and 1 L per minute. Maximum flow rate depends on tubing type, size, and length.
Maximum pressure for each is 25 psi.

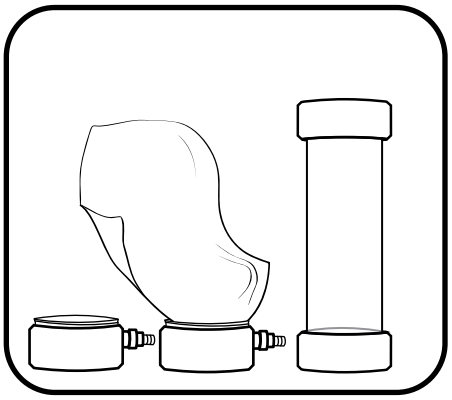


1 Disassemble flow cell

To clean the flow cell after use, unscrew and remove the sonde from the flow cell.

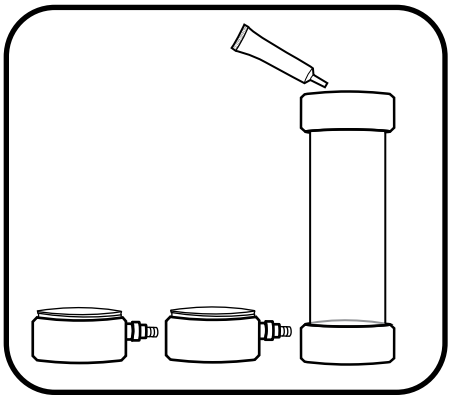
Take apart the flow cell by unscrewing the base from the locking ring. Remove the flow cell tube by gently pulling the base and the tube apart. The locking ring will remain on the tube due to the stainless steel retaining ring.

Repeat the same steps to remove the top of the flow cell from the flow cell tube.



2 Clean flow cell

Use water and a mild detergent and water to wipe clean the flow cell parts.



3 Reassemble flow cell

Make sure that the o-rings and threads are clean and free of any particles such as sand, grit, or debris. Apply a thin coat of Krytox grease to the two o-rings on the flow cell tube.

Make sure that the o-rings and stainless steel retaining rings are properly seated on the flow cell tube. Push the base of the flow cell onto the flow cell tube until it is firmly seated. This creates the watertight seal.

Screw the locking ring on to the base by turning it clockwise; do not use a tool and do not overtighten.

Repeat the same steps to reconnect the top of the flow cell to the flow cell tube.

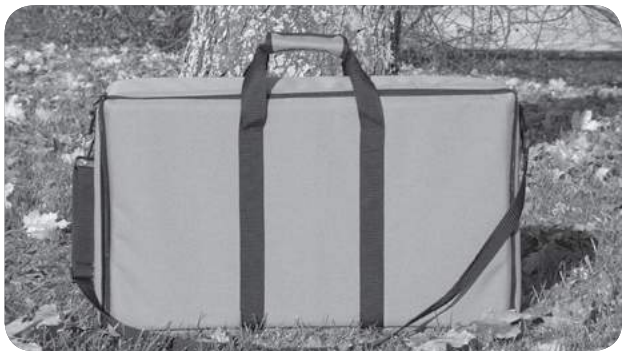
5.20 Storage Cases
Packing Options

EXO sondes are built with the most rugged and durable materials to safeguard against the risks of water monitoring. Out of the water, the EXO Hard-Sided Carrying Case provides a secure manner in which to store your EXO equipment for travel or until the next trip into the field. As seen below, the EXO Hard-Case provides the perfect safe storage solution, though we do offer several case options.

EXO Hard-Sided Wheeled Carrying Case
#599020-01 (**EXO1**) and #599020-02 (**EXO2 / EXO3**)

EXO1, EXO2 and EXO3 Storage Solutions

Within the heavy-grade plastic frame, protective foam form fits your EXO sondes. Additionally, the handheld and detached sensors rest safely within foam housing. The central portion of the case allows users to securely stow other miscellaneous items. There are two separate versions, one which will hold an EXO1 sonde, and another that holds an EXO2 or EXO3 sonde. Both versions include wheels for your convenience.



#696162 - 6-Series Soft-Sided Carrying Case

It is important to note, however, that with greater durability comes increased size and weight. The dimensions of the EXO Hard-Sided Carrying Case are larger than those of its 6-Series counterpart. Additionally, the new EXO case weighs approximately double that of the 6-Series cloth case.

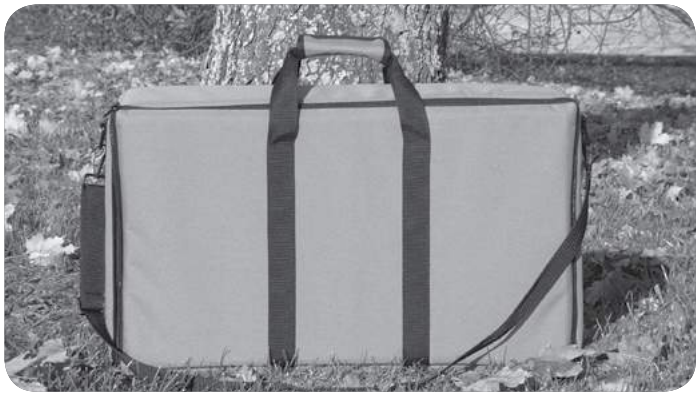
Our EXO sondes are compatible with both YSI carrying cases however, and users should choose the storage solution that is tailored to their individual circumstances. In terms of carrying capacity, both cases are unable to hold multiple EXO2 or EXO3 sondes, and the cloth YSI case can hold up to two EXO1 sondes. Thus, EXO1 users may find it advantageous to utilize that storage option.

EXO1 configuration, Soft-Sided Case

While the EXO case is designed exclusively for EXO sondes and equipment, the cloth YSI case was originally intended for use with the 6-Series product line. It is important to note that the cloth case is versatile in nature – allowing users the ability to configure their own storage structure with its Velcro lining and interlocking padded strips. This flexibility enables both EXO1 & EXO2 or EXO3 equipment to fit inside using configurations as seen in the photos.

EXO2 configuration, Soft-Sided Case

Ultimately, while the EXO equipment is built to withstand harsh field environments, we recommend users take care to safely store their systems while not in use. Both the EXO Hard-Sided Carrying Case and the cloth YSI case are viable options, but other non-YSI products may better suit more specialized user needs.
(See Appendix below for more information.)



Item Description	Part #'s
EXO1 Wheeled Carrying Case	#599020-01
EXO2 or EXO3 Wheeled Carrying Case	#599020-02

Item Description	Part #
6-Series Carrying Case, Soft-Sided (EXO1, EXO2 or EXO3 Sonde and equipment)	#696162

Appendix: Pelican Cases

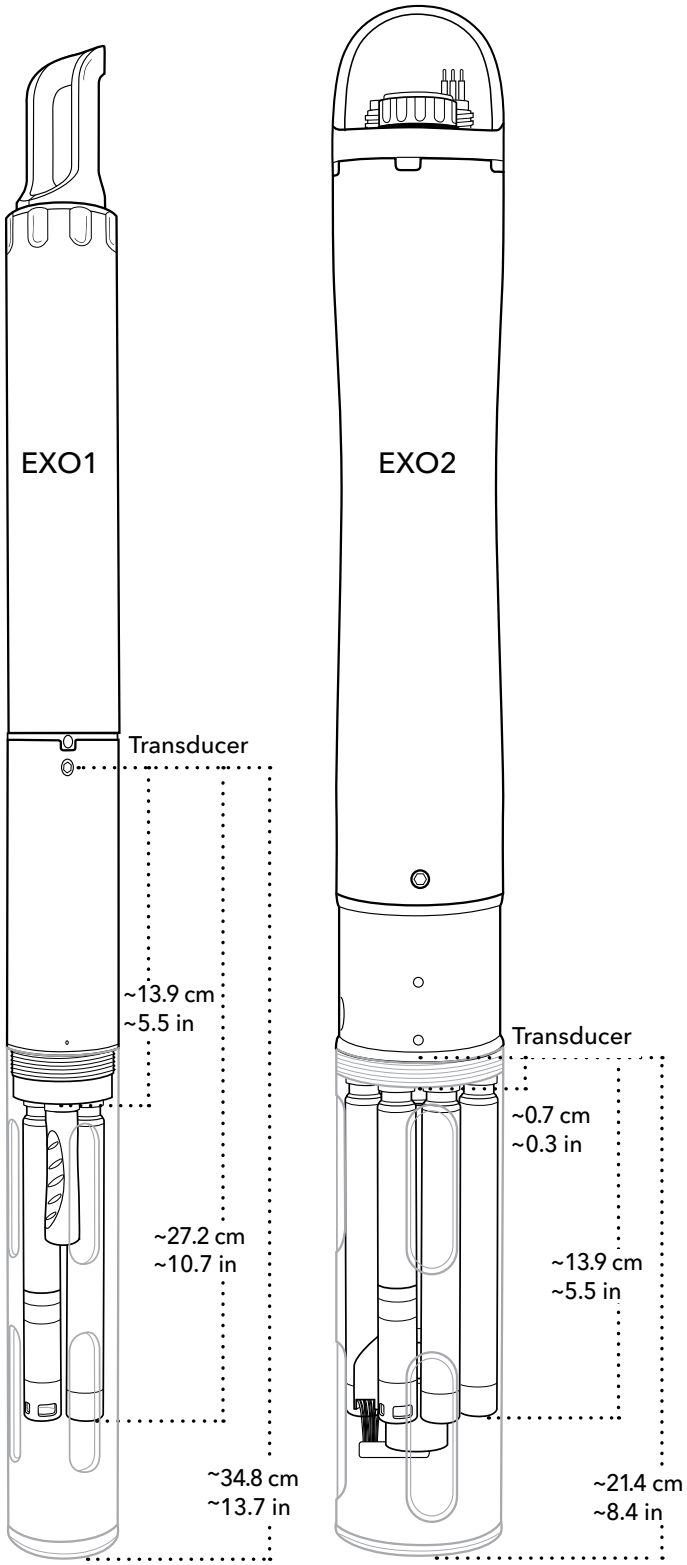
Pelican storage cases are another option for EXO users. This third party storage solution is an option for those that prefer to create their own cases for specific purposes. Two Pelican models work the best for storing EXO equipment, the Pelican 1600 and 1700. These cases can be purchased online through a number of portals but do require the user to personally customize the foam interior to fit our sondes and equipment.

Pelican-1600

Pelican-1700

Section 6
Vented Level Sonde

6.1 Vented Level Sonde
Overview



NOTE: *EXO3 sondes do not come equipped with a vented level option.*

Like EXO depth sensors, level sensors use a differential transducer with one side exposed to the water. However, unlike the depth sensors which have their back side sealed in a vacuum, the other side of the level transducer is vented to the atmosphere.

Because of this venting to the surface the transducer will only measure the water pressure exerted by the water column. Thus, the vented level option for depth measurement eliminates errors due to changes in barometric pressure because the barometric pressure is being seen on both sides of the pressure sensor. This is accomplished by using a special sensor that has been vented to the outside atmosphere by way of a tube that runs through the sonde and cable. This tube must remain open and vented to the outside atmosphere to function. No foreign objects can block the openings.

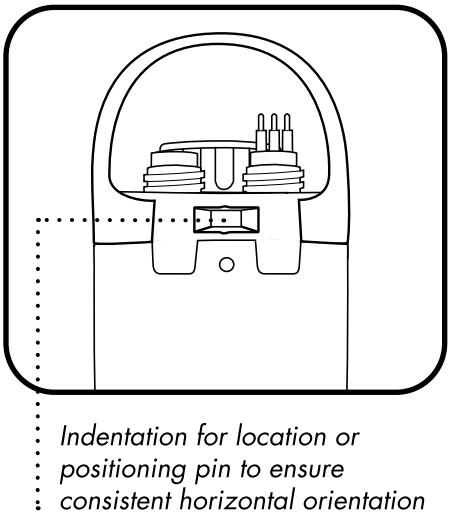
NOTICE: Never expose the sonde or the cable to the atmosphere for more than a few minutes without an active desiccant or connector dummy plug in place. Moisture or high humidity air entering the vent tubes can condense and block the tube, affecting accuracy; it could also cause damage to the transducer that is not covered by the warranty.

Special field cables are required for vented level measurements. These cables have a vent tube running through the center and connect to the EXO sonde at the connector near the bail. In the center of the sonde's connector is a matching vent hole. When attached, the vented cable allows the sonde to vent through the water column and thus gain a more accurate depth measurement.

6.2 Vented Level Sonde
Installation

When installing a vented level sonde, users must ensure that the sonde never exceeds an operational depth of 10 meters. Provisions for floods, astronomical tides and severe storm events should be factored in.

NOTICE: Exposing the depth sensor to depths greater than 10 meters could result in damage to the pressure sensor that is not covered by the warranty.



Indentation for location or positioning pin to ensure consistent horizontal orientation

Location of Depth Sensor

For best measurement accuracy when installing a sonde, the sonde's orientation and position must remain fixed.

When deploying the sonde vertically, take care to ensure the sonde is redeployed in the same position. Use a location pin or suspend the sonde using materials that cannot stretch (chain, wire rope) to ensure a fixed location.

Depth sensors on the EXO2 sondes are not on center. In horizontal deployments, take care to ensure the redeployments are always in the same orientation.

To assist with consistent horizontal orientation, the EXO2 sonde has an indentation at the top of the sonde for a location or positioning pin.

NOTICE: Never band clamp a sonde. This can lead to the sonde body becoming warped and taking on water.

EXO1 Depth Sensor Reference Points (see diagram in Section 6.1)

- From bottom of sensor guard (metal or plastic) to transducer diaphragm: ~34.8 cm / ~13.7 inches
- From face of sensor endcap to transducer diaphragm: ~27.2 cm / ~10.7 inches
- From face of connector bulkhead to transducer diaphragm: ~13.9 cm / ~5.5 inches

EXO2 Depth Sensor Reference Points (see diagram in Section 6.1)

- From bottom of sensor guard (plastic or metal) to transducer diaphragm: ~21.4 cm / ~8.4 inches
- From face of sensor endcap to transducer diaphragm: ~13.9 cm / ~5.5 inches
- From face of connector bulkhead to transducer diaphragm: ~0.7 cm / ~0.3 inches
- Horizontally positioned sonde, from outer case (location pin down) to transducer diaphragm: ~2.1 cm / ~0.8 inches

Ambient Light Interference

When deploying horizontally, it is best to keep the sonde's optical sensors out of direct sunlight. We suggest:

- Installing the sonde in a PVC pipe that has adequate openings for flow
- Aiming the sensors north in northern hemisphere or south in southern hemisphere
- Using a sun shield if the sonde is in the open

6.3 Vented Cables and Desiccants
Installation

Cables

Vented cables for EXO have a maximum length of 33 meters, so when connecting a sonde to a data logger, users should use a junction box to reach further distances. In the junction box, the EXO cable can connect to the desiccant, as well as another cable running to the data logger or DCP device.

- Avoid bending vented cables sharply to prevent the inner tube from kinking. (Min. bend radius 20.3 cm/8 in.)
- EXO vented cables have a reduced length to prevent tube damage from their own weight.
- EXO vented cables **do not** have wet-mate connectors—any water or humidity entering the vent tube will cause damage to the pressure sensor that is not covered by the warranty.
- EXO vented cables are not equipped with the barbed fitting for small desiccant cartridges.

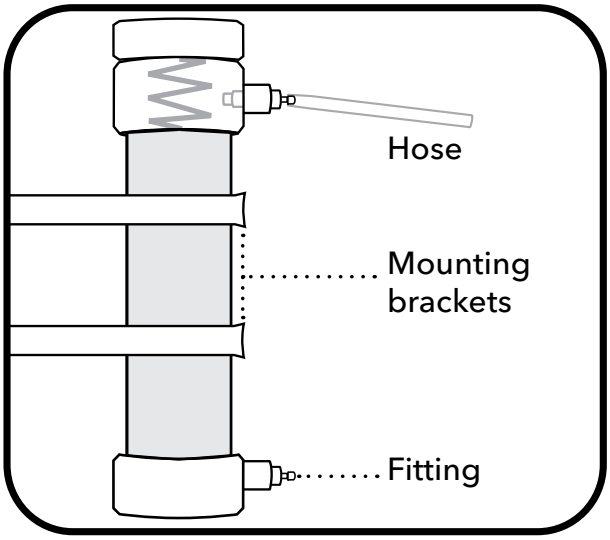
Desiccants

> **NOTICE:** All EXO sondes with vented level require the use of a desiccant. Any damage to the sensor due to the lack of desiccant use is not covered under warranty.

Two desiccant systems are available, a cartridge kit (YSI 6108) and a canister kit (YSI 6109). *For all EXO sondes we strongly recommend the 6109 canister kit*. The 6109 desiccant canister contains a larger amount of desiccant and is intended for long-term deployments (can last up to 1 year in severe conditions). It also contains mounting brackets for mounting the canister to a nearby structure. The smaller 6108 kit requires replacement frequently in high humidity environments.

> **NOTICE:** A desiccant or a connector dummy plug must always be attached to the sonde and cable to prevent moisture from entering into the vent tubes.

Users must also ensure that the desiccant always remains active. Active desiccant is a blue color, and when it can absorb no more moisture, it is a pink color. The end that is vented to the atmosphere will begin to change color first. As long as the desiccant closest to the sonde is blue, no maintenance is required. Local conditions will dictate how long the desiccant will last. In humid environments, the desiccant may need to be changed or regenerated before it is completely exhausted to ensure that it lasts the entire deployment.



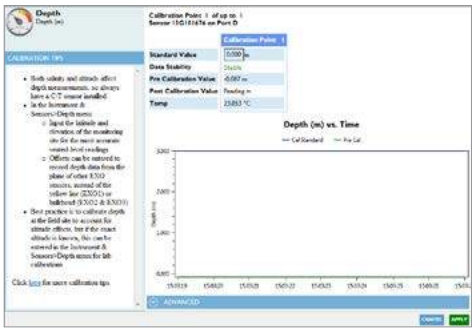
Installing YSI 6109 Desiccant Canister

- Remove the 1/8" NPT plugs from the stainless steel fittings on the canister.
- Install the 1/8" NPT to 1/8" hose fittings into the stainless steel fittings located on the side of the desiccant canister. Do not over-tighten.
- Place the plugs over the fittings on the canister until you are ready to use the canister.
- Using suitable screws fasten the canister mounting brackets to an appropriate support structure. The spacing between the brackets must accommodate the length of the canister. The canister must be located within a few feet of the cable end.
- Remove the plug from the top fitting of the canister. Remove the plug from the barbed fitting on the end of the cable. Using the tubing provided in the kit, connect the canister to the fitting on the end of the cable. Remember to remove the remaining plug from the canister when ready to begin sampling. When putting the sonde into service, remove the plug to ensure that the sensor in the sonde is vented to the atmosphere.

6.4 Calibration

NOTE: *This calibration option is available only if your sonde is equipped with a vented level sensor.*

For the calibration, make certain that the vented level sensor is in air and not immersed in any solution. Orient the sonde in the same position as it will be deployed. Also, never calibrate a vented level depth sensor with a non-vented cable.



In the desktop KorEXO Calibrate menu, select Depth, then select Depth m to calibrate.

NOTE: If a depth offset is entered, the output value will shift by the value of the offset. Users may use an offset if referencing a water elevation against a known datum.

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point. This process zeros the depth sensor.

Click Exit to return to the sensor calibration menu.

For best performance of vented level measurements, users should ensure that the orientation of the sonde remains constant while taking readings. Keep the sonde still and in one position while calibrating.

Advanced

Mounting: Use the Advanced menu to select if a sonde will be mounted in a moving/profiling deployment instead of a fixed location.

Depth Offset: Enter a value in meters (m) to offset the depth at the point of measurement.

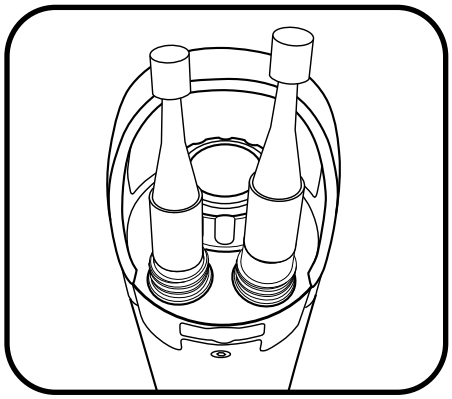
Altitude/Latitude: Enter the coordinates for the local altitude (in meters, relative to sea level) and latitude (in degrees) where the sonde is sampling. Latitude values are used in the calculation of depth and level to account for global variations in the gravitational field.

NOTE: *You must be within 500 feet (152.4 meters) and 1 degree, respectively.*

6.5 Maintenance and Storage

Short-term Storage

NOTICE: It is important that the air in a sonde's vent tube remains dry at all times.



Level Sensor Storage

Users can store these sensors either dry or submerged in clean water. However, regardless of storage method or length, ensure the vent tube remains dry. Always attach the port plug to the cable connector, or leave the cable installed with a cap over the desiccant's vent.

Level Desiccant Maintenance

Active desiccant is blue; saturated desiccant is pink or rose red. When the desiccant closest to the sonde begins to turn pink, you should replace (YSI 6108), or regenerate (YSI 6109) the desiccant cartridge.

To regenerate desiccant, remove it from the cartridge and heat it for one hour at 200°C (about 400°F); then cool it an airtight container before refilling. Also heat the felt filters at 100°C (about 200°F) for 30 minutes. The desiccant will turn blue following a successful recharge.

Connectors Maintenance

Connectors on vented level cables have five pins and a vent pin. Periodically inspect the connectors for signs of contamination. If you detect debris, carefully remove it. Prior to initial installation, or when dry, apply a *light* coat of Krytox grease to the rubber mating surfaces of the connector (including the rubber portions of the pins).

NOTICE: Do not allow grease to enter or block the vent tube on the cable connector or the vent opening on the sonde connector.

When not in use, always install the sonde and cable dummy plugs.

Cable Storage

Users should leave the cable installed on the sonde to protect the connectors. If necessary users may remove it from the sonde, but extra care should be taken to protect the connectors. For vented cables, ensure the storage cap is affixed to the desiccant inlet. Store vented cables in a bag containing desiccant.

NOTE: *Minimum bend radius for coiling cable is 8 inches (20.32 cm).*

Section 7
Accessories

7.1 Accessories
Ordering

Telephone: 800 897 4151 (USA)
+1 937 767 7241 (Globally) Monday through Friday, 8:00 AM to 5:00 ET
Fax: +1 937 767 9353 (orders)
Email: info@ysi.com
Mail: YSI Incorporated 1725 Brannum Lane
Yellow Springs, OH 45387 USA
YSI.com

When placing an order please have the following available:

1. YSI account number (if available)
2. Name and phone number
3. Purchase Order or Credit Card number
4. Model Number or brief description
5. Billing and shipping addresses
6. Quantity

EXO1 Sondes

YSI Item #	Description
599501-00	EXO1 Sonde, No Depth, 4 Sensor Ports
599501-01	EXO1 Sonde, 10 meter Depth, 4 Sensor Ports
599501-02	EXO1 Sonde, 100 meter Depth, 4 Sensor Ports
599501-03	EXO1 Sonde, 250 meter depth, 4 Sensor Ports
599501-04	EXO1 Sonde, 10 meter vented level depth, 4 Sensor Ports

EXO2 Sondes

YSI Item #	Description
599502-00	EXO2 Sonde, No Depth, 6 Sensor Ports, 1 Wiper Port
599502-01	EXO2 Sonde, 10 meter depth, 6 Sensor Ports, 1 Wiper Port
599502-02	EXO2 Sonde, 100 meter Depth, 6 Sensor Ports, 1 Wiper Port
599502-03	EXO2 Sonde, 250 meter depth, 6 Sensor Ports, 1 Wiper Port
599502-04	EXO2 Sonde, 10 meter vented level depth, 6 Sensor Ports, 1 Wiper Port

EXO3 Sondes

YSI Item #	Description
599503-00	EXO3 Sonde, No Depth, 4 Sensor Ports, 1 Wiper Port
599503-01	EXO3 Sonde, 10 meter depth, 4 Sensor Ports, 1 Wiper Port
599503-02	EXO3 Sonde, 100 meter Depth, 4 Sensor Ports, 1 Wiper Port
599503-03	EXO3 Sonde, 250 meter depth, 4 Sensor Ports, 1 Wiper Port

EXO Handheld

YSI Item #	Description
599622	EXO Classic Handheld, Rechargeable Lithium-Ion Battery Pack
599960	EXO Handheld (v2) Display

EXO Signal Output Adapters

YSI Item #	Description
599820	EXO Signal Output Adapter - Data Collection Platform (DCP) 2.0
599825	EXO Signal Output Adapter - Modbus
599810	EXO Signal Output Adapter - USB (Necessary for firmware updates.)

EXO Cables

YSI Item #	Description
599040-2	EXO 2 meter Field Cable
599040-4	EXO 4 meter Field Cable
599040-10	EXO 10 meter Field Cable
599040-15	EXO 15 meter Field Cable
599040-33	EXO 33 meter Field Cable
599040-66	EXO 66 meter Field Cable
599040-100	EXO 100 meter Field Cable
599040-150	EXO 150 meter Field Cable
599040-200	EXO 200 meter Field Cable
599040-250	EXO 250 meter Field Cable
599040-300	EXO 300 meter Field Cable
599008-10	EXO 10 meter Flying Lead Cable
599008-15	EXO 15 meter Flying Lead Cable
599008-33	EXO 33 meter Flying Lead Cable
599008-66	EXO 66 meter Flying Lead Cable
599008-100	EXO 100 meter Flying Lead Cable
599210-4	EXO 4 meter VENTED Flying Lead Cable
599210-10	EXO 10 meter VENTED Flying Lead Cable
599210-15	EXO 15 meter VENTED Flying Lead Cable
599210-33	EXO 33 meter VENTED Flying Lead Cable

EXO Sensors & EXO Central Wiper

YSI Item #	Description
599870	EXO Conductivity/Temperature Sensor
599827	EXO Wiped Conductivity/Temperature Sensor
599701	EXO pH Sensor Assembly, Guarded
599705	EXO pH/ORP Sensor Assembly, Guarded
599702	EXO pH Sensor Assembly, Unguarded
599706	EXO pH/ORP Sensor Assembly, Unguarded
599710	EXO Ammonium Sensor Assembly,Guarded
599711	EXO Chloride Sensor Assembly, Guarded
599709	EXO Nitrate Sensor Assembly, Guarded
599100-01	EXO Optical DO Sensor
599101-01	EXO Turbidity Sensor
599102-01	EXO Total Algae - PC Sensor
599103-01	EXO Total Algae - PE Sensor
599104-01	EXO fDOM Sensor
599090-01	EXO Central Wiper

EXO Replaceable Sensor Tips

YSI Item #	Description
599795-01	EXO pH Sensor Replacement Module, Guarded (User replaceable tip for 599701)
599795-02	EXO pH Sensor Replacement Module, Un-Guarded (User replaceable tip for 599702)
599797-01	EXO pH/ORP Sensor Replacement Module, Guarded (User replaceable tip for 599705)
599797-02	EXO pH/ORP Sensor Replacement Module, Un-Guarded (User replaceable tip for 599706)
599744-01	EXO Ammonium Sensor Replacement Module, Guarded (User replaceable tip for 599710)
599743-01	EXO Nitrate Sensor Replacement Module, Guarded (User replaceable tip for 599709)
599745-01	EXO Chloride Sensor Replacement Module, Guarded (User replaceable tip for 599711)

EXO General Accessories

YSI Item #	Description
599020-01	EXO1 Wheeled Carrying Case, Black
599020-02	EXO2 / EXO3 Wheeled Carrying Case, Black
599470	EXO C/T Sensor Cleaning Brush
599831	EXO Wiped C/T Sensor, Spacing Kit
599080	EXO1 Flow Cell
599201	EXO2 / EXO3 Flow Cell
599786	EXO1 Calibration/Storage Cup
599316	EXO2 / EXO3 Calibration / Storage Cup
599471	EXO1 Sonde Weight Kit
599472	EXO2 / EXO3 Sonde Weight Kit
599473	EXO1 Replacement Bail
599474	EXO2 / EXO3 Replacement Bail
599475	EXO 4-Pin Bulkhead Connector Port Plug
599594	EXO Tool Kit
599680	EXO1 Replacement O-Ring Kit
599681	EXO2 / EXO3 Replacement O-Ring Kit
599677	EXO Sensor O-Ring Kit

YSI Item #	Description
599110	DO Sensor Cap Replacement Kit
599595	EXO Coastal Anode Kit
599520	EXO1 Coastal Anode Guard Weight Kit
599521	EXO2 Coastal Anode Guard Weight Kit
599338	KorEXO User Interface Software USB
599668	EXO Sensor Retaining Nut Kit, Sensors
599669	EXO Sensor Retaining Nut Kit, Wiper
599666	EXO1 Guard Assembly Kit
599667	EXO2 / EXO3 Guard Assembly Kit
599673	EXO Central Wiper Brush Kit
599665	EXO Replacement 6-pin Female Dummy Plug
599664	EXO Replacement 6-pin Male Dummy Plug
599676	EXO Wiper Brush Guard replacement Kit
599469	EXO Sensor tool and magnet activation kit
599352	Krytox Lubricant
006109	Desiccant Canister Kit
006108	Desiccant Cartridge Kit

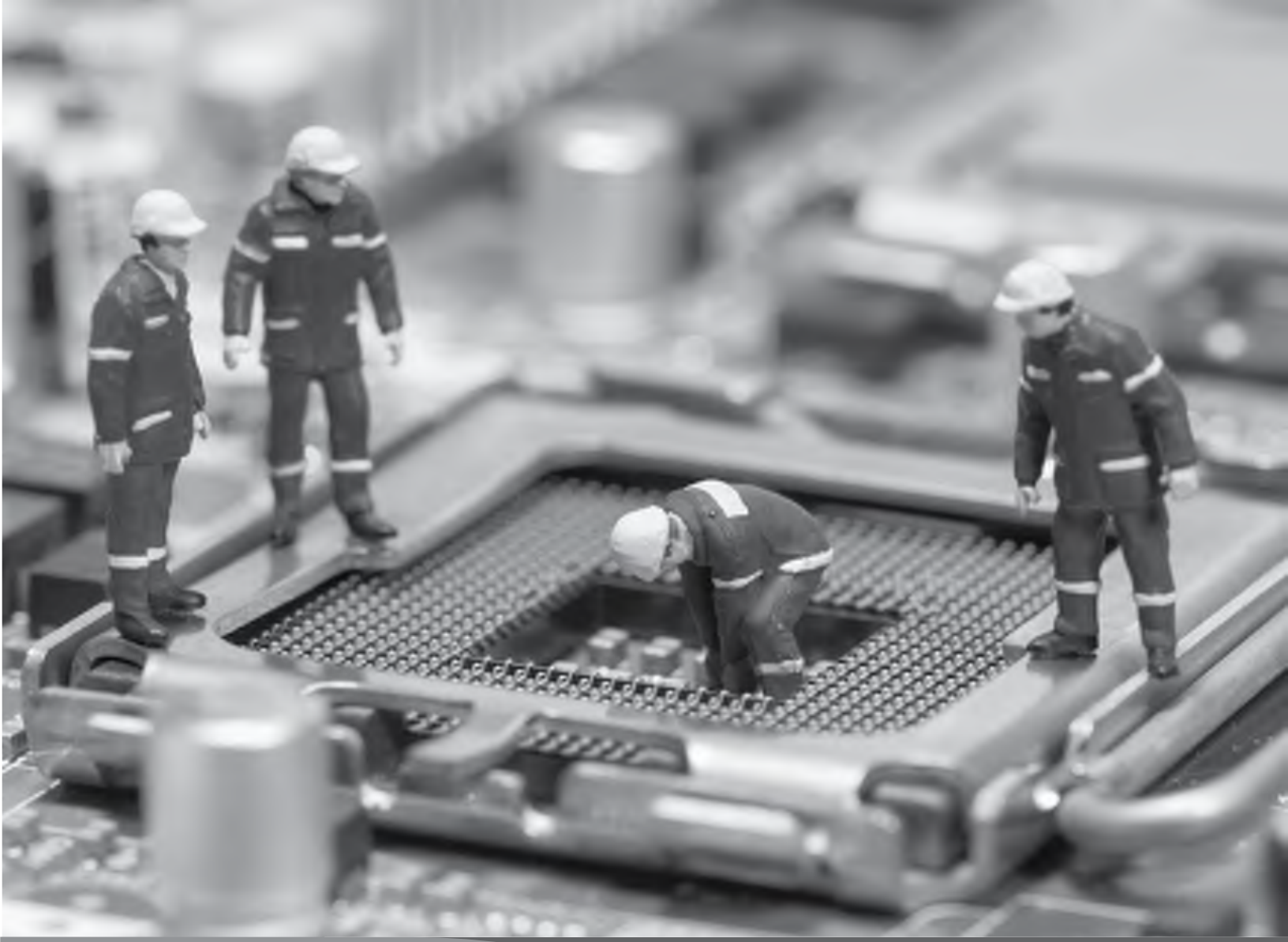
EXO Antifouling Accessories

YSI Item #	Description
599867	EXO Anti Fouling C/T Screen
599563	EXO1 Anti-Fouling Guard
599564	EXO2 / EXO3 Anti-Fouling Guard
599663	EXO2 / EXO3 Probe and Sonde protective sleeves
6189-AF	Copper tape kit
C-SPRAY	Protective probe solution, 100 mL bottle

Calibration Standards and Solutions

YSI Item #	Description
065270	Conductivity Cal. - 1,000 umhos/cm (quart)
065272	Conductivity Cal. - 10,000 umhos/cm (quart)
065274	Conductivity Cal. - 100,000 umhos/cm (quart)
060907	Conductivity Cal. - 1,000 umhos/cm (8 ea, pint)
060911	Conductivity Cal. - 10,000 umhos/cm (8 ea, pint)
060660	Conductivity Cal. - 50,000 umhos/cm (8 ea, pint)
061320	Zobell Solution - For ORP cal. - 125 mL
061321	Zobell Solution - For ORP cal. - 250 mL
061322	Zobell Solution - For ORP cal. - 500 mL

YSI Item #	Description
003821	pH 4 Buffer - Box of 6 pints
003822	pH 7 Buffer - Box of 6 pints
003823	pH 10 Buffer - Box of 6 pints
603824	Assorted pH Buffers - 2 pints of 4 - 2 pints of 7 - 2 pints of 10"
003841	Ammonium Cal Solution - 1 mg/L (500mL)
003842	Ammonium Cal Solution - 10 mg/L (500mL)
003843	Ammonium Cal Solution - 100 mg/L (500mL)
003885	Nitrate Standard - 1 mg/L (500mL)
003886	Nitrate Standard - 10 mg/L (500mL)
003887	Nitrate Standard - 100 mg/L (500mL)
608000	Turbidity Std. - 0 NFU, 0 NTU - 1 Gallon
607200	Turbidity Std. - 12.4 FNU - 1 Gallon
607300	Turbidity Std. - 124 FNU - 1 Gallon
607400	Turbidity Std. - 1010 FNU - 1 Gallon



Section 8
Health and Safety, Warranty, Service

8.1 Health and Safety
Chemicals

NOTE: *For additional health, safety, and disposal information about reagents, download the MSDS documents for the chemical in question from the EXO manufacturers' websites*: www.ysi.com or www.wtw.de.

First Aid for all solutions

Inhalation	Move to fresh air. If breathing is difficult, give oxygen. If symptoms persist, seek medical attention.
Skin Contact	Remove contaminated clothing and wash. Wash exposed area with soap and water for at least 15 minutes. If irritation persists, seek medical attention.
Eye Contact	Rinse eyes immediately with large amounts of water, also under eyelids, for at least 15 minutes. If irritation persists, seek medical attention.
Ingestion	Wash out mouth with water and then drink plenty of water. If symptoms persist, seek medical attention.

Ammonium Solutions

3841, 3842, and 3843

Ingredients: Water, Ammonium Chloride, Lithium Acetate Dihydrate, Sodium Azide, Hydrochloric Acid

Nitrate Solutions

3885, 3886, and 3887

Ingredients: Water, Potassium Nitrate, Magnesium Sulfate Heptahydrate, Gentamycin Sulfate

Inhalation: Avoid breathing vapors or mists. Ensure adequate ventilation is available before handling.

Skin: Wear lightweight protective clothing, gloves, and apron.

Eyes: Wear safety glasses with side-shields or face shield. Contact lenses should not be worn when working with these solutions.

Ingestion: May be harmful if swallowed. Wear a mouth cover or face shield when there is splashing. Keep away from food and drink.

First Aid: See box at left.

Conductivity Solutions

3161, 3163, 3165, 3167, 3168, and 3169

Ingredients: Water, Potassium Chloride

Inhalation: Avoid breathing vapors or mists. Inhalation of dust may cause irritation of respiratory tissues. Ensure adequate ventilation is available before handling.

Skin: Exposure may cause irritation with repeated exposure. Wear lightweight protective clothing, gloves, boots, and apron.

Eyes: Can cause irritation and potential eye damage with repeated exposure. Wear safety glasses with side-shields or face shield.

Ingestion: May cause irritation of mouth, throat, and an upset stomach. Wear a mouth cover or face shield when there is splashing. Keep away from food and drink. Do not swallow.

First Aid: See box at left.

pH 4.00, 7.00, 10.00 Buffer Solutions

3821, 3822, and 3823

pH 4 Ingredients: Water, Potassium Hydrogen Phthalate, Red food coloring

pH 7 Ingredients: Water, Potassium Phosphate Monobasic, Sodium Hydroxide, Yellow food coloring

pH 10 Ingredients: Water, Potassium Hydroxide, Disodium EDTA dihydrate, Potassium Borate, Potassium Carbonate, Bromphenol Blue Sodium Salt, Bromphenol Green Sodium Salt

Inhalation: Avoid breathing vapors or mists. Inhalation of dust may cause irritation of respiratory tissues. Ensure adequate ventilation is available before handling.

Skin: Exposure may cause irritation with repeated exposure. Wear rubber or neoprene gloves.

Eyes: Can cause irritation and potential eye damage with repeated exposure. Wear safety glasses with side-shields or face shield. Contact lenses should not be worn when working with these solutions.

Ingestion: May cause nausea, vomiting, or diarrhea. Wear a mouth cover or face shield when there is splashing. Do not swallow. Do not induce vomiting.

First Aid: See First Aid table.

Zobell Solution

3682

Ingredients: Potassium Chloride, Potassium Ferrocyanide Trihydrate, Potassium Ferricyanide

Inhalation: Inhalation of dust may cause irritation of respiratory tissues. Ensure adequate ventilation is available before handling.

Skin: Exposure may cause irritation. Wear lightweight protective clothing, gloves, boots, and apron.

Eyes: May cause irritation. Wear safety glasses with side-shields or face shield.

Ingestion: May cause an upset stomach. Wear a mouth cover or face shield when there is splashing. Keep away from food and drink. Do not swallow. If large amount is ingested and person is conscious, induce vomiting.

First Aid: See First Aid table.

Turbidity Standard

6073

Ingredients: Water, Styrene divinyl Benzene copolymer beads

The material is not volatile and has no known ill effects on skin, eyes, inhalation or ingestion. Therefore, no special precautions are required when using the standards. However, general precautions should be adopted as required with all materials to minimize unnecessary contact.

First Aid: See First Aid table.

Ultraviolet Light

The fDOM sensor radiates ultraviolet light (UV light) which can be harmful to the eyes even during brief periods of exposure. Do not look into the light at the tip of the probe and wear protective eyewear when handling UV LEDs.

Lithium-Ion Battery Handling

⚠ **WARNING:** Failure to exercise care when handling this product and to comply with the following conditions and guidelines could result in product malfunction, excessive heat, fire, property damage, and ultimately injury.

- **DO NOT** alter, puncture, or impact battery or related components.
- **DO NOT** directly connect the terminals with metal objects.
- **DO NOT** expose the battery to extreme temperatures or direct extended exposure to sunlight.
- Always disconnect batteries when not in use and for long term storage.
- Store batteries in a non-conductive and fireproof container.
- For best results, store the battery at approximately 50% of the capacity.

If at any time the battery becomes damaged, hot, or begins to balloon or swell, discontinue charging (or discharging) immediately. Quickly and safely disconnect the charger. Then place the battery and/or charger in a safe, open area way from flammable materials. After one hour of observation, remove the battery from service. **DO NOT** continue to handle, attempt to use, or ship the battery. Failure to follow these procedures can cause damage to the battery, personal property or cause serious injury.

Damaged or swollen batteries can be unstable and very hot. **DO NOT** touch batteries until they have cooled. In the event of a fire use a Class A, B, or C fire extinguisher. **DO NOT** use water.

If the internal battery fluid comes into contact with your skin, wash the affected area(s) with soap and water immediately. If it comes into contact with your eye(s), flush them with generous amounts of water for 15 minutes and seek immediate medical attention.

8.2 Radio Frequency

Xylem certifies that the EXO product line has been tested and complies with the following radio frequency (RF) interference standards and are approved for use in the following countries:

- United States: FCC Part 15 compliant
- Canada: RSS compliant
- European Union (EU): CE compliant
- Australia: CISPR 11 compliant
- New Zealand: CISPR 11 compliant
- Republic of Korea: Radio Waves Act compliant
- Japan: TELEC Radio Law compliant
- Brazil: Anatel certification compliant

Reference the Declaration of Conformity in the next section for further details.

Bluetooth wireless technology and similar approvals and regulations can be country-specific. Check local laws and regulations to insure that the use of wireless products purchased from Xylem or its subsidiaries are in full compliance.

8.3 Declarations of Conformity

The undersigned hereby declares that the products listed below conform with all applicable requirements of FCC Part 15 for the U.S. and Industry Canada (IC) ICES-003 for Canada.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO Sondes (EXO1, EXO2 and EXO3), EXO Handheld (V2) and EXO GO
Model numbers:	599501-xx, 599502-xx, 599503-xx, 599960, 577400
Intentional Radiators:	EXO Sondes (EXO1, EXO2 and EXO3) contain a *Bluetooth* module: FCC ID: T7VPAN10 IC: 216Q-PAN10 EXO GO contains a Wi-Fi/*Bluetooth* module: FCC ID: T9J-RN42 IC: 6514A-RN42
Regulations:	• FCC 47 CFR Part 15 • IC ICES-003

Gregory Popp, Quality Manager
January 14th, 2019

The undersigned hereby declares that the products listed below conform with all applicable Essential Requirements of the listed Directives and Standards and carry the CE mark accordingly.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO Sondes (EXO1, EXO2 and EXO3), EXO Handheld (v2) and EXO GO
Model numbers:	599501-xx, 599502-xx, 599503-xx, 599960, 577400
Accessories/Sensors:	599090-xx, 599100-xx, 599101-xx, 599102-xx, 599104-xx, 599118-xx, 599800, 599810, 599870, 599040-xx, 599008-xx
Intentional Radiators:	EXO Sondes (EXO1, EXO2 and EXO3) contain a *Bluetooth* module. The EXO GO (577400) contains a *Bluetooth* module. Nemko Certified Body ID#CE 2302.

Directives:

- EMC 2014/30/EU
- RED 2014/53/EU
- LVD 2014/35/EU
- R&TTE 1999/5/EC
- WEEE 2012/19/EU
- RoHS 2011/65/EU

Harmonized Standards:

- EN61326-1:2013, Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements
- EN 61326-2-3:2013, Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 2-3: Particular requirements - Test configuration, operational conditions and performance criteria for transducers with integrated or remote signal conditioning
- EN 60950-1:2006 + A11:2009 + A12:2011 + A1:2010 + A2:2013, Information technology equipment - Safety - Part 1: General requirements
- EN 300 328 V2.1.1:2017, Wideband transmission systems; Data transmission equipment operating in the 2,4 GHz ISM band and using wide band modulation techniques; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU
- EN 301 489-1 V1.9.2:2011, Electromagnetic compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements
- EN 301 489-17:2009, V2.1.1, Electromagnetic compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment; Part 17: Specific conditions for Broadband Data Transmission Systems
- EN61000-3-2:2014, Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)
- EN61000-3-3:2013, Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current <= 16 A per phase and not subject to conditional connection

Gregory W. Popp

Gregory Popp, Quality Manager
January 14th, 2019

The undersigned hereby declares that the products listed below conform with the Australian and New Zealand Electromagnetic Compatibility (EMC) requirements for generic products to be used in residential, commercial, and light industrial environments, and carry the C-Tick mark accordingly.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO Sondes (EXO1, EXO2 and EXO3), EXO Handheld (v2) and EXO GO
Model numbers:	599501-xx, 599502-xx, 599503-xx, 599960, 577400
Accessories/Sensors:	599090-xx, 599100-xx, 599101-xx, 599102-xx, 599104-xx, 599118-xx, 599800, 599810, 599870, 599040-xx, 599008-xx
Intentional Radiators:	EXO Sondes (EXO1, EXO2 and EXO3) contain a *Bluetooth* module. EXO GO (577400) contains a *Bluetooth* module. Nemko Certified Body ID#CE 2302.

Regulations:

- Australian ACMA Standards for C-Tick mark, Section 182 of the Radiocommunications Act 1992.
- New Zealand RSM Standards, Radiocommunications Act 1992.
- Telecommunications Labeling, Notice 2001 under section 407 of the Australian Telecommunications Act 1997.

Standards:

- EN61326-1:2006, Electrical equipment for measurement, control, and laboratory use – EMC requirements – Part 1: General Requirements.
- ACMA Radio Communications (Short Range Devices), 2004.
- AS/NZ 4268, 2008.
- Radio Communications (Electromagnetic Radiation - Human Exposure) Standard, March 2003.

Gregory Popp, Quality Manager
January 14th, 2019

The undersigned hereby declares that the products listed below conform with all applicable requirements of the Radio Waves Act of Korea, for intentional radiators.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO Sondes (EXO1, EXO2 and EXO3) and EXO GO
Model numbers:	599501-xx, 599502-xx, 599503-xx, 577400
Intentional Radiators:	EXO Sondes (EXO1, EXO2 and EXO3) contain the PAN1026 *Bluetooth* module. Broadcasting and certification number R-C-XYL-EXO1 (for EXO1), R-C-XYL-EXO2 (for EXO2) and R-C-XYL-EXO3-PAN1026 (for EXO3). EXO GO (577400) contains a *Bluetooth* module. Broadcasting and certification number KCC-CRI-AEP-RN-42.
Type Identification:	LARN8-IO2Y2402/2480TR0.000003F1D79 (EXO1) LARN8-IO2Y2402/2480TR0.00001F1D79 (EXO2) LARN8-IO2Y2402/2480TR0.001F1D79 (EXO3) LARN8-IO2Y2402/2480TR0.00003F1DG1D79 (EXO Handheld)
Regulation:	Radio Waves Act of the Republic of Korea.

A급 기기 (업무용 방송통신 기자재)
이 기기는 업무용 (A급) 전자파 적합기기로서
판매자 또는 사용자는 이 점을 주의하시기 바라
며, 가정 외의 지역에서 사용하는 것을 목적으 로 합니다.

Class A device (Broadcasting and communication equipment for office work).

Seller and user shall be noticed that this equipment is suitable for electromagnetic equipment for office work (Class A) and it can be used outside the home.

KCC notice 2012-12. Radio device using 2400-2483.5 MHz and 5725-5825 MHz.

해당 무선설비는 전파혼신
가능성이 있으므로 인명안전과
관련된 서비스는 할 수 없음.

Service related to human safety is not allowed because this device may have the possibility of the radio interference.

Gregory Popp, Quality Manager
January 14th, 2019

The undersigned hereby declares that the products listed below conform with all applicable requirements of the Radio Regulations of China, for intentional radiators.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO GO
Model numbers:	577400
Intentional Radiators:	The EXO GO (577400) contains a *Bluetooth* module.
CMIIT ID:	CMIIT ID: 2018DJ2145 (EXO GO)
Regulation:	Radio Regulations of the People's Republic of China.

A级设备（办公用广播和通讯设备）
销售商和使用者应注意本设备适用于办公条件下的电磁环境（A级）并可以在室外使用。

Class A device (Broadcasting and communication equipment for office work).
Seller and user shall be noticed that this equipment is suitable for electromagnetic equipment for office work (Class A) and it can be used outside the home.

Gregory Popp, Quality Manager
January 14th, 2019

The undersigned hereby declares that the products listed below conform with all applicable requirements of TELEC and Radio Law of Japan for intentional radiators.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO Sondes (EXO1,EXO2 and EXO3) and EXO GO
Model numbers:	599501-xx, 599502-xx, 599503-xx, 577400
Intentional Radiators:	EXO Sondes contain transmitter module with certification number: MIC ID: [R]202-LSE095 EXO GO contains transmitter module with certification number: MIC ID: [R]201-125709
Regulations:	TELEC; Article 38-24 Paragraph 1 of the Radio Law.

Gregory W. Popp

Gregory Popp, Quality Manager
January 14th, 2019

The undersigned hereby declares that the products listed below conform with all applicable requirements of the Anatel Regulations of Brazil for intentional radiators.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO Sondes (EXO1, EXO2 and EXO3) and EXO GO
Model numbers:	599501-xx, 599502-xx, 599503-xx, 577400
Intentional Radiators:	Intentional Radiators: EXO Sondes (EXO1, EXO2 and EXO3) contain the PAN1026 *Bluetooth* module: Certificate of Homologation No. 01640-18-08838; Certificate of Conformity No. 00106288. EXO GO (577400) contains the RN42 *Bluetooth* module: Certificate of Homologation No. 00436-18-08838; Certificate of Conformity No. 00099335.
Regulations:	Anatel; Transceptor de Radiacao Restrita - Categoria II

Gregory W. Popp

Gregory Popp, Quality Manager
January 14th, 2019

8.4 Instrument Warranty

Warranty Card

Register your product with the online warranty card: www.YSI.com/warranty

Warranted against defects in workmanship and materials when used for their intended purposes and maintained according to instructions and exclusive of batteries and any damage caused by defective batteries.

Two years: cables; sondes (bulkheads); handheld; conductivity, temperature, depth, and optical sensors; electronics base for pH, pH/ORP, ammonium, chloride, and nitrate sensors; and accessories.

One year: optical DO membranes and replaceable reagent modules for pH and pH/ORP.

Three months: replaceable reagent modules for ammonium, chloride, and nitrate.

Regular maintenance of sondes and sensors, such as replacing damaged o-rings, is described in the Maintenance section of this manual. Users are expected to follow these guidelines to keep their equipment in good and proper working order and to protect the warranty on the product. Damage due to accidents, misuse, tampering, or failure to perform prescribed maintenance is not covered.

This warranty does not include batteries or damage resulting from defective batteries. As documented in the Maintenance section of this manual, batteries should be removed from all sondes and handheld when the product is not in use. Since many battery manufacturers will repair or replace any equipment that has been damaged by their batteries, it is essential that leaky or defective batteries be retained with the damaged product until the manufacturer has evaluated the claim.

The warranty period for chemicals and reagents is determined by the expiration date printed on their labels. Within the warranty period, we will repair or replace, at our sole discretion, free of charge, any product that we determine to be covered by this warranty.

To exercise this warranty, write or call your local representative, or contact Technical Support. Send the product and proof of purchase, transportation prepaid, to the Authorized Service Center selected by the manufacturer. Repair or replacement will be made and the product returned transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days from date of repair or replacement.

Limitation of Warranty

This Warranty does not apply to any EXO product damage or failure caused by (i) failure to install, operate or use the product in accordance with the written instructions, (ii) abuse or misuse of the product, (iii) failure to maintain the product in accordance with the written instructions or standard industry procedure, (iv) any improper repairs to the product, (v) use by you of defective or improper components or parts in servicing or repairing the product, or (vi) modification of the product in any way not expressly authorized by the manufacturer.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. YSI's LIABILITY UNDER THIS WARRANTY IS LIMITED TO REPAIR OR REPLACEMENT OF THE PRODUCT, AND THIS SHALL BE YOUR SOLE AND EXCLUSIVE REMEDY FOR ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY. IN NO EVENT SHALL YSI BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY.

EXO Authorized Service Centers are located in the United States and around the world. Please refer to the YSI website (www.YSI.com/Repair) for your nearest Authorized Service Center.

8.5 Instrument Service

Cleaning and Packing

Product Return Form

Find the product return form online:
www.YSI.com/Repair

Cleaning Certificate

Find the cleaning certificate on the back of the online product return form:
www.YSI.com/Repair

Cleaning Instructions

Before they can be serviced, equipment exposed to biological, radioactive, or toxic materials must be cleaned and disinfected. Biological contamination is presumed for any instrument, probe, or other device that has been used with body fluids or tissues, or with wastewater. Radioactive contamination is presumed for any instrument, probe or other device that has been used near any radioactive source.

If an instrument, probe, or other part is returned or presented for service without a Cleaning Certificate, and if in our opinion it represents a potential biological or radioactive hazard, our service personnel reserve the right to withhold service until appropriate cleaning, decontamination, and certification has been completed. We will contact the sender for instructions as to the disposition of the equipment. Disposition costs will be the senders responsibility.

When service is required, either at the user's facility or at the manufacturer, the following steps must be taken to insure the safety of our service personnel:

- In a manner appropriate to each device, decontaminate all exposed surfaces, including any containers. 70% isopropyl alcohol or a solution of 1/4 cup bleach to 1 gallon tap water are suitable for most disinfecting. Instruments used with wastewater may be disinfected with .5% Lysol® if this is more convenient to the user.

- The user shall take normal precautions to prevent radioactive contamination and must use appropriate decontamination procedures should exposure occur.

- If exposure has occurred, the customer must certify that decontamination has been accomplished and that no radioactivity is detectable by survey equipment.

- Cleaning must be completed and certified on any product before returning.

Packing Instructions

- Clean and decontaminate items to insure the safety of the handler.
- Complete and include the Product Return Form, found online.
- Place the product in a plastic bag to keep out dirt and packing material.
- Use a large carton, preferably the original, and surround the product completely with packing material.

8.6 Instrument Service
Recycling

Batteries

The user must remove and dispose of alkaline batteries when they no longer power the EXO1 sonde, EXO2 sonde, or EXO Handheld. Disposal requirements vary by country and region, and users are expected to understand and follow the battery disposal requirements for their specific locale.

The circuit board in these instruments may contain a manganese dioxide lithium "coin cell" battery that must be in place for continuity of power to memory devices on the board. This battery is not user serviceable or replaceable. When appropriate, an authorized service center will remove this battery and properly dispose of it, per service and repair policies.

Rechargeable Li-Battery Pack

(1) When the battery is worn out, insulate the terminals with adhesive tape or similar materials before disposal.

(2) Dispose of batteries in the manner required by your city, county, state or country. For details on recycling lithium-ion batteries, please contact a government recycling agency, your waste-disposal service, or visit reputable online recycling sources such as **www.batteryrecycling.com.**

This product must not be disposed of with other waste. Instead, it is the user's responsibility to dispose of their waste equipment by handing it over to a designated collection point for the recycling of waste electrical and electronic equipment. The separate collection and recycling of your waste equipment at the time of disposal will help to conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment.

For more information about where you can drop off your waste equipment for recycling, please contact your local city office, or your household waste disposal service. **DO NOT ship batteries to YSI.**

Manufacturer

We are committed to reducing the environmental footprint of our products. While materials reduction is the ultimate goal, we also make a concerted effort to responsibly deal with materials after a long, productive life-cycle. Our recycling program ensures that old equipment is processed in an environmentally responsible way, reducing the amount of materials going to landfills.

- Printed circuit boards are sent to facilities that process and reclaim as much material for recycling as possible.
- Plastics enter a material recycling process and are not incinerated or sent to landfills.
- Batteries are removed and sent to battery recyclers for dedicated metals.

Xylem |'zīləm|

1) The tissue in plants that brings water upward from the roots;
2) a leading global water technology company.

We're a global team unified in a common purpose: creating advanced technology solutions to the world's water challenges. Developing new technologies that will improve the way water is used, conserved, and re-used in the future is central to our work. Our products and services move, treat, analyze, monitor and return water to the environment, in public utility, industrial, residential and commercial building services settings. Xylem also provides a leading portfolio of smart metering, network technologies and advanced analytics solutions for water, electric and gas utilities. In more than 150 countries, we have strong, long-standing relationships with customers who know us for our powerful combination of leading product brands and applications expertise with a strong focus on developing comprehensive, sustainable solutions.

For more information on how Xylem can help you, go to www.xylem.com

xylem
Let's Solve Water

YSI, a Xylem brand
1725 Brannum Lane
Yellow Springs, OH 45387
Tel +1.800.897.4151
Fax +1.937.767.9353
www.xylem.com

Appendix B

California Water Quality Monitoring Plan

KLAMATH RIVER RENEWAL CORPORATION

Lower Klamath Project
FERC Project No. 14803

California Water Quality Monitoring Plan

Klamath River Renewal Corporation
2001 Addison Street, Suite 317
Berkeley, CA 94704

Prepared By:
Camas LLC
680 G Street, Suite C
Jacksonville, OR 97530

February 2021

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Appendices

1.0 Introduction

The California Water Quality Monitoring Plan is a sub-plan of the Water Quality Monitoring and Management Plan that will be implemented as part of the Proposed Action for the Lower Klamath Project (Project).

1.1 Purpose of Water Quality Monitoring Plan

The purpose of the California Water Quality Monitoring Plan is to state the methodology and procedures the Renewal Corporation will implement to evaluate water quality conditions associated with the decommissioning of Copco No. 1, Copco No. 2, and Iron Gate Developments. Water quality will be evaluated through monitoring and sampling to assess Proposed Action-related effects and to inform adaptive management actions for the protection of aquatic resources and the beneficial uses of the Klamath River.

1.2 Relationship to Other Management Plans

The California Water Quality Monitoring Plan is supported by elements of the following management plans for effective implementation: Water Quality Monitoring and Management Plan (sub-plans), Reservoir Area Management Plan and Recreation Facilities Plan. So as to not duplicate information, elements from these other management plans are not repeated herein but are, where appropriate, referred to in this California Water Quality Monitoring Plan.

2.0 Background

2.1 Clean Water Act Section 303(d)

Several reaches of the Klamath River below J.C. Boyle Dam, including Project reservoirs, are listed on the Clean Water Act Section 303(d) list of impaired water bodies. According to the California State Water Resources Control Board (SWRCB), the Klamath River from the Oregon border to the Pacific Ocean is listed for nutrients, dissolved oxygen, and temperature. In addition, Iron Gate and Copco No. 1 Reservoirs are listed for mercury and microcystin, the Klamath River from Copco No. 1 Reservoir to the Trinity River is listed for microcystin, the Klamath River from the Trinity River to the Pacific Ocean is listed for sediment, and the Klamath River from Iron Gate Dam to the Scott River is listed for aluminum (SWRCB 2018).

2.2 KHSA Interim Measure 15 Monitoring

As part of the Klamath River Hydroelectric Settlement (KHSA), PacifiCorp is funding long-term baseline water quality monitoring of the Klamath River from Upper Klamath Lake to the Klamath River Estuary (Interim Measure 15 – Water Quality Monitoring (KHSA 2020). The monitoring includes a combination of continuous water quality monitoring of physical water properties and discrete grab sampling for dissolved and suspended organic and inorganic constituents. Under this measure, twenty-two stations have been monitored from 2009 through the present including stations on the mainstem Klamath River, in the reservoirs, and at the mouths of four major

tributaries (KHSA 2020). Several of the water quality parameters and stations are similar to those that will be monitored as part of this California Water Quality Monitoring Plan.

2.3 Sediment Transport in the Klamath River Watershed

As stated in the Final Environmental Impact Report for the Lower Klamath Project License Surrender (EIR, SWRCB 2020a), the majority of annual sediment delivery from the Klamath River to the ocean, a total of approximately 6,237,500 tons/year (tons/year) on average, is contributed by three major tributaries downstream of the Hydroelectric Reach. The average delivery from Keno Dam (Oregon) to Iron Gate Dam is estimated to be approximately 150,000 tons/year, while the Scott River supplies approximately 607,000 tons/year, the Salmon River 320,000 tons/year, and the Trinity River 3,300,000 tons/yr. These contributions change dramatically from year-to-year, with wet years contributing many times more sediment than dry years. The estimated total amount of sediment impounded behind the dams to be removed is approximately 3,600,000 tons (SWRCB 2020a).

2.4 Impounded Sediment Analysis

An evaluation of sediment chemistry in J.C. Boyle, Copco No. 1, and Iron Gate Reservoirs was completed using samples collected in 2004-2005 and 2009-2010 (USDOI 2011). As stated in the EIR, the results of chemical analyses and toxicological bioassay procedures indicate that, if released, the impounded sediments from the three reservoirs does not pose a significant toxicological threat to the downstream environment (SWRCB 2020a). The Renewal Corporation analyzed high-resolution bathymetric surveys conducted in 2002 and again in 2018 to estimate the total sediment volume in the reservoirs as well as the accumulation rate. Based on these analyses, the United States Environmental Protection Agency (EPA) determined that the existing data are adequate to proceed with project permitting (EPA 2020).

3.0 Monitoring and Sampling Program

3.1 Continuous Water Quality Monitoring

The Renewal Corporation will deploy a series of continuously recording data sondes at stations along the mainstem of the Klamath River. Stations were chosen based on proximity to existing/historical sensor locations and strategic locations between reservoirs to determine the source(s) of any water quality impacts during implementation of the Proposed Action. Each monitoring station will consist of a data sonde equipped with sensors.

3.1.1 Monitoring Locations

The locations of the continuous monitoring stations are listed here and are presented in Figure 3-1.

- Klamath River at United State Geological Survey (USGS) gage no. 11509500 (below Keno Dam)
- Klamath River at USGS gage no. 11510700 (below J.C. Boyle Dam)

- Klamath River upstream of Copco No. 1 Reservoir, and downstream of Shovel Creek
- Klamath River downstream of Copco No. 2 Powerhouse, no further downstream than the Daggett Road bridge crossing of the Klamath River
- Klamath River at USGS gage no. 11516530 (below Iron Gate Dam)
- Klamath River at or near Walker Bridge
- Klamath River at USGS gage no. 11520500 (below Seiad Valley)
- Klamath River at USGS gage no. 11523000 (Orleans)
- Klamath River at USGS gage no. 11530500 (Klamath)
- Klamath Estuary near the mouth of the Klamath River

3.1.2 Monitoring Parameters

The Renewal Corporation will monitor the following parameters at each location presented in Section 3.1.1.

- Temperature
- Conductance
- pH
- Dissolved oxygen (concentration and percent saturation)
- Turbidity

Each sonde will record data at 15-minute intervals and the sensors will undergo calibration and quality assessment/quality control measures detailed in the Quality Assurance Project Plan (QAPP, Appendix A). The QAPP also contains technical specifications of the sondes and contingency plans to avoid data gaps due to sensor damage, malfunction, power, or telemetry issues.

The six continuous monitoring stations associated with USGS gages (see Section 3.1.1) will have telemetry capabilities and the data will be transmitted and stored in an online database automatically. The sondes at these stations will be powered from an external source.

The remaining four continuous monitoring stations not associated with a USGS gage (see Section 3.1.1) will log data internally but will not transmit the data automatically to the online database. Renewal Corporation staff will manually download data from these stations when they visit the sites to take water quality grab samples (see Section 3.2). The sondes deployed at these stations will have data logging capabilities and will be equipped with internal batteries. The capacity of the data logger and batteries is sufficient to collect data on 15-minute intervals for up to 90 days, but the data will be retrieved monthly and batteries will be changed every two months. If the battery status on the interim monthly visit indicates lower than expected battery levels, the batteries will be changed at that time.

3.1.3 Monitoring Schedule and Frequency

The Renewal Corporation will initiate continuous monitoring one year prior to drawdown and will continue until water quality objectives are met as outlined in Section 3.5. Continuous water

quality parameters will be recorded at 15-minute intervals. The continuous water quality monitoring stations will be maintained and will continue collecting data for 36 months following the initiation of drawdown or as described in Section 3.5.

3.1.4 Monitoring Objectives

The Renewal Corporation will monitor water quality for compliance with the numeric water quality monitoring objectives of the Water Quality Control Plan for the North Coast Region (North Coast Basin Plan, RWQCB 2018), which were summarized and presented in the California Section 401 Clean Water Act Certification (CA 401 WQC, SWRCB 2020b) as *Table 1: Minimum Parameters to Demonstrate Attainment of Numeric Water Quality Objectives* and are stated below. The Renewal Corporation will use these objectives when comparing data from upstream and downstream of Project activities as well as comparing to data collected as part of Interim Measure - 15. See Section 3.5 regarding the Compliance Schedule.

- **Temperature**: Elevated temperature waste discharges into COLD[1] interstate waters are prohibited. Thermal waste discharges having a maximum temperature greater than 5° Fahrenheit above natural receiving water temperature are prohibited. At no time or place shall the temperature of WARM[2] intrastate water be increased more than 5° Fahrenheit above natural receiving water temperature.
- **Specific conductance**: Klamath River above Iron Gate Dam and including Iron Gate and Copco Reservoirs: 275 micromhos (50% upper limit)[3] and 425 micromhos (90% upper limit)[4]. Middle Klamath River below Iron Gate Dam: 275 micromhos (50% upper limit) and 350 micromhos (90% upper limit). Lower Klamath River: 200 micromhos (50% upper limit) and 300 micromhos (90% upper limit).
- **pH**: pH shall be between 7.0 and 8.5. Changes in normal ambient pH levels shall not exceed 0.2 units in waters designated marine or saline beneficial uses nor 0.5 units within the range specified above in fresh waters with designated COLD or WARM.
- **Dissolved oxygen**: Stateline to the Scott River: October 1 to March 31: 90% saturation, April 1 to September 30: 85%. Scott River to Hoopa: 90%. Downstream of Hoopa to Turwar: June 1 to August 31: 85%, September 1 to May 31: 90%. Upper and Middle

[1] COLD is defined as Cold Freshwater Habitat uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

[2] WARM is defined as Warm Freshwater Habitat uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

[3] 50% upper and lower limits represent the 50 percentile values of the monthly means for the calendar year. 50% or more of the monthly means must be less than or equal to an upper limit and greater than or equal to a lower limit.

[4] 90% upper and lower limits represent the 90 percentile values of the monthly means for the calendar year. 90% or more of the monthly means must be less than or equal to an upper limit and greater than or equal to a lower limit.

Estuary: September 1 to October 31: 85%, November 1 to May 31: 90%, June 1 to July 31: 85%, August 1 through August 31: 80%.

- **Turbidity**: Turbidity[5] shall not be increased more than 20% above naturally occurring background levels.

[5] The Renewal Corporation will assess turbidity during baseflow conditions.

er Klamath Project

Water and Sediment Quality Monitoring Stations

PRELIMINARY DESIGN (NOT FOR CONSTRUCTION)

Figure 3-1. Water Quality Monitoring Stations

3.2 Water Quality Grab Sampling

The Renewal Corporation will collect and analyze water quality grab samples. The analytical parameters, sampling and collection methods, laboratory analytical methods, frequency and schedule, and objectives are provided in the following sections.

3.2.1 Grab Sampling Locations

The locations of the water quality grab sampling stations are listed here and are presented in Figure 3-1.

- Klamath River at USGS gage no. 11509500 (below Keno)
- Klamath River at USGS gage no. 11510700 (below J.C. Boyle)
- Klamath River upstream of Copco No. 1 Reservoir, and downstream of Shovel Creek
- Klamath River downstream of Copco No. 2 Powerhouse, no further downstream than the Daggett Road bridge crossing of the Klamath River
- Klamath River at USGS gage no. 11516530 (below Iron Gate)
- Klamath River at USGS gage no. 11520500 (below Seiad Valley)
- Klamath River at or near USGS gage no. 11523000 (Orleans)
- Klamath River at or near USGS gage no. 11530500 (Klamath)
- Klamath Estuary near the mouth of the Klamath River

3.2.2 Sampling Parameters

The Renewal Corporation will analyze water quality grab samples for the following parameters.

- Total Nitrogen
- Nitrate
- Nitrite
- Ammonia
- Total Phosphorus
- Particulate Organic Phosphorus
- Orthophosphate
- Particulate Organic Carbon
- Dissolved Organic Carbon
- Chlorophyll-A (Beginning May 1 following drawdown activities and continuing annually from May 1 through October 31)
- Turbidity
- Microcystin (Beginning May 1 following drawdown activities and continuing annually from May 1 through October 31)
- Suspended Sediment Concentrations
- Methylmercury (Only at Klamath River Monitoring Locations Below Copco No. 1)
- Settleable Solids
- Particulate and Dissolved Aluminum (only at Klamath River monitoring locations downstream of Iron Gate)

3.2.3 Grab Sample Collection Methods

The Renewal Corporation will use sample collection methods as described in detail in the QAPP (Appendix A). These collection methods are consistent with protocols developed and published by the EPA, USGS, California Department of Water Resources (DWR), California Department of Fish and Wildlife (CDFW), or California Surface Water Ambient Monitoring Program (SWAMP).

3.2.4 Laboratory Analytical Methods

The Renewal Corporation will use analytical methods as described in detail in the QAPP (Appendix A). These methods comply with Code of Federal Regulations, Title 40, Part 136, or applicable methods approved by California's Environmental Laboratory Accreditation Program (ELAP). Samples that require laboratory analysis will be analyzed by ELAP-certified laboratories.

3.2.5 Sampling Frequency and Schedule

The Renewal Corporation will collect water quality grab samples monthly, beginning one year prior to drawdown at approximately the same time of day, and will continue monthly sampling for all parameters listed in Section 3.2.2 during and after drawdown. In addition, suspended sediment concentration samples will be collected every two weeks at the locations specified in Section 3.3.1 during and after drawdown. Water quality grab samples will be collected for 36 months following the initiation of drawdown or as described in Section 3.5.

3.2.6 Sampling Objectives

Table 3.1 presents the water quality objectives for each parameter identified in Section 3.2.2. If the North Coast Basin Plan identified a numeric value for one of the parameters, this value will represent the water quality objective. For those remaining analytes where there are no North Coast Basin Plan documented Numeric Values, the Renewal Corporation will compare water quality results with: 1) pre-drawdown analytical results relative to general narrative statements made in the North Coast Basin Plan, 2) the results from pre-drawdown monitoring conducted as part of Interim Measure – 15 and the pre-drawdown water quality grab sample results outlined in this Plan (Section 3.2.2), and 3) results from concurrent monitoring at upstream stations. For the latter, water quality grab sample results for each station will be compared to the long-term distribution for that parameter at that station and for the month in which it was collected.

When making comparisons of results for parameters with no numeric objective (Table 3.1), the Renewal Corporation will consider reasonably available data to evaluate and determine whether the given parameter is lower or higher than it would have been without implementation of the Proposed Action. For example, if results for a particular analyte are elevated at a station just downstream from a Proposed Action activity but not upstream, the Renewal Corporation will evaluate the event using data from other parameters and by consulting with regional water quality experts (including the North Coast Regional Water Quality Control Board (RWQCB) and SWRCB) to determine the source. The Renewal Corporation will investigate deviations from upstream values and baseline conditions on a case-by-case basis. The Renewal Corporation

expects many of these analytes to be elevated during and immediately following drawdown; see Section 3.5 regarding the Compliance Schedule.

Table 3.1. Water Quality Grab Sampling Objectives

ANALYTE	WATER QUALITY OBJECTIVES	NUMERIC VALUE SOURCE
Nitrite	1 mg/L	North Coast Basin Plan[1]
Nitrate	10 mg/L	North Coast Basin Plan[1]
Total Nitrogen	10 mg/L	North Coast Basin Plan[1]
Ammonia	Compare to pre-drawdown and upstream results[2]	NA
Total Phosphorus	Compare to pre-drawdown and upstream results[2]	NA
Particulate Organic Phosphorus	Compare to pre-drawdown and upstream results[2]	NA
Orthophosphate	Compare to pre-drawdown and upstream results[2]	NA
Particulate Organic Carbon	Compare to pre-drawdown and upstream results[2]	NA
Dissolved Organic Carbon	Compare to pre-drawdown and upstream results[2]	NA
Chlorophyll-a	Compare to pre-drawdown and upstream results[2]	NA
Turbidity	Compare to pre-drawdown and upstream results[2]	NA
Microcystin	California Water Quality Monitoring Council trigger levels[3]	NA
Suspended Sediment Concentration	Compare to pre-drawdown and upstream results[2]	NA
Methylmercury	Compare to pre-drawdown and upstream results[2]	NA
Settable Solids	Compare to pre-drawdown and upstream results[2]	NA
Particulate and Dissolved Aluminum	Compare to pre-drawdown and upstream results[2]	NA

Notes:

1. North Coast Basin Plan references Title 22 California Code of Regulations-Table 64431-A: Maximum Contaminant Levels – Inorganic Chemicals.

2. Sampling results will be compared to pre-drawdown analytical results for KHSA stations as part of Interim Measure – 15 monitoring and to pre-drawdown water quality grab sample results.
3. California Water Quality Monitoring Council (2020) Table 3 – CCHAB trigger levels for posting planktonic advisory signs: No Advisory – <0.8 µg/L, Caution (Tier 1) – 0.8 µg/L, Warning (Tier 2) – 6.0 µg/L, Danger (Tier 3) – 20.0 µg/L, see Section 4.1.5.

3.3 Sediment Grab Samples

In addition to water quality sampling, the Renewal Corporation will collect and analyze sediment grab samples. The analytical parameters, sampling and collection methods, laboratory analytical methods, frequency and schedule, and objectives are provided in the following sections.

3.3.1 Sampling Locations

The locations of sediment chemistry grab sampling stations are listed here and are presented in Figure 3-1.

- Klamath River upstream of Copco No. 1 Reservoir and downstream of Shovel Creek.
- Three locations in the Copco No. 1 Reservoir footprint, in areas where sediments will likely be terraced. If terracing does not occur at the previously sampled location, the sample location will be moved to a location with terraced sediments.
- Klamath River downstream of Copco No. 2 Powerhouse, no farther downstream than the Daggett Road bridge crossing of the Klamath River.
- Three locations in the Iron Gate Reservoir footprint, in areas where sediments will likely be terraced. If terracing does not occur at the previously sampled location, the sample location will be moved to a location with terraced sediments.
- Klamath River at or near USGS gage no. 11516530 (below Iron Gate).
- Klamath River at or near USGS gage no. 11523000 (Orleans).
- Klamath Estuary.

3.3.2 Sampling Parameters

The sediment grab samples will be analyzed for the following parameters.

- Arsenic
- Lead
- Copper
- Nickel
- Iron
- Aluminum
- Dioxin
- Cyanide
- Mercury
- Ethyl Benzenes
- Total Xylenes
- Dieldrin
- 4,4’-dichlorodiphenyltrichloroethane (DDT)
- 4,4’-dichlorodiphenyldichloroethane (DDD)
- 2,3,7,8-tetrachlorodibenzodioxin (TCDD)
- 4,4’-dichlorodiphenyldichloroethylene (DDE)
- 2,3,4,7,8-pentachlordibenzofuran (PECDF)

3.3.3 Sample Collection Methods

The Renewal Corporation will use sample collection methods as described in detail in the QAPP (Appendix A). These collection methods are consistent with protocols developed and published by the EPA, USGS, DWR, CDFW, or SWAMP.

3.3.4 Laboratory Analytical Methods

The Renewal Corporation will use analytical methods as described in detail in the QAPP (Appendix A). These methods comply with Code of Federal Regulations, Title 40, Part 136, or methods approved by California's ELAP, where such methods are available. Samples that require laboratory analysis will be analyzed by ELAP-certified laboratories.

3.3.5 Sampling Frequency and Schedule

As stated in the EIR, the United States Bureau of Reclamation conducted sediment sampling of the reservoirs and Klamath Estuary in 2009 and 2010 (SWRCB 2020a). This sampling effort provides pre-drawdown sediment chemistry data for the reservoirs and estuary, and the Renewal Corporation will collect additional pre-drawdown sediment grab samples from the four Klamath River stations listed below.

- Klamath River upstream of Copco No. 1 Reservoir and downstream of Shovel Creek.
- Klamath River downstream of Copco No. 2 Powerhouse, no farther downstream than the Daggett Road bridge crossing of the Klamath River.
- Klamath River at or near USGS gage no. 11516530 (below Iron Gate).
- Klamath River at or near USGS gage no. 11523000 (Orleans).

The Renewal Corporation will also take sediment grab samples from all locations listed in Section 3.3.1 (Figure 3-1) within 12 to 24 months of completing drawdown activities.

3.3.6 Sampling Objectives

The sediment chemistry analytes listed in Section 3.3.2 have no North Coast Basin Plan documented Numeric Values, so sediment chemistry results will be compared with: 1) pre-drawdown analytical results relative to general narrative statements made in the North Coast Basin Plan and (2) the results from pre-drawdown sediment chemistry grab sample results (Section 3.3.2).

3.4 Reporting Procedures

Prior to, during, and for a minimum of one year following completion of drawdown, the Renewal Corporation will submit monthly monitoring reports to FERC, SWRCB, Oregon Department of Water Quality (ODEQ), and the RWQCB. The Renewal Corporation will submit reports containing all available data collected within the reporting period, but some data may be reported two- and three-months following data collection to allow for laboratory analysis, data post-processing, and reporting by the analytical laboratory. The Renewal Corporation will

continue to submit monthly monitoring reports until water quality objectives have been met, as described and supported by data in the monitoring reports.

At a minimum, the Renewal Corporation will include the following information in the monthly monitoring reports.

- A summary of the results of the month's monitoring, including continuous water quality monitoring, water quality grab samples, and any sediment grab sampling that was completed within the reporting period.
- A Microsoft Excel spreadsheet containing all data collected during the reporting period.
- Highlights of any exceedances of water quality objectives.
- Highlights of observed trends.
- Reporting on any adaptive management measures taken and proposals of any additional or substitute adaptive management measures to address exceedances.
- Proposals to modify, reduce, or discontinue monitoring and reporting. The Renewal Corporation will use sampling results to support the rationale for modifications of the monitoring efforts described in this Plan.

3.5 Implementation Schedule

The Renewal Corporation expects several parameters to be elevated during and following drawdown. The SWRCB has established a 36-month time period after the initiation of drawdown for water quality to improve. Within 36 months of beginning drawdown, the Renewal Corporation will submit a report to FERC and SWRCB that documents: 1) Project attainment of sediment-related water quality objectives over a range of flows, including high winter flows and low summer flows; and 2) post-dam removal Klamath River water quality conditions following attenuation of effects associated with drawdown and establishment of new riverine conditions. The Renewal Corporation will discontinue water quality monitoring 36 months following the beginning of drawdown unless, based on the data, it expects that sediment-related water quality objectives will be exceeded beyond the 36-month Compliance Period.

In addition, at 32 months following the beginning of drawdown, the Renewal Corporation will submit to FERC, the SWRCB, and the Hoopa Tribe an assessment as to whether the Proposed Action is anticipated to result in exceedance of water quality objectives beyond 36 months after the beginning of drawdown. If exceedances are anticipated beyond the 36-month Compliance Period, water quality monitoring will continue until the Renewal Corporation determines that the objectives have been met and receives approval from FERC and the SWRCB to discontinue sampling.

4.0 Other Water Quality Project-Related Monitoring

Beyond reservoir drawdown and dam removal, the Proposed Action includes the following activities that may impact water quality and require monitoring efforts.

4.1 Recreation Areas Water Quality Monitoring

The Renewal Corporation will collect and analyze grab water quality samples as outlined below for the protection of the recreational water contact (REC-1) beneficial use as defined in the North Coast Basin Plan.

4.1.1 Sampling Locations

The Renewal Corporation will conduct water quality sampling at all newly constructed facilities identified in the FERC License Surrender Order, until such time as the Order is considered final. The Renewal Corporation will collect water quality grab samples from the locations presented below and in Figure 4-1.

- Copco Valley Recreation Site (newly constructed)
- Copco No. 2 Powerhouse Recreation Site (newly constructed)
- Iron Gate Fish Hatchery Day Use Area Recreation Site (modified)

4.1.2 Sampling Parameters, Frequency, and Schedule

The Renewal Corporation will perform the following water quality monitoring.

4.1.2.1 Iron Gate Fish Hatchery Day Use Area Recreation Site (modified)

Prior to drawdown, the Renewal Corporation will collect fecal coliform samples during the 30-day periods that span the Independence Day holiday (June-July) and the Labor Day holiday (August-September). Following completion of drawdown, sampling will be performed twice every year and as necessary to monitor for water quality and beneficial use protection.

Prior to drawdown, the Renewal Corporation will monitor microcystin toxin annually. Following drawdown, at a minimum, the Renewal Corporation will monitor microcystin monthly (May through October) for two years following the completion of drawdown.

4.1.2.2 Copco Valley and Copco No. 2 Powerhouse Recreation Sites (newly constructed)

Following completion of construction of these recreation sites, the Renewal Corporation will monitor microcystin toxins monthly (May through October) for two years following the completion of drawdown.

4.1.3 Sampling Collection Methods

The Renewal Corporation will use sampling methods as described in detail in the QAPP (Appendix A). These methods comply with protocols developed and published by USEPA, USGS, DWR, CDFW, or SWAMP. For fecal coliform, sampling will use the five samples in 30-day methodology (see Section 4.1.5) or other future protocol identified in the North Coast Basin Plan.

4.1.4 Laboratory Analytical Methods

Analytical methods will comply with the eCFR Title 40, Part 136, or methods approved by ELAP, where such methods are available. Samples that require laboratory analysis will be analyzed by ELAP-certified laboratories.

4.1.5 Water Quality Analytical Results

Per the North Coast Basin Plan, for waters designated for contact recreation the median concentration of fecal coliform for at least five samples in any 30-day period shall not exceed 50 MPN[6] per 100 milliliters (mL), nor shall more than 10% of total samples during any 30-day period exceed 400 MPN per 100 mL (RWQCB 2018).

Per California Water Quality Monitoring Council (2020) *Table 3 – CCHAB trigger levels for posting planktonic advisory signs*, the Renewal Corporation will use the following trigger levels to determine advisory posting efforts for microcystin toxins:

- No Advisory – <0.8 µg/L
- Caution (Tier 1) – 0.8 µg/L
- Warning (Tier 2) – 6.0 µg/L
- Danger (Tier 3) – 20.0 µg/L

If results for fecal coliform or microcystin exceed these levels, the Renewal Corporation will post appropriate public notice(s) at the affected recreation site(s).

4.1.6 Reporting Procedures

The Renewal Corporation will notify FERC and the SWRCB when fecal coliform advisory levels are exceeded, and public notices are posted. The Renewal Corporation will also report monitoring results annually to FERC and the SWRCB. Reporting will summarize monitoring results, highlight any exceedances of fecal coliform or microcystin toxin, and propose adaptive management measures to address exceedances.

[6] MPN is defined as the Most Probable Number, based on laboratory analysis.

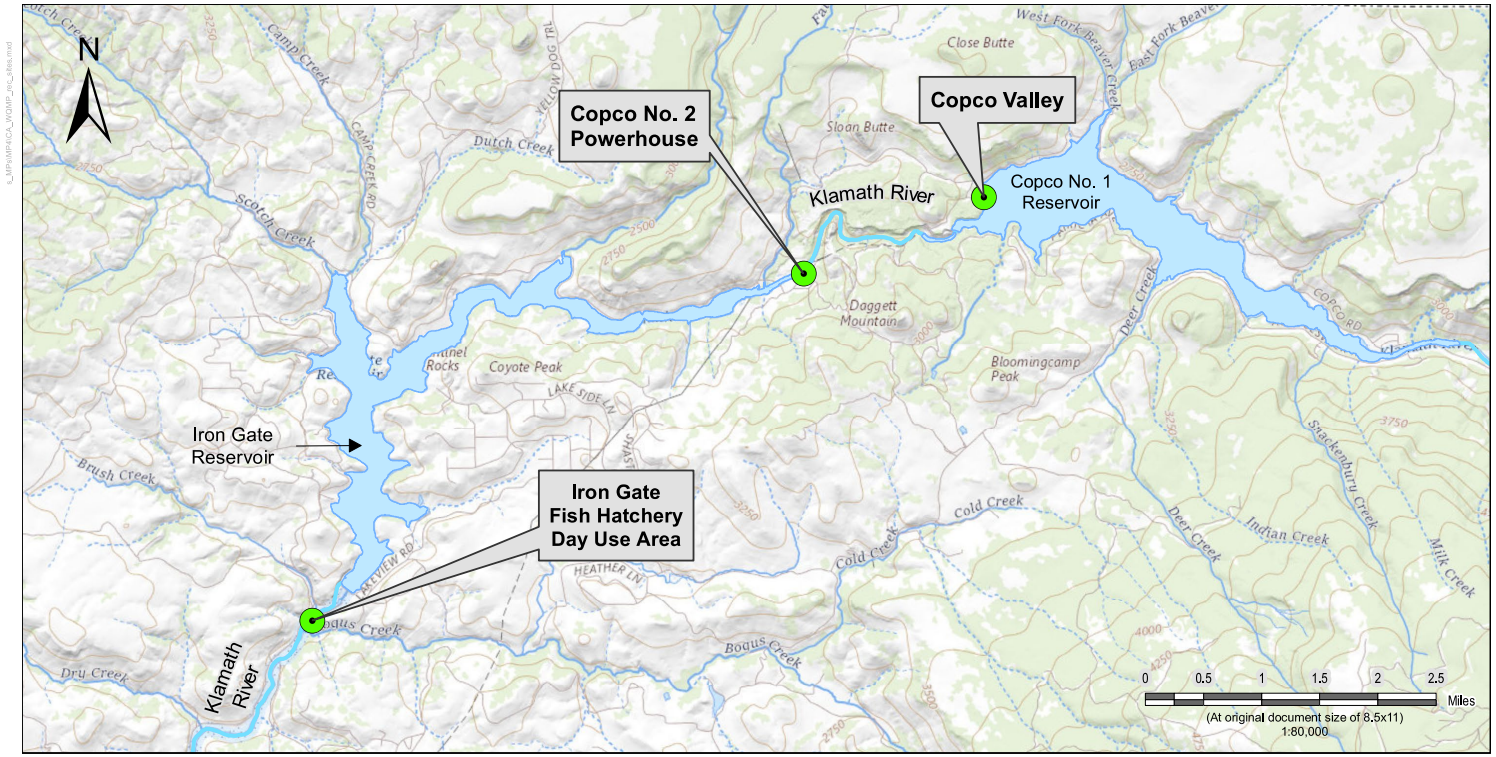

Figure 4-1. Recreation Site Water Quality Monitoring Locations

5.0 Sediment Load Quantification

5.1 Method to Quantify Sediment within Reservoir Footprints

The Renewal Corporation calculated sediment quantities for Copco No. 1 and Iron Gate Reservoirs utilizing high-resolution bathymetric surveys conducted in 2002 and 2018 (SWRCB 2020a). The volume of sediment that accumulated between these two surveys was used to estimate annual sediment deposition within the reservoirs, and this annual load estimate was used to quantify how much sediment has accumulated since the 2018 survey in order to calculate the total sediment volume in the reservoirs in 2020 (SWRCB 2020a).

5.2 Method to Quantify Sediment Exporting Reservoir Footprints

Following drawdown, the Renewal Corporation will conduct sediment survey mapping at each reservoir via drones. The Renewal Corporation will compare the 2018 bathymetric surveys to the post-drawdown drone data to evaluate the reduction in the volume of sediment within the reservoir footprints. Sediment shrinkage will be accounted for using the shrinkage factor of 60% assumed and presented in the Definite Plan Report (KRRC 2018).

5.3 Method to Quantify Sediment between Iron Gate and Cottonwood Creek

The Renewal Corporation conducted a bathymetric survey for the reach of the Klamath River between Iron Gate Dam and Cottonwood Creek in 2018 and will conduct additional bathymetric surveys in the same reach at 12- and 24-months following drawdown. The Renewal Corporation will compare post-drawdown bathymetric survey results to the 2018 bathymetry to evaluate the amount of sediment that may have settled in this reach as a result of drawdown activities.

5.4 Reporting

The Renewal Corporation will issue Sediment Load reports to FERC and the SWRCB at 15- and 27-months following completion of drawdown.

At a minimum, the Sediment Load reports will include the following information:

- Amount of sediment present in each Project reservoir footprint.
- Total amount of sediment exported from the Project reservoirs.
- Amount of sediment that has settled in the Klamath River between Iron Gate Dam and Cottonwood Creek (River Mile 185).

6.0 References

California State Water Resources Control Board. 2018. Final 2014 and 2016 California Integrated Report (Clean Water Act Section 303(d) List / 505(b) Report). Website: https://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2014_2016.shtml. Accessed November 3, 2020.

California State Water Resources Control Board. 2020a. Final Environmental Impact Report for the Lower Klamath Project License Surrender. April.

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California Water Quality Monitoring Council (CWQMC). 2020. California Voluntary Guidance for Response to HABs in Recreational Inland Waters. Website: https://mywaterquality.ca.gov/habs/resources/habs_response.html. Accessed November 12, 2020.

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Klamath River Renewal Corporation (KRRC). 2018. Definite Plan for the Lower Klamath Project. June.

North Coast Regional Water Quality Control Board (RWQCB). 2018. Water Quality Control Plan for the North Coast Region. Santa Rosa, California. June.

United States Department of the Interior (USDOI). 2011. Screening-Level Evaluation of Contaminants in Sediments from Three Reservoirs and the Estuary of the Klamath River, 2009-2011. Prepared for the United States Department of the Interior Klamath Dam Removal Water Quality Sub Team by CDM. September.

United States Environmental Protection Agency (EPA). 2020. EPA Evaluation of Existing Sediment Quality Data for Permitting the Removal of Four Dams on the Lower Klamath River. Transmittal from EPA to United States Army Corps of Engineers August 25, 2020.

Appendix A

Quality Assurance Project Plan

Klamath River Renewal Corporation
Water Quality Monitoring Network for the Klamath River Renewal Project

Water Quality Sampling and Analysis

Quality Assurance Project Plan

February 2021

KLAMATH RIVER RENEWAL CORPORATION

USGS science for a changing world

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A. Project Management

A.1 Title and Approval Sheet

PROJECT TITLE:	Water Quality Monitoring for the Klamath River Renewal Project
LEAD ORGANIZATION:	Klamath River Renewal Corporation 2001 Addison Street, Suite 300, Office 317 Berkeley, California 94704
PRIMARY CONTACT:	Darrell Smolko RES Project Manager 22 Battery Street, Suite 508 San Francisco, CA 94111 Mobile: (510) 910-0916 dsmolko@res.us
EFFECTIVE DATE:	October 1, 2021 to Program End
VERSION:	01
PREFACE:	SWAMP-compliant QAPP for Klamath River water quality monitoring at 10 monitoring stations in preparation for the Klamath River Renewal Project. This document was produced using the SWAMP-EPA Review Checklist.
QAPP PREPARED BY:	Darrell Smolko, Restoration Engineer Resource Environmental Solutions, LLC Susan Fricke, Water Quality Manager Karuk Tribe Water Program Lisa DeRose Camas, LLC

Approvals

Darrell Smolko, RES
Klamath River Renewal Corporation Water Quality Monitoring Program Manager

_____Date_____

Lisa DeRose, Camas
Klamath River Renewal Corporation Water Quality Monitoring Program Coordinator

_____Date_____

A.2 Table of Contents

A.2.1 QAPP Information Sections

A.2.2 List of Tables and Figures

A.2.3 Appendices and Standard Operating Procedures

Appendix A	Karuk Tribe QAPP 2019
Appendix B	Karuk Tribe QAPP 2018
Appendix C	Field Operations and Sampling Forms
Appendix D	Standard Operating Procedures
Appendix E	YSI EXO Datasonde User and Calibration Manual

Distribution List

The final Quality Assurance Project Plan (QAPP) will be kept on file by the Karuk Tribe Water Program, Yurok Tribe Environmental Program, Resource Environmental Solutions (RES), and the United States Geological Survey (USGS). The following individuals will receive copies of the approved QAPP and any subsequent revisions. Field personnel will have a copy of the QAPP and Health and Safety Plan (HSP) during all field activities:

Table 1. Distribution List

Title	Contact Information
Darrell Smolko **RES** **Project Manager**	22 Battery Street, Suite 508 San Francisco, CA 94111 Mobile: (510) 910-0916 dsmolko@res.us
Laura Hazlett **KRRC** **Chief Operations Officer and Chief Financial Officer**	2001 Addison Street, Suite 317 Berkeley, CA 94704 Mobile: (510) 679-6928 lhazlett@klamathrenewal.org
Lisa DeRose **Camas** **Project Scientist**	680 G Street, Suite C Jacksonville, OR 97530 Mobile: (908) 229-6488 lisa@camasllc.com
Chauncey Anderson **USGS** **KRRP Monitoring Site & Sediment Monitoring Coordinator**	2130 SW 5th Avenue Portland, OR 97201 Office: (503) 251-3206 chauncey@usgs.gov
Scott Wright **USGS – California** **Program QA/QC Officer & Monitoring Team Leader**	USGS California Water Science Center 6000 J Street, Placer Hall Sacramento 95819 Office: (916) 278-3024 Mobile: (916) 862-0163 sawright@usgs.gov
Liam Schenk **USGS – Oregon** **Monitoring Team Leader**	2795 Anderson Avenue, Suite 106 Klamath Falls, Oregon 97603 Office: (541) 273-8689 x208 lschenk@usgs.gov
Alex Etheridge **USGS** **QA/QC and Program Data Manager**	6000 J Street, Placer Hall Sacramento, CA 95819 Office: (916) 995-0784 aetherid@usgs.gov
Dennis O'Halloran **USGS**	6000 J Street, Placer Hall Sacramento, CA 95819

Title	Contact Information
QA/QC	Office: (916) 278-3168 Mobile: (530) 412-0578 dohall@usgs.gov
Susan Fricke **Karuk Tribe Water Program** **WQ Monitoring Team Coordinator & Monitoring Team Lead**	P.O. Box 282 Orleans, CA 95556 Office: (530) 598-3414 sfricke@karuk.us
Grant Johnson **Karuk Tribe Water Program** **QA/QC**	P.O. Box 282 Orleans, CA 95556 Office: (530) 469-3258 gjohnson@karuk.us
Matt Hanington **Yurok Tribe Environmental Program** **Monitoring Team Leader & QA/QC**	15900 Hwy 101 N P.O. Box 1027 Klamath, CA 95548 Office: (707) 482-1822 ext. 1002 Mobile: (707) 954-7519 mhanington@yuroktribe.nsn.us
Stephen Low **USGS Sediment Lab** **Lab Manager**	2885 Mission Street Santa Cruz, CA 95060 Office: (831) 460-7500 stephlow@usgs.gov

A.3 Project Organization

A.3.1 Key Individual and Responsibilities

Resource Environmental Solutions, LLC (RES) is a prime consultant to the Klamath River Renewal Corporation ("Renewal Corporation"), for the Project and is managing the Water Quality Monitoring Program. As collaborators and partners with the Renewal Corporation, the Project Water Quality Monitoring Team comprised of RES, the Karuk and Yurok Tribes, and USGS, will conduct the data collection activities, perform field and laboratory analysis of samples and data, help to manage the program and contracts, and assist with the development of all reporting documents. The USGS Sediment Laboratory (USL) located in Santa Cruz, CA will perform suspended sediment concentration (SSC) analyses of the water samples. Camas is providing regulatory compliance oversight and reviewing all documents and plans related to the requirements within the California and Oregon 401 Water Quality Certifications for the Project. The Karuk Tribe, Yurok Tribe, and the USGS are sharing the monitoring responsibilities of the Water Quality Monitoring Plan based on monitoring site location and the type of monitoring to be conducted (see Section A.6).

The key individuals involved in all major aspects of the project, including contractors, and outlined in Table 2 and includes their responsibilities. Figure 1 provides an organizational chart that shows lines of authority and reporting responsibilities.

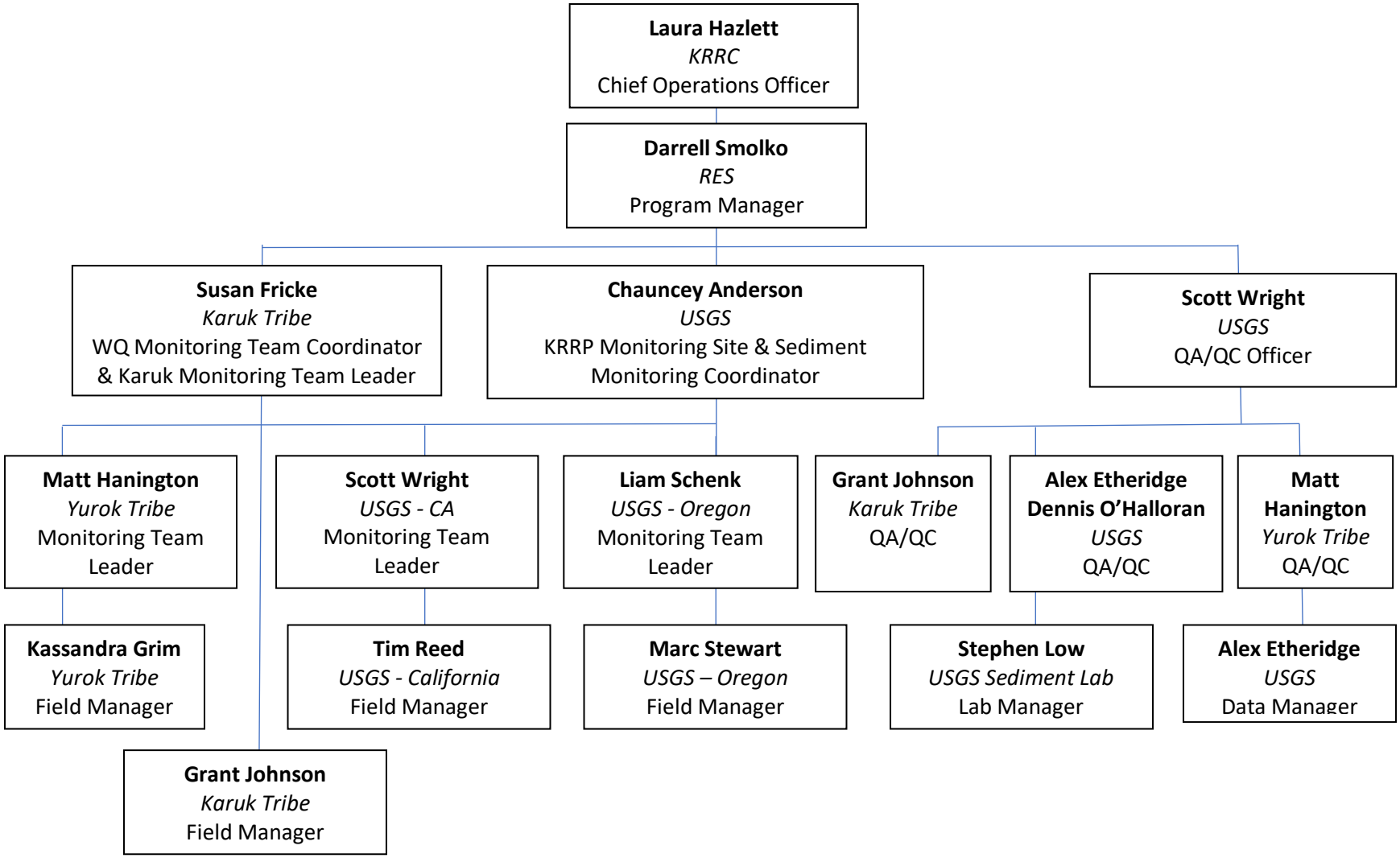
Table 2. Personnel, contact information, and responsibilities.

Program Team Member	Contact Information	Responsibility
Program Management/Administration		
Laura Hazlett KRRC	(510) 679-6928 lhazlett@klamathrenewal.org	Chief Operations Officer
Darrell Smolko RES	(510) 910-0916 dsmolko@res.us	Program Manager
Water Quality Monitoring Team		
Susan Fricke, Karuk Tribe Water Program	(530) 598-3414 sfricke@karuk.us	WQ Monitoring Team Coordinator & Karuk Tribe Monitoring Team Leader
Chauncey Anderson, USGS	(503) 251-3206 chauncey@usgs.gov	KRRP Monitoring Site & Sediment Monitoring Coordinator
Scott Wright USGS - California	(916) 862-0163 sawright@usgs.gov	USGS California Monitoring Team Leader
Liam Schenk, USGS - Oregon	(541) 273-8689 ext. 208 lschenk@usgs.gov	USGS Oregon Monitoring Team Leader
Matt Hanington, Yurok Tribe Environmental Program	(707) 482-1822 ext. 1002 mhanington@yuroktribe.nsn.us	Yurok Tribe Monitoring Team Leader
Grant Johnson Karuk Tribe Water Program	(530) 469-3258 gjohnson@karuk.us	Karuk Tribe Field Manager
Tim Reed USGS California	(530) 246-5282 treed@usgs.gov	USGS California Field Manager
Marc Stewart USGS Oregon	(541) 776-4258 mastewar@usgs.gov	USGS Oregon Field Manager
Kassandra Grim Yurok Tribe Environmental Program	(707) 482-1822 ext. 1003 kgrimm@yuroktribe.nsn.us	Yurok Tribe Field Manager
Quality Assurance/Quality Control		
Scott Wright USGS	(916) 862-0163 sawright@usgs.gov	Program QA/QC Officer
Grant Johnson, Karuk Tribe Water Program	(530) 469-3258 gjohnson@karuk.us	Karuk Tribe QA/QC

Program Team Member	Contact Information	Responsibility
Alex Etheridge, USGS	(916) 995-0784 aetherid@usgs.gov	USGS QA/QC – Sondes
Denis O'Halloran, USGS	(916) 278-3168 dohall@usgs.gov	USGS QA/QC - Sediment
Matt Hanington, Yurok Tribe Environmental Program	(707) 482-1822 ext. 1002 mhanington@yuroktribe.nsn.us	Yurok Tribe QA/QC
Laboratory Manager		
Stephen Low, USGS Sediment Laboratory	(831) 460-7500 stephlow@usgs.gov	Oversee USL analysis of SCC samples
Data Manager		
Alex Etheridge USGS	(916) 995-0784 aetherid@usgs.gov	Monitoring Data Management and Validation

A.3.2 Organizational chart that shows lines of authority and reporting responsibilities

Figure 1.



A.3.3 Project Quality Assurance Officer

The Quality Assurance/Quality Control (QA/QC) Officer role is independent of data generation. This individual's role is to establish the quality QA/QC procedures found in this QAPP as part of the sampling, field analysis, and laboratory analysis procedures (Figure 1). The QA/QC Officer will also work with the Laboratory Manager from USL by communicating all quality assurance and quality control issues contained in this QAPP. The QA/QC Officer will also review and assess all procedures during the life of this project against QAPP requirements. The QA/QC Officer will report all findings to the Water Quality Team Coordinator, including all requests for corrective action. The QA/QC Officer may stop all actions, including those conducted by subcontractors if there are significant deviations from required practices or if there is evidence of a systematic failure, (Table 2. Personnel, contact information, and responsibilities).

A.4 Project Background

The Lower Klamath River Project (Lower Klamath Project) Federal Energy Regulatory Commission (FERC) No. 14803 is located on the Klamath River in Klamath County in south-central Oregon, and Siskiyou County in north-central California. The Lower Klamath Project consists primarily of four dams and associated facilities, listed from upstream to downstream: (1) J.C. Boyle (Oregon); (2) Copco No. 1 (California); (3) Copco No. 2 (California); and (4) Iron Gate (California) (Figure 1 1).

The Renewal Corporation has applied to the FERC to surrender the license for the Lower Klamath Project for the purpose of implementing the Klamath River Hydroelectric Settlement (KHSA). Among other goals the KHSA was established to create a free-flowing river that allows volitional fish passage. The Proposed Action includes the deconstruction of the J.C. Boyle Dam and Powerhouse, Copco No. 1 Dam and Powerhouse, Copco No. 2 Dam and Powerhouse, and Iron Gate Dam and Powerhouse, as well as associated features. Associated features vary by development, but generally include powerhouse intake structures, embankments, and sidewalls, penstocks and supports, decks, piers, gatehouses, fish ladders and holding facilities, pipes and pipe cradles, spillway gates and structures, diversion control structures, aprons, sills, tailrace channels, footbridges, powerhouse equipment, distribution lines, transmission lines, switchyards, original cofferdam, portions of the Iron Gate Fish Hatchery, residential facilities, and warehouses.

The Water Quality Monitoring and Management Plan (WQMMP) identifies the methodology and procedures the Renewal Corporation will implement to evaluate water quality conditions associated with the decommissioning of J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate developments. Water quality will be evaluated through monitoring and sampling to assess project-related effects and to inform adaptive management actions for the protection of aquatic resources and the beneficial uses of the Klamath River.

The WQMMP is being implemented by a multi-agency working group in accordance with the Oregon Clean Water Act (CWA) Section 401 Water Quality Certification (Oregon Department of Environmental Quality 2018) and the California CWA Section 401 Water Quality Certification (California State Water Resources Control Board 2019). The purpose of this QAPP is to describe the Project's monitoring goals, data needs and assessment, responsible individuals, quality assurance plan, equipment maintenance,

quality control measures, and reporting deadlines. This QAPP reflects conditions stated within the Oregon 401 WQ Certification and the California 401 WQ Certification.

A.5 Project Description

A.5.1 Geographic Setting

The Klamath River flows 257 miles through Oregon and California to the Pacific Ocean and is the second largest river in California. It originates in the high desert of south-central Oregon and moves through the Klamath Mountains. **Error! Reference source not found.** shows the overall geographic location of selected sites. A total of 12 monitoring sites were selected to develop a longitudinal profile of the Klamath River from below Keno Dam to the Klamath River estuary.

Monitoring site locations were determined by considering existing water quality monitoring stations in the Klamath River Basin, site access, land use, and input received during consultation. Six existing USGS stream gage sites along the mainstem of the Klamath River within California and Oregon are being utilized to conduct continuous water quality monitoring. Two additional continuous monitoring sites will be established leading up to reservoir drawdown. Additional sites were selected for water and sediment grab samples after the considerations above. These 12 site locations are provided in Table 3 and Figure 2.

A.5.2 Summary of Work to be Performed

Under this QAPP, three types of water quality monitoring will be conducted: Continuous Monitoring, Water Quality Grab Sampling, and Sediment Grab Samples. The types of monitoring to be conducted and monitoring site locations are outlined in Table 3. Different parameters will be analyzed depending on the type of sampling conducted. These parameters are provided in Table 4. All information collected under this QAPP is critical for the Project and there are no collections outlined below that are for informational purposes only.

Figure 2. Site Layout and Sampling Locations

KLAMATH RIVER RENEWAL CORPORATION

Lower Klamath Project

Water and Sediment Quality Monitoring Stations

January 2021

PRELIMINARY DESIGN (NOT FOR CONSTRUCTION)

Monitoring Locations

- Continuous
- Continuous, Grab
- Continuous, Grab, Sediment
- Sediment

Klamath River

N

0 10 20 40 Miles

Notes

1. Coordinate System: WGS 1984 UTM Zone 10N

2.Data Sources: Klamath River: USGS National Hydrography Dataset; Surface Water Diversions: Camas LLC

3. Background: USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, National Structures Dataset, and National Transportation Dataset; USGS Global Ecosystems; U.S. Census Bureau TIGER/Line data; USFS Road Data; Natural Earth Data; U.S. Department of State Humanitarian Information Unit; and NOAA National Centers for Environmental Information, U.S. Coastal Relief Model. Data refreshed May, 2020.

Table 3. Sampling locations and the associated type(s) of water quality monitoring to be conducted.

Sampling Location	Continuous Monitoring	Water Quality Grab Sampling	Sediment Grab Samples
Klamath River at or near USGS gage no. 11509500 (below Keno)	X	X	
Klamath River at or near USGS gage no. 11510700 (below J.C. Boyle)	X	X	
Klamath River upstream of Copco No. 1 Reservoir, and downstream of Shovel Creek	X	X	X
Three locations in the Copco No. 1 Reservoir footprint, in areas where sediments will likely be terraced.[1]			X
Klamath River downstream of Copco No. 2 Powerhouse, no further downstream than the Daggett Road bridge crossing of the Klamath River	X	X	X
Three locations in the Iron Gate Reservoir footprint, in areas where sediments will likely be terraced.1			X
Klamath River at or near USGS gage no. 11516530 (below Iron Gate)	X	X	X
Klamath River at or near Walker Bridge	X		
Klamath River at or near USGS gage no. 11520500 (below Seiad Valley)	X	X	
Klamath River at or near USGS gage no. 11523000 (Orleans)	X	X	X
Klamath River at or near USGS gage no. 11530500 (Klamath)	X	X	
Klamath Estuary near the mouth of the Klamath River	X	X	X

[1] If terracing does not occur at the previously sampled location, the sample location will be moved to a location with terraced sediments.

Table 4. Parameters to be monitored under the three different monitoring type under this QAPP.

Continuous Monitoring	Water Quality Grab Sampling	Sediment Grab Samples
• Temperature • Conductivity • pH • Dissolved oxygen (concentration and percent saturation) • Turbidity	• Total Nitrogen • Nitrate • Nitrite • Ammonia • Total Phosphorus • Particulate Organic Phosphorus • Orthophosphate • Particulate Organic Carbon • Dissolved Organic Carbon • Chlorophyll-A • Turbidity • Microcystin • Suspended Sediment Concentrations • Methylmercury • Settleable Solids • Particulate and Dissolved Aluminum	• Arsenic • Lead • Copper • Nickel • Iron • Aluminum • Dioxin • Cyanide • Mercury • Ethyl Benzenes • Total Xylenes • Dieldrin • 4,4’-dichlorodiphenyltrichloroethane (DDT) • 4,4’-dichlorodiphenyldichloroethane (DDD) • 2,3,7,8-tetrachlorodibenzodioxin (TCDD) • 4,4’-dichlorodiphenyldichloroethylene (DDE) • 2,3,4,7,8-pentachlordibenzofuran (PECDF)

A.5.3 Work Schedule

The work schedule, indicating critical project points, is provided in Table 5.

Table 5. Work schedule.

Task/Deliverables	Anticipated date of Completion
Task 1: Perform Field Data Collection Activities	
Continuous Water Quality Monitoring	• For sonde locations in California monitoring shall begin one year prior to drawdown and shall continue unless otherwise approved by the Deputy Director in CA. • For sonde locations in Oregon monitoring shall begin one year prior to drawdown and shall continue for a minimum of four years after initiating drawdown unless otherwise approved by ODEQ.
Water Quality Grab Sampling	• Sampling in California shall occur on a monthly basis, at the same time of day, beginning one year prior to drawdown and will continue unless otherwise approved by the Deputy Director in CA. • Suspended sediment concentration samples collected in California shall be collected every two weeks. • Sampling in Oregon shall occur on a monthly basis, at the same time of day, beginning one year prior to drawdown and shall continue for a minimum of four years after initiating drawdown unless otherwise approved by ODEQ. • Suspended sediment concentration samples collected in Oregon shall be collected every two weeks from January 2022 through September 2023 and monthly beginning October 2023.
Sediment Grab Samples	One sediment grab sampling event will be conducted prior to drawdown activities and one event within 12 to 24 months of completing drawdown activities.
Task 2: Data Management and Analysis	
Continuous provisional Karuk and Yurok data published in real-time	Ongoing through contract
Laboratory Analysis	2-3 months after sample collection
Task 3: Annual Progress Reporting	
Monthly monitoring reports will be issued to the following California agencies: SWRCB, ODEQ, DEQ, and the RWQCB.	Prior to, during, and for a minimum of one year following completion of drawdown, until otherwise approved by the CA Deputy Director.
Annual Compliance Report submitted to ODEQ	Annually, on April 1 for at least two years.

A.5.4 Resource and Time Constraints

Every effort will be made to collect storm event samples for SSC. Personnel availability may create challenges in collecting samples if multiple sites require sampling at the same time. However, automated pump samplers (ISCO) are deployed to collect samples when the sites cannot be visited. High flow events will be captured to the best of the Project teams' ability. Weather conditions will dictate sampling events, and the safety of the crews collecting the samples will be the top priority. If weather conditions create unsafe working environment for sampling crews, the samples will be collected by the automated samplers described above.

A.6 Quality Objectives and Criteria

This section discusses the quality objectives for the project and the performance criteria to achieve those objectives.

For continuous time-series measurements, the data quality criteria to be assessed quantitatively include precision and accuracy alone. These assessments will be different for water and sediment grab sample data. The associated acceptance criteria (types and frequencies of QC checks and acceptance limits) for the Project follow SWAMP guidelines and are summarized in Table .

A.6.1 Measurement Quality Objectives

This section discusses the quality objectives for the project and the performance criteria to achieve those objectives.

For continuous time-series measurements, the data quality criteria to be assessed quantitatively include precision and accuracy, as outlined below.

These assessments will be different for grab water quality and sediment samples, which involve laboratory analyses. The measurement quality objectives for these sampling types follow SWAMP guidance and are summarized in Table 6.

A.6.2 Precision and Accuracy

Precision is a measure of agreement among replicate measurements of the same property, under prescribed similar conditions.

Precision will be assessed quantitatively with duplicate samples and expressed as relative percent difference (RPD) by the following equation:

$$RPD(\%) = \frac{\frac{|x1 - x2|}{(x1 + x2)}}{2} X\ 100$$

where,

RPD (%) = relative percent difference

x1 = Original sample concentration

x2 = Duplicate sample concentration

|x1 - x2| = Absolute value of x1 - x2

To assess precision associated with all steps of the project (from sample collection through analysis), field duplicates will be collected and analyzed for all water and sediment grab samples. Composite (cross-section) grab samples will always be collected in duplicate and are referred to as A and B sets in USGS terminology. An A set represents one cross-section sample, and a B set is collected directly after, representing a duplicate cross-section sample. To assess laboratory precision alone, the USGS QA Plan for the Analysis of Fluvial Sediment by the USGS California Water Science Center (CAWSC) will be followed (Appendix D).

Precision of field results will be tested using duplicate samples, with a target of less than 20% RPD, as described previously.

Accuracy is the degree of agreement of a measurement with the true value. Accuracy includes a combination of random error (precision) and systematic error (bias) that result from sampling and analytical operations. Accuracy of water quality measurements contained in this QAPP are a function of the equipment used during sampling, and of the sampling methods.

For automatic (pump) samples, single bottle samples collected in conjunction with cross-section samples will be collected at a frequency of 5% (1 duplicate/20 field samples). Collecting a pump sample in conjunction with a cross-section sample allows for accuracy testing of the pump samples, by determining if the pump samples are representative of the cross section as a whole. If the pump samples and cross section samples differ in concentrations, then a box coefficient is applied to the pump samples. The box coefficient is simply a multiplier that is applied to the pump sample to adjust the concentration of that sample to the concentration of the cross-section sample that was collected in conjunction with the pump sample. Applying box coefficients to pump samples is a common practice by USGS, and more documentation can be found in Edwards and Glysson (1999).

A.6.3 Bias

Bias describes the tendency for under or over prediction of sampled or measured values relative to the true value. Bias is typically assessed using matrix spikes and reference materials. Samples of known sediment concentrations are routinely tested as described in the QA Plan for the Analysis of Fluvial Sediment by the USGS California Water Science Center Sediment Laboratory (Appendix D), and as described in the USGS Office of Surface Water technical memo 98.05 (USGS, 1998). Bias is also assessed in the lab through negative controls (Blanks). Detectable quantities in the blank would indicate positive bias. The CAWSC Santa Cruz Sediment Lab bi-annually participates in the Sediment Lab QA Plan described in Appendix D.

A.6.4 Representativeness

This is the expression of the degree to which data accurately and precisely represent a characteristic of an environmental condition or a population. Field crews collecting samples will maximize

representativeness of samples by selecting sites and employing methodologies to best characterize environmental conditions.

A.6.5 Completeness

Completeness on this project with regards to expected number of collected SSC samples is expected to be approximately 90%. Completeness with regards to continuous water quality data is expected to be as close to a complete record as possible (a complete record is retaining all unit values over a water year), recognizing that data loss can occur for several reasons. These reasons include loss of data during field visits and on-site calibrations, potential issues with data transmission, and other unforeseen circumstances that could result in loss of data.

Table 6. Quality control measures, frequency analyses, and measurement quality objectives for water and sediment grab samples.

Laboratory Quality Control	Frequency of Analysis	Measurement Quality Objective
Laboratory Blank	Per 20 samples or per analytical batch, whichever is more frequent	<RL for target analyte
Matrix Spike and Matrix Spike Duplicate	Per 20 samples or per analytical batch, whichever is more frequent (n/a for chlorophyll a)	Conventional Parameters: 80-120% recovery Inorganic Analytes: 75-125% recovery Nutrients: 80-120% recovery RPD<25% for duplicates
Laboratory Duplicate	Per 20 samples or per analytical batch, whichever is more frequent (chlorophyll a: per method)	RPD<25% (n/a if native concentration of either sample<RL)
Field Quality Control	**Frequency of Analysis**	**Measurement Quality Objective**
Field Duplicate	5% of total project sample count	RPD<25% (n/a if native concentration of either sample<RL)
Field Blank, Travel Blank, Equipment Blank	Per method	Blanks<RL for target analyte

A.7 Special Training /Certifications

There are no certifications that apply to this work. However, informal training has been conducted for the Karuk and Yurok tribal staff on collection of samples. Similar training will be conducted for any new staff that will conduct field sampling.

In July 2018, USGS conducted training for the Karuk and Yurok tribal staff on collection of samples for grab samples. Additional sampling training is offered annually through USGS in Castle Rock, WA, which could be attended by new staff within USGS or the Tribes.

For operation of continuous monitoring sondes, the USGS California Water Science Center (CAWSC) is planning to offer a water quality data collection training class, which includes turbidity as well as the other water quality parameters, to the relevant Tribal and USGS staff. In November 2018, the Yurok Tribe hosted training on YSI data sonde operation, which was available to all project participants.

Monitoring team leaders for Karuk tribal staff, Yurok tribal staff, and USGS will be responsible for ensuring sufficient training and certification for their team members. All relevant training and certification documentation will be stored by respective organization in accordance with their standard operating procedure.

A.8 Documentation and Records

All USGS data will be maintained and served publicly through the National Water Information System (NWIS) database. Provisional continuous time series data will be published in real-time on the USGS NWIS website, with final approved records for water years will be available by April 1 the following year. Laboratory results will be provided by the USGS via the NWIS web database. Laboratory results may also be provided electronically for inclusion in a separate project database.

Continuous water quality data collected by the Karuk and Yurok Tribe will be available on the Karuk website and be submitted electronically for inclusion in the project database. The Karuk and Yurok continuous data and associated field data will be stored on their individual servers indefinitely in addition to the project database. Any SSC samples collected by the Karuk and Yurok tribes will be sent to nearest USGS field office under a Chain of Custody (COC) (Appendix C) where a Sediment Laboratory Analysis Request (SLAR) electronic form can be filled out by USGS staff and then sent to USGS Santa Cruz sediment lab, so those records will be available through the USGS NWIS database.

All monitoring entities will provide a summary of data collected each month in quarterly reports to be submitted to RES for review and then to the Renewal Corporation Technical Team.

Field records will include a written (Appendix C) or electronic record (Aquarius Software) of site visits documenting field observations, site conditions, calibration and maintenance conducted. A field visit summary will be provided in the quarterly reports. Field crews will also collect dated photo documentation of site conditions from each visit showing the condition of equipment and gage and unusual site and river conditions. Additionally, field staff will fill out a Field Inspection Sheet for SSC sampling (Appendix C) including all monitoring sites where SSC samples are collected with information including date, time, number of samples collected, and notes on site conditions.

The Karuk Tribe, Yurok Tribe and USGS will prepare and submit an annual monitoring season summary that covers work completed including upgrades and development of monitoring locations, samples collected, all other monitoring conducted, photos, and recommendations for program modifications. The annual season summaries will be compiled in an Annual Progress Report that will include site

descriptions with photos, mapping, and coordinates, summarize monitoring activities, and provide links to data and results. The report will also present recommendations for program modifications needed to prepare for the required monitoring activities during successive years.

Each sampling entity's QA/QC staff will be tasked with ensuring that all relevant personnel have the most recent version of this QAPP.

Table 2. Document and Record Retention, Archival, and Disposition Information

	Identify Type Needed	Retention	Archival	Disposition
Station Log	Station Description files (record of site visits and conditions – road logs, ownership, equipment, etc.)	Onsite and copy retained in CAWSC and ORWSC (Oregon Water Science Center) Data Program Offices	Archived according to USGS policy SM 502.9 and/or in accordance with this QAPP	Indefinite
Field Visit and Sample Collection Records	Field notes for (1) monitor calibration, (2) Grab Sample collection	Retained in CAWSC and ORWSC Data Program Offices, and Karuk and Yurok Tribal offices.	Archived according to USGS policy and/or in accordance with this QAPP	Indefinite
Analytical Records	Laboratory analyses for water and sediment grab samples	Stored at USL, Santa Cruz, CA	Archived according to USGS policy and in accordance with this QAPP	Indefinite
Data Records	Time Series Data	Retained in CAWSC and ORWSC Data Program Offices, and Karuk and Yurok Tribal offices and project database.	Archived according to USGS policy and in accordance with this QAPP	Indefinite
Assessment Records	Surrogate Model Archives, WQ Station Analyses	Retained in CAWSC and ORWSC Data Program Offices	Archived according to USGS policy	Indefinite

B. Data Acquisition

B.1 Sampling Design

Site selection criteria included the use of existing USGS gaging stations, located to enable measurement of changing water quality conditions below project actions.

B.1.1. Continuous Water Quality Monitoring

Continuous water quality monitoring will begin one year prior to drawdown and will continue in California until otherwise approved by the SWB Deputy Director and for a minimum of four years in OR unless otherwise approved by ODEQ (Table 5). This monitoring will be conducted at ten locations on the Klamath River from below Keno Dam to near Klamath, CA (Table 3). These locations are presented in Figure 2. Continuous monitoring stations will have telemetry capabilities and the data will be transmitted and stored in online databases held and managed by the Karuk Tribe and USGS. Each sonde will be configured to record data at 15-minute intervals for the stations located in Oregon and 30-minute intervals for the stations located in California. All information collected from continuous monitoring sondes is critical for the Project.

All continuous monitoring will be conducted uniformly and in accordance with the USGS protocols and EPA-approved Karuk and Yurok protocols (Wagner *et al.*, 2006; Rasmussen *et al.*, 2009; Appendix A; Appendix B).

If a sonde becomes inoperable during the monitoring period, appropriate actions will take place to repair the sonde and resume continuous monitoring as soon as possible (Appendix E). One potential source of misrepresentation may arise from sondes that have not been calibrated correctly or frequently enough. This potential will be minimized by regular bi-monthly (every two weeks) calibrations of monitoring sondes in accordance with manufacturers standard (Appendix E).

B.1.2. Grab Water Samples

Water quality samples will be collected one year prior to drawdown at a minimum frequency of once per month, at the same time of day, during and following drawdown. Suspended sediment concentration samples will be collected bi-monthly (every two weeks). For a complete compliance schedule including determination of cessation of sampling refer to Table 5.

Water quality grab samples will be collected from the locations outlined in Table 3. Water quality grab samples will be collected at CA sampling locations until otherwise approved by the SWB Deputy Director and for a minimum of four years in OR unless otherwise approved by ODEQ.

One potential source of bias or misrepresentation may arise from grab samples being collected from different locations within a site or from a location not representative of river conditions (e.g., eddy or backwater). This potential will be minimized by standardizing grab sample locations that are sufficiently within the river channel.

B.1.3. Sediment Grab Samples

Sediment grab samples will be collected in California only. One sediment grab sampling event will be conducted prior to drawdown activities and one event within 12 to 24 months of completing drawdown activities. Sediment grab samples will be collected at locations detailed in Table 3.

If a sampling site becomes inaccessible, the Renewal Corporation will collect a sediment grab sample when the site becomes accessible again. This should not pose an issue, given the required time frame of

12 to 24 months following reservoir drawdown. One potential source of bias or misrepresentation may arise from grab samples being collected from different locations within a site. This potential will be minimized by standardizing grab sample locations to occur at the same location between sampling events. However, at sampling locations within reservoir footprints, it is possible that terracing may not occur at the previously sampled location. In this case, the sample location will be moved to a location with terraced sediments.

B.2 Sampling Methods

B.2.1. Procedures

The procedures for calibrating sondes are in the protocols, SOPs (Appendices D and E) and the Karuk Tribe and Yurok Tribe QAPPs, summarized in Section B.7. They are also described in Wagner *et al.* (2006) and Rasmussen *et al.* (2009) for USGS sites.

B.2.2. Continuous Water Quality Monitoring

Continuous water quality monitoring will be conducted with YSI EXO2 data sondes. Data collection by USGS at the Keno and JC Boyle sites will follow protocols detailed in Wagner *et al.* (2006), and Rasmussen *et al.* (2009). The USGS, Karuk and Yurok Tribe will perform all data collection and equipment maintenance as outlined by manufacturer specifications, this QAPP and in accordance with their respective EPA approved QAPPs, and SOPs (Appendices A, B, D, and E). The sondes will be housed within a protective PVC perforated pipe, which will secure the sondes in the water column to avoid damage to equipment. Communication cables will be attached to the submerged sondes and routed to the gage house where they will be connected to a datalogger. The datalogger will send USGS data to the database through a GOES satellite window. The Karuk and Yurok Tribes sondes are connected to FTS Axiom data loggers with an SDI-12 cable. Once data is recorded by sonde it is sent to data logger. Both the data logger and sonde retain data. The data logger will transmit data via the GOES satellite network and will be available on Karuk and USGS servers. In addition, Karuk and Yurok data will be made available on the Karuk water quality web portal in real time. Sondes will record data at a 15-minute interval.

USGS will deploy and operate high-range continuous turbidity sensors at the JC Boyle, Iron Gate, Seiad, Orleans, and Klamath sites. The sensors will be ANALITE NEP-5000 180-degree backscatter sensors, and will be calibrated and operated by the published protocols referenced in Section **Error! Reference source not found.**2.

B.2.3. Grab Water Samples

Sample collection methods will be consistent with protocols developed and published by the EPA, USGS, California Department of Water Resources (DWR), California Department of Fish and Wildlife (CDFW), or California Surface Water Ambient Monitoring Program (SWAMP). Sampling equipment and proper use of field equipment to ensure collection of a representative sample are detailed in Section B.4.1.

B.2.4. Sediment Grab Samples

Sample collection methods will be consistent with protocols developed and published by the EPA, USGS, DWR, CDFW, or SWAMP. Sampling equipment and proper use of field equipment to ensure collection of a representative sample are detailed in Section B.4.1.

B.3 Sample Handling and Custody

Water and sediment grab samples will be delivered to the appropriate laboratory dependent upon analysis and media as detailed in Table 9 within designated hold times (Table 8) of sample collection for analysis. Samples will be stored, packaged and shipped on ice. Samples collected by Karuk and Yurok Tribes will be either directly shipped to the lab or physically transferred to USGS personnel under a COC, who will then transport the samples to the lab. Analytical service request forms (ASR) will be filled out by USGS personnel using field forms from USGS, Karuk, and Yurok personnel. The sample bottles will be labeled by Site ID, Date, median sample time (the median time between the start and stop time of the samples), gage height at time of sample, and the sample set (A or B). USGS personnel will fill out necessary information into the electronic forms prior to submitting samples to the lab.

Table 8. Sample Handling

Analyte	Bottle Size/Type (1 bottle per event)	Preservative Requirements (Chemical, Temperature, and Light)	Maximum Hold Time
Total Nitrogen	250ml, polyethylene bottle	4◦C	48 hours
Nitrate			
Nitrite			
Ammonia			
Total Phosphorus			
Particulate Organic Phosphorus			
Orthophosphate			
Particulate Organic Carbon	100ml, glass bottle	Filter and preserve to pH<2 within 48 hours of collection; cool to ≤6	28 days
Dissolved Organic Carbon		Cool to ≤6 ◦C; acidify to pH<2 with HCl, H_3PO_4, or H_2SO_4	
Chlorophyll *a*	1L, polyethylene bottle	Filter as soon as possible after collection; keep samples at ≤6C	Samples must be frozen or analyzed within 4 hours of collection; filters can be stored frozen for 28 days
Turbidity	1L, polyethylene bottle	4◦C	48 hours
Microcystin	250ml, clear glass bottle	Freeze and ship at <4◦C	14 days
Suspended Sediment Concentrations	250ml, polyethylene bottle	4◦C	7 days

Methylmercury	250ml, polyethylene bottle	Immediately after collection, cool to ≤6 ◦C in the dark; acidify to 0.5% with pre-tested HCl within 48 hours; if salinity is >0.5 ppt, acidify with H2SO4	6 months at to ≤6 ◦C in the dark following acidification
Settleable Solids	250ml, polyethylene bottle	4◦C	7 days
Particulate and Dissolved Aluminum	250ml, polyethylene bottle	HNO3 to pH<2 within 48 hours and at least 24 hours prior to analysis	6 months at room temperature following acidification

B.4 Equipment, Analytical Methods and Field Measurements

Samples will be collected and analyzed as outlined below.

B.4.1 Field Equipment

Continuous Monitoring Methods

The EXO2 sondes contain sensors that continuously record observations of water temperature, pH, dissolved oxygen, specific conductance, and turbidity. Water temperature and specific conductance are located on the same probe. The temperature thermistor is a calibrated with a NIST-traceable wet calibration and an accuracy specification of 0.01 degrees Celsius and a resolution of 0.001 degrees Celsius. The specific conductance sensor reports water conductance compensated to 25 degrees Celsius and uses four internal pure-nickel electrodes to measure solution conductance. Conductance resolution is 0.0001 to 0.01 ms/cm. The dissolved oxygen sensor is an optical sensor and operates by shining a blue light of a specified wavelength onto a luminescent dye which is immobilized in a matrix and formed to a disk. Accuracy of the dissolved oxygen sensor is increased by irradiating a red light during the measurement cycle to act as a reference in the determination of the luminescence lifetime. Dissolved oxygen resolution is 0.01 mg/L, or 0.1% air saturation. pH is measured using two electrodes combined into the same probe: one for hydrogen ions and one for a reference. The sensor is a glass bulb filled with a solution of stable pH. pH range is 0 to 14 units with a resolution of 0.01 units. The turbidity sensor employs a near-infrared light source and detects scattering at 90 degrees of the incident light beam, also characterized as a nephelometric near-IR turbidimeter, non-radiometric. As such, units are reported as formazin nephelometric units (FNU). The sensor range is 0-4000 FNU with a resolution of 0.01 FNU for 0-999 FNU, and 0.1 FNU for 1000-4000 FNU. The high-range ANALITE NEP-5000 turbidity sensor is a backscatter sensor that detects scattering at 180 degrees of the incident light beam. The units are reported as nephelometric turbidity units (NTUs). The ANALITE NEP-5000 sensor range is 0-30,000 NTU with a resolution of +/- 1.5 NTU for 0-5,000 NTU, +/- 3.0 NTU for 5,000-10,000 NTU, +/- 9.0 NTU for 10,000-30,000 NTU.

For calibration, maintenance, see manufacturer's instructions (Appendix E), and auditing procedures. Raw data from sondes will be collected and stored on dataloggers in the USGS gage houses. This data will also be transmitted via the GOES network and made publicly available.

Automated Samplers

The Teledyne ISCO automated pump samplers function using a peristaltic pump head that is capable of pumping volumes of water up to 26 vertical feet from the point of pumping to the pump head, and at manufacturer-recommended velocities. The sampler can be configured to hold bottles sized from 1-L to 5.5 gallons if needed. No measurement principle is associated with this equipment. Major attributes include the ability to program the sampler to collect samples at specified temporal frequencies and at specified turbidity thresholds. An SDI-12 interface allows connection with the YSI EXO2 sondes via the data logger to trigger the samples at specified turbidity thresholds without disrupting the transmission of continuous water quality data from the sondes.

Grab Water Sampling

Standard water quality grab sample procedures will be used for collection of water quality parameters, nutrients, chlorophyll, and microcystin, using a churn to mix samples and following an appropriate regimen of blanks, duplicates and other steps to assure quality. Calibration and maintenance of data sondes adheres to protocols established by USGS and the manufacture. To ensure reliability YSI multi-channel data sondes are calibrated in the field on a daily basis before use following YSI instructions and other standard procedures for calibration (U.S. EPA, 2001) that are attached as Appendix E.

Grab water samples will be collected at nine discrete locations (Table 3), collected with a churn splitter to ensure that the sample is homogeneously mixed before the sample bottles are filled. Depending on location with or without bridge access, two collection methods may be used. For most sites, the churn is fully submerged into the stream and filled to the lid with flowing water, not stagnant water. For sites from a bridge (Daggett Road and Walker), a Van Dorn sampler can be used to collect three samples from across the channel. The samples are poured into the churn and treated the same as all other sites. Prior to filling the churn for nutrient, chlorophyll, or microcystin sampling, the churn will be decontaminated by rinsing three times with distilled water. After rinsing with distilled water, the churn will be rinsed three times with stream water. Samples shall be collected from uniformly mixed water with the churn fully submerged into the stream and filled to the lid with sample water. Completely filling the churn allows for all sample bottles to be filled from one churn; thereby minimizing differences in water properties and quality between samples. The churn should be stirred at a uniform rate by raising and lowering the splitter at approximately 9 inches per second while bottles are being filled (Bel-Art Products, 1993). Care must be taken to avoid breaking the surface of the water as the splitter rises toward the top of the water in the churn.

Sample bottles are filled directly from the churn and collected samples are placed on ice in coolers with completed and signed chain of custody for transport to accredited laboratory for analysis. For quality assurance/ quality control (QA/QC) purposes duplicate, and blank bottle sets are prepared and collected

according to the schedule outlined in Table 6. These additional bottle sets are handled, prepared and filled following the same protocol used for regular bottle sets and samples.

Isokinetic Suspend-Sediment Sampling

Composite and individual analyses suspended-sediment sampling will be conducted from bridges, boats, cableways, and by wading the stream cross section following methods described in Edwards and Glysson (1999). For bridge, cableway, and boat samples, a USGS D-49, D-96, D-74, D-95, DH-95 or DH-59 sediment sampler with appropriate glass or plastic bottles or plastic bags for the D-96 bag sampler will be used to collect the samples. These samplers will be lowered and raised through the water column using cable and reel devices. For wading samples, a hand-held DH-81 sediment sampler enclosing a 1-L Nalgene plastic bottle, or a DH-48 sediment sampler enclosing a glass pint bottle will be used. These samplers will be manually lowered and raised through the water column during sample collection. Individual sample bottles will be sent to the Santa Cruz lab for analysis. The measurement principle of these samplers follows isokinetic sampling theory, which states that the water approaching and entering the sampler intake does not change velocity while the sampler is being moved through the water column and collecting the sample. Isokinetic samplers are limited to water velocities greater than 1.5 feet per second and depths less than 15-ft for samplers with rigid bottles (D-74, D-95, DH-95, DH-59). The D-96 bag sampler can be used in velocities from 2.0 to 12.5 ft/s and depths up to 110-ft depending on the nozzle diameter.

Two cross-section composite samples will be collected per sampling event generating 10 1-L sample containers. The first sample (A-set) will generate 5 sample bottles that will be analyzed individually for SSC and percent of sample finer than 63 microns (percent fines). The second sample will composite all of the 5 containers resulting in one SSC and percent fines value and will be analyzed for full particle size distribution.

Grab Sediment Streambed Sampling

Obtaining sediment samples that are representative of the river reach is essential to maintain data and sampling program integrity. The sediment sample collection strategy focuses on obtaining samples of fine-grained surficial sediments from natural depositional zones, in part because specific trace elements that are part of the sampling program, such as methylmercury have a strong affinity to organic carbon content and fine grain sediment *(*Ravichandran, 2004; Lambertsson and Nilsson, 2006). In wadeable sections, sediment sample locations should include the insides and outsides of meander bends, crossovers, as well as forewater and backwater side habitats (USGS 2008). Sample locations will be chosen in areas outside the hydraulic effects of bridges and other man-made objects.

The surficial 0 to 3 centimeter of bed sediment within each sample location or zone will be subsampled several times in the same reach and combined to create a composite sample for each sample location. Compositing subsamples from different depositional areas within the same reach or zone will smooth the local scale variability and provide samples that are more representative of the average or mean contaminant concentrations (USGS 1994). To minimize possible contamination, sediment samples should be collected with non-metallic materials or from the center of the grab sampler, avoiding areas that are near or directly contacting metal surfaces. In addition to sediment-sampling activities, stream-

water field measurements of pH, specific conductance, dissolved oxygen (DO), temperature, and streamflow also are collected at the time of sampling. (USGS 2008). In addition, locational information should be supplemented with Global Positioning System (GPS) coordinates recorded at each sampling area (2008 USGS). Sample equipment decontamination between all collection locations in accordance with USGS and EPA SWAMP shall be completed to minimize cross contamination.

B.4.2 Analytical Methods and Field Measurements

This QAPP requires laboratory analysis for grab water and grab sediment samples collected at locations described in section B.1.2 and B.1.3, respectively for analytes listed in Table 11 and Table 12, respectively. All laboratory analysis will be completed in accordance with 40 CFR 136 methodology by California Environmental Laboratory Accreditation Program (ELAP) or Oregon Environmental Laboratory Accreditation Program (ORELAP) certified laboratories as necessary. Grab water analysis with the exception of microcystin will be performed at ELAP accredited Aquatic Research Laboratories in Seattle, WA. Microcystin analysis will be performed by EPA Region 9 Laboratory in Richmond, CA. Suspended Sediment Concentration will be analyzed by the USGS Sediment Laboratory in Santa Cruz, CA. Grab sediment samples will be analyzed by Aquatic Research Laboratories in Seattle, WA. Table 10 provides a detailed list of analytes, laboratories, and reporting limits.

Table9. Laboratories & Reporting Limits

Analyte	Media	Reporting* Limits	Unit	Laboratory
Arsenic	Sediment		mg/kg	Aquatic Research
Lead	Sediment		mg/kg	Aquatic Research
Copper	Sediment		mg/kg	Aquatic Research
Nickel	Sediment		mg/kg	Aquatic Research
Iron	Sediment		mg/kg	Aquatic Research
Aluminum	Sediment		mg/kg	Aquatic Research
Dioxin	Sediment		mg/kg	EMA
Cyanide	Sediment		mg/kg	Aquatic Research
Mercury	Sediment		mg/kg	Aquatic Research
Ethyl Benzenes	Sediment		mg/kg	Aquatic Research
Total Xylenes	Sediment		mg/kg	Aquatic Research
Dieldrin	Sediment		mg/kg	EMA
4,4'-dichlorodiphenyltrichloroethane (DDT)	Sediment		mg/kg	EMA
4,4'-dichlorodiphenyldichloroethane (DDD)	Sediment		mg/kg	EMA
2,3,7,8-tetrachlorodibenzodioxin (TCDD)	Sediment		mg/kg	EMA
4,4'-dichlorodiphenyldichloroethylene (DDE)	Sediment		mg/kg	EMA
2,3,4,7,8-pentachlordibenzofuran (PECDF	Sediment		mg/kg	EMA
Total Nitrogen	Water		mg/L	Aquatic Research

Nitrate	Water		µg/L	Aquatic Research
Nitrite	Water		µg/L	Aquatic Research
Ammonia	Water		µg/L	Aquatic Research
Total Phosphorus	Water		µg/L	Aquatic Research
Particulate Organic Phosphorus	Water		µg/L	Chesapeake Biological
Orthophosphate	Water		µg/L	Aquatic Research
Particulate Organic Carbon	Water		mg/L	Chesapeake Biological
Dissolved Organic Carbon	Water		mg/L	Aquatic Research
Chlorophyll-A	Water		µg/L	Aquatic Research
Microcystin	Water		µg/L	EPA Region 9 Laboratory
Methylmercury	Water		µg/L	Aquatic Research
Particulate and Dissolved Aluminum	Water		mg/L	Chesapeake Biological
Settleable Solids	Water		mg/L	Aquatic Research
Suspended Sediment Concentration	Water		mg/L	USGS Sediment Laboratory
Turbidity	Water		NTU	Aquatic Research

*Reporting limits to be confirmed with contracted laboratories

Chemistry

SSC will be analyzed using method, ASTM D 3977-97, Standard Test Method for Determining Sediment Concentration in Water Samples (ASTM, 1999). This is the USGS standard for determining concentrations of suspended material in surface water samples. This method is used by all USGS sediment laboratories, and by cooperating laboratories certified to provide suspended-sediment data to the USGS. The laboratory will report both concentration in mg/L and percent of sample less than 63 microns, operationally defined as the break between silt and sand.

Table 10. Analytical Methods – Grab Water

Analyte	Unit	Analytical Method or Standard
Total Nitrogen	mg/L	EPA 351.2
Nitrate	mg/L	EPA 353.2
Nitrite	mg/L	EPA 353.2
Ammonia	mg/L	SM 4500 C/G
Total Phosphorus	mg/L	EPA 365.4
Particulate Organic Phosphorus	mg/L	EPA 200.7
Orthophosphate	mg/L	EPA 365.3
Particulate Organic Carbon	mg/L	ASTM D4129
Dissolved Organic Carbon	mg/L	ASTM D7573
Chlorophyll-A	CFU	EPA 446
Microcystin	µg/L	Enzyme-Linked ImmunoSorbent Assay (ELISA) Microcystin-ADDA Method
Methylmercury	µg/L	EPA 245.1 / SW-846 Method 7470
Particulate and Dissolved Aluminum	mg/L	EPA 200.7
Settleable Solids	mg/L	SM 2540F
Suspended Sediment Concentration	mg/L, % < 63 microns	ASTM D 3977-97

Turbidity	NTU	EPA 180.1

Table 11. Analytical Methods – Sediment

Analyte	Unit	Analytical Method or Standard
Arsenic	mg/kg	EPA 6010B
Lead	mg/kg	EPA 6010B
Copper	mg/kg	EPA 6010B
Nickel	mg/kg	EPA 6010B
Iron	mg/kg	EPA 6010B
Aluminum	mg/kg	EPA 6010B
Dioxin	mg/kg	EPA 8290A
Cyanide	mg/kg	EPA 335.4
Mercury	mg/kg	EPA 7470
Ethyl Benzenes	mg/kg	EPA 8260B
Total Xylenes	mg/kg	EPA 8260B
Dieldrin	mg/kg	EPA 8081
4,4'-dichlorodiphenyltrichloroethane (DDT)	mg/kg	EPA 8081
4,4'-dichlorodiphenyldichloroethane (DDD)	mg/kg	EPA 8081
2,3,7,8-tetrachlorodibenzodioxin (TCDD)	mg/kg	EPA 8290A
4,4'-dichlorodiphenyldichloroethylene (DDE)	mg/kg	EPA 8081
2,3,4,7,8-pentachlordibenzofuran (PECDF)	mg/kg	EPA 8081

Sample Disposal

This section does not apply to any type of sampling conducted under this QAPP.

B.5 Quality Control

B.5.1 Quality Control Activities

Quality control activities are outlined in Table 6 for conventional parameters, nutrients, and inorganic analytes. This includes laboratory blanks, spikes, and duplicates, and field duplicates and blanks.

If control limits are exceeded, corrective actions will be assessed and documented following guidance in SWAMP Quality Control and Sample Handling Tables.

Procedures and formulas for calculating quality control results are outlined in Section A.7.

B.6 Instrument/Equipment Testing, Inspection, and Maintenance

B.6.1 Sampling Equipment

Sampling equipment will be inspected regularly prior to use for safety and operational reasons. Cable reels will also be inspected to ensure crew safety during sample collection. The full lists of all sampling equipment are described in the SOPs (Appendix D).

Table 12 outlines field and laboratory equipment maintenance activities, frequencies, criteria, and corrective actions.

Calibration and maintenance of field equipment/instruments will be performed according to the manufacturer's instructions (Appendix E) and sampling organizations' SOPs (Appendix D) and recorded in an instrument/equipment logbook.

The project-specific criteria for calibration (frequency, acceptance criteria, and corrective actions associated with exceeding the acceptance criteria) are provided in Table 12. Field Equipment Calibration, Maintenance, Testing, and Inspection.

The chemistry analytical laboratory maintains its equipment in accordance with its SOPs, which include those specified by the manufacturer and those specified by the method. Problems with the instrumentation during analysis will require repair, recalibration, and re-analysis of the sample. Table 12 outlines analytical equipment, maintenance frequencies, and the responsible person.

Table 12. Field Equipment Calibration, Maintenance, Testing, and Inspection

Analytical Parameter	Instrument	Calibration Activity	Maintenance & Testing/ Inspection Activity	Frequency	Acceptance Criteria	Corrective Action
Temperature (Sensor)	EXO2 MPS Multi Probe System: YSI Precision ™ Thermistor		According to Wagner *et al.* (2006) Manufacturer's manual Karuk QAPP[1] Yurok QAPP[2]	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	± 0.15°C of true value at both endpoints or as dictated in Wagner *et al.* (2006)	Remove from use and replace with backup sensor if doesn't pass calibration criteria
pH (electrode)	EXO2 MPS Multi Probe System: YSI Glass Combination electrode	Initial: Two-point calibration bracketing expected field sample range (using 7.0 and 10.0 pH buffer) Post: single-point check with 7.0 pH buffer	According to Wagner *et al.* (2006) and Manufacturer's manual Karuk QAPP Yurok QAPP	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	Initial: Two- point calibration done electronically Post: ±0.1 pH units of true value or as dictated in Wagner *et al.* (2006)	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria and replace with backup sensor.
Dissolved oxygen (sensor)	EXO2 MPS Multi Probe Optical Sensor	Initial: One-point calibration with saturated air (need temp, barometric pressure). Post: single-point check at full saturation	According to Wagner *et al.* (2006) and Manufacturer's manual Karuk QAPP Yurok QAPP	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	Initial: One-point calibration done electronically Post: ±0.5 mg/L of true saturated value or as dictated in Wagner *et al.* (2006)	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria and replace with backup sensor.
Turbidity (sensor)	EXO2 MPS Multi Probe System	Initial: 2 or 3-point calibration using 0, 124, 1010 FNU copolymer beads Post: same calibration as pre-deployment	According to Wagner *et al.* (2006) and Manufacturer's manual Karuk QAPP Yurok QAPP	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	Initial: One-point calibration done electronically Post: ±1 NTU of true value or as dictated in Wagner *et al.* (2006) and Rasmussen *et al.* (2009)	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria and replace with backup sensor.

Analytical Parameter	Instrument	Calibration Activity	Maintenance & Testing/ Inspection Activity	Frequency	Acceptance Criteria	Corrective Action
Conductivity (sensor)	EXO2 MPS Multi Probe System: YSI 4-electrode cell with auto ranging	Initial: One- point calibration at high end of expected field sample range (1000 mS/cm standard)	According to Wagner *et al.* (2006) and Manufacturer's manual Karuk QAPP Yurok QAPP	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	Initial: one-point calibration done electronically	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria and replace with backup sensor.
		Post: two-point check with high (1000 mS/cm) and low (0 mS/cm) standards			Post: high standard ±5% of true value and low standard ±10% of true value, or as dictated in Wagner *et al.* (2006)	

[1]Karuk Tribe Water Quality Program 2018; [2]Yurok Tribe Environmental Program 2017

Table 13. Testing, Inspection and Maintenance of Analytical Instruments

Equipment / Instrument	Responsible Person	Frequency	SOP Reference
Sartorius Analytical Balance LA230S	Lab Manager	Daily during periods of operation	Knott *et al.* (1992)
Sartorius Macro Balance AZ4101	Lab Manager	Daily during periods of operation	Knott *et al.* (1992)
Fisher Scientific Isotemp Premium Oven 700 Series 13247750F	Lab Manager	Weekly during periods of operation	Knott *et al.* (1992)
Filtration Equipment	Lab Manager	Weekly during periods of operation	Knott *et al.* (1992)

B.7 Instrument/Equipment Calibration and Frequency

For a description of equipment, tools, and instruments and the frequency of calibration see Appendices A and B for Karuk protocols, Table 12. Field Equipment Calibration, Maintenance, Testing, and Inspection and Table 13. Testing, Inspection and Maintenance of Analytical Instruments. Calibration of EXO2 sondes and documentation of the calibrations will follow procedures outlined in Wagner *et al.* (2006) and Rasmussen *et al.* (2009) for the USGS sites at Keno and JC Boyle. At Iron Gate, Seiad Valley and Orleans calibrations will follow the SOPs outlined in Karuk QAPP (Karuk Tribe Water Quality Program 2018) and at the Klamath site procedures will follow the Yurok QAPP (Yurok Tribe Environmental Program 2017). Any deficiencies in sampling will be documented in quarterly report and resolved by individual sampling entities.

B.8 Inspection/Acceptance for Supplies and Consumables

USGS hydrographers from the Klamath Falls field office will be responsible for the purchase of consumables necessary for the operation and maintenance of continuous water quality sondes at Keno and JC Boyle. Acceptance criteria are addressed by the internal USGS supply store prior to shipping to field offices. Tracking and storing of the materials is conducted by USGS hydrographers at the field office.

The field measurement supplies the Karuk and Yurok Tribe will use, such as calibration solutions, will be acquired from standard traceable sources, such as the instrument manufacturer or reputable suppliers. The Karuk Tribe will obtain calibration standards from Fondriest Environmental, Inc. The lot number and expiration date on standards and reagents will be checked prior to use. Expired solutions will be discarded and replaced. The source, lot number, and expiration dates of all standards and reagents will be recorded in the field log books.

B.9 Non-direct Measurements

For comparison purposes, previous field measurements and laboratory analytical results collected from the Project area may be reviewed through Annual Reports and online databases. These sources could

include, but are not limited to, the U.S. Geological Survey, the United States Forest Service, the Karuk Tribe, the Hoopa Tribe, and the Yurok Tribe.

Previously collected data that will be used for comparison purposes will have gone through the QAPP review process (Karuk QAPP 2019, Yurok QAPP 2017). However, for data that has not been EPA-SWB-approved, it will first be reviewed to verify that they are of sufficient quality to meet the needs of the project by examining:

- the sample collection and location information;
- the data to see whether they are consistent with data collected from other Tribal monitoring programs from the same general vicinity; and
- the QA/QC information associated with the data.

If the data are of insufficient or unknown quality, limitations will be placed on its use in supporting project decisions. In general, it is anticipated that decisions for the current project will be based on data collected by the Tribe following this current QA Project Plan.

B.10 Data Management

Management of data collected by USGS will follow established protocols, and will be stored in the NWIS database, which is publicly accessible. USGS databases retain all original raw data, and records processing and management follows guidelines detailed in Wagner *et al.* (2006) and Rasmussen *et al.* (2009).

The Karuk Tribe will ensure that all field collected audit and calibration data will be recorded on paper and digitally. All raw continuous monitoring data collected by the Karuk and Yurok Tribe will be stored on their individual servers or the Karuk server and made available to the Renewal Corporation. Filling of project related documents will follow the guidelines in the Karuk and Yurok Tribes QAPPs (Karuk 2018, Yurok 2017). Raw continuous time series data will be entered into Aquatic Informatics, Inc. Time Series software to be evaluated and corrected based upon procedures outlined in the Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and Data Reporting (Wagner *et al.*, 2006, and Rasmussen *et al.*, 2009) by the USGS. Both real time and corrected data will be made available on the Karuk Tribes Water Quality Web Portal and submitted to the project database.

C. Assessment and Oversight

During the course of the Project, it is important to assess the Projects' activities to ensure that the QAPP is being implemented as planned. This helps to ensure that everything is on track and serves to minimize learning about critical deviations toward the end of the project when it may be too late to remedy the situation. For the current project, the ongoing assessments will include:

- Field Oversight;
- Readiness review of the field team prior to starting field efforts;
- Field activity audits;

- Review of field sampling and measurement activities methodologies and documentation at the end of each event; and
- Laboratory Oversight - evaluation of laboratory data generated for each quarterly sampling event.

Monitoring team leaders for Karuk tribal staff, Yurok tribal staff, and USGS will be responsible for conducting assessments. These individuals have the authority to issue stop work orders if it is found that quality control measures are insufficient. These individuals will also be responsible for submitting these assessments to the Klamath River Renewal Corporation Water Quality Monitoring Program Manager. Monitoring team leasers will implement corrective actions, either as they see fit, or upon discussions with the Program Manager.

C.1 Reports to Management

Prior to, during, and for a minimum of one year following completion of drawdown, monthly monitoring reports will be issued to the following California agencies: SWRCB, ODEQ, DEQ, and the RWQCB until otherwise approved by the CA Deputy Director.

At least two annual progress reports will also be prepared and submitted to the ODEQ by April 1. The annual progress reports will describe equipment installation and site reinforcement with photos, mapping and site coordinates, all monitoring activities, links to USGS, Karuk and Yurok data results or an established repository with all the results, and recommended QAPP revisions and site modifications, as necessary. Note that a detailed report of data trends and analysis will not be included in this report.

D. Data Validation and Usability

Prior to utilizing data to make project decisions, the quality of the data needs to be reviewed and evaluated to determine whether the data satisfy the projects' objectives. This process involves technical evaluation of the off-site laboratory data, as well as, review of the data in conjunction with the information collected during the field sampling and field measurement activities. This latter, more qualitative review provides for a clearer understanding of the overall usability of the projects' data and potential limitations on their use. Section A.7: Quality Objectives and Criteria outline various criteria that will be used to evaluate project data.

D.1 Data Review, Verification, and Validation

Section A.7 discusses the quality objectives for the project and the performance criteria used for accepting, rejecting, or qualifying project data.

For continuous time-series measurements, the data quality criteria to be assessed quantitatively include precision and accuracy alone. These assessments will be different for water and sediment grab sample data. The associated acceptance criteria (types and frequencies of QC checks and acceptance limits) for the Project follow SWAMP guidelines and are summarized in Table .

D.2 Verification and Validation Methods

The setting of data review, verification, and validation requirements helps to ensure that project data are evaluated in an objective and consistent manner. For the current project, such requirements have been defined for information gathered and documented as part of field sampling and field measurement activities, as well as for data generated by the off-site laboratory.

Individual monitoring agencies will be responsible for validating various components of project information in accordance with their respective QAPPs (Karuk 2018, Yurok 2017).

D.3 Reconciliation with User Requirements

The Karuk and Yurok tribes will flag data that does not meet the acceptance criteria outlined in Section A.7.

Uncertainty for data collected by USGS is reported and quantified as part of the records processing that is required for all USGS data sets. Data limitations are reported by flagging of data and qualitative rating of water quality records. These flags and ratings are retained with the data when retrieved from the USGS database.

Once all the data from the field and laboratory have been evaluated, the QA Officers will make an overall assessment concerning the final usability of the data (and any limitations on its use) in meeting the projects' needs. The initial steps of this assessment will include, but are not necessarily limited to:

- Discussions with the Field Technicians,
- Review of deviations from the QAPP or associated SOPs to determine whether these deviations may have impacted data quality (and determining whether any impacts are widespread or single incidents, related to a few random samples or a batch of samples, and/or affecting a single or multiple analyses),
- Evaluation of the field and laboratory results and QC information,
- Review of any other external information which might influence the results, such as activities up stream, meteorological conditions, wildfires, and data from other sources,
- Evaluation of whether the completeness goals defined in this QA Project Plan have been met,
- Examination of any assumptions made when the study was planned, if those assumptions were met and, if not, how the project's conclusions are affected.

In addition, the Monitoring Management Team will assess the effectiveness of the monitoring program and data collection at the end of each calendar year. Sampling locations, frequency, list of analytical parameters, field measurement protocols, choice of the analytical laboratory, etc. will be modified as needed to reflect the changing needs and objectives of the KRRP. This QAPP will be revised and/or amended accordingly.

E. References

California State Water Resources Control Board. 2018. Draft Water Quality Certification – Klamath River Renewal Corporation's Lower Klamath Project Federal Energy Regulatory Commission Project No. 14803. June 18, 2018.

Edwards, T.K., and Glysson, G.D., 1999, Field methods for measurement of fluvial sediment: Techniques of Water-Resources Investigations of the U.S. Geological Survey, book 3, chap. C2, 89 p.

Gray, J.R., Glysson, G.D., and Edwards, T.E., 2008, Suspended sediment samplers and sampling methods, in, Sediment transport measurements, in, Marcelo Garcia, ed., *Sedimentation Engineering—Processes, Measurements, Modeling, and Practice: American Society of Civil Engineers Manual 110*, Chapter 5.3, p. 320–339.

Karuk Tribe Water Quality Department, *Quality Assurance Project Plan,* KTWQP, CA, 2018.

Klamath River Renewal Corporation. 2018. *Definite Plan for the Lower Klamath Project*. June 2018.

Oregon Department of Environmental Quality. 2018. *Clean Water Act Section 401 Certification for the Klamath River Renewal Corporation License Surrender and Removal of the Lower Klamath Project (FERC no. 14803) Klamath County, Oregon*. September 7, 2018.

Rasmussen, P.P., Gray, J.R., Glysson, G.D., and Ziegler, A.C., 2009, *Guidelines and procedures for computing time-series suspended-sediment concentrations and loads from in-stream turbidity-sensor and streamflow data*: U.S. Geological Survey Techniques and Methods, book 3, chap. C4, 52 p.

U.S. Geological Survey (USGS). 1998. U.S. Geological Survey, 1998, A National Quality Assurance Program for Sediment Laboratories Operated or Used by the Water Resources Division: Office of Surface Water Technical Memorandum No. 98.05. Available online at: https://water.usgs.gov/admin/memo/SW/sw98.05.html

Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, *Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods*. 1–D3, 51 p., 8 attachments.

Yurok Tribe Environmental Program, "Quality Assurance Program Plan", YTEP, CA 2017.

APPENDIX A

Karuk Tribe QAPP 2019

Klamath River Renewal Corporation
Water Quality Monitoring Network for the Klamath River Renewal Project

Water Quality Sampling and Analysis

Quality Assurance Project Plan

April 2019

KLAMATH RIVER RENEWAL CORPORATION

USGS science for a changing world

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A. Project Management

A.1 Title and Version

PROJECT TITLE:	Water Quality Monitoring for the Klamath River Renewal Project – Water Year 2019
LEAD ORGANIZATION:	Klamath River Renewal Corporation 2001 Addison Street, Suite 300, Office 317 Berkeley, California 94704
PRIMARY CONTACT:	Seth Gentzler AECOM Program Manager 300 Lakeside Drive, Suite 220 Oakland, CA 94612 Office: (510) 874-3018 Mobile: (415) 722-5129 Seth.gentzler@aecom.com
EFFECTIVE DATE:	October 1, 2018 to Program End
VERSION:	00
PREFACE:	SWAMP-compliant QAPP for Klamath River water quality monitoring at 6 monitoring stations in preparation for the Klamath River Renewal Project. This document was produced using the SWAMP-EPA Review Checklist.
QAPP PREPARED BY:	Susan Fricke, Water Quality Manager Karuk Tribe Water Program Grant Johnson Karuk Tribe Water Program Chauncey Anderson, Water Quality Specialist US Geological Survey, Oregon Water Science Center Matthew Hanington, Water Division Manager Yurok Tribe Environmental Program Suzanne Wilkins, Senior Environmental Planner CDM Smith Inc. Stefan Schuster, Associate CDM Smith Inc.

A.2 Approvals

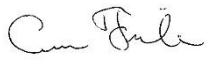
Seth Genzler, AECOM
Klamath River Renewal Corporation Water Quality Monitoring Program Manager

_____

Benjamin Swann, CDM Smith
Klamath River Renewal Corporation Water Quality Monitoring Program Coordinator

_____

Susan Fricke, Karuk Tribe Water Program
Water Quality Monitoring Team Coordinator and Karuk Tribe Monitoring Team Leader



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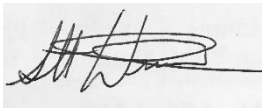
Chauncey Anderson, USGS
Monitoring Site & Sediment Monitoring Coordinator

_____

Matt Hanington, Yurok Tribe Environmental Program
Yurok Tribe Monitoring Team Leader

_____

Scott Wright, USGS
Program Quality Assurance/Quality Control Manager



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Stephen Low
USGS Sediment Lab Manager

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A.3 Table of Contents

A.3.1 QAPP Information Sections

A.3.2 List of Tables

A.3.3 List of Figures

A.3.4 Appendices and Standard Operating Procedures

List of Abbreviations and Acronyms

ASR	Analytical Service Request
ASTM	American Society of Testing Materials
CAWSC	California Water Science Center
COC	Chain of Custody
CWA	Clean Water Act
DO	Dissolved Oxygen
DWR	Department of Water Resources
EPA	Environmental Protection Agency
FNU	Formazin Nephelometric Units
FPS	Federal Priority Stream gages
HSP	Health and Safety Plan
ISCO	Automated Pump Samplers
JHA	Job Hazard Analysis
KRRC	Klamath River Renewal Cooperation
KRRP	Klamath River Renewal Project
NTU	Nephelometric Turbidity Units
NWIS	National Water Information System
ORWSC	Oregon Water Science Center
pH	Potential Hydrogen
QA	Quality Assurance
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	Quality Control
RPD	Relative Percent Difference
SOP	Standard Operating Procedure
SRM	Standard Reference Material
SSC	Suspended Sediment Concentration
SWAMP	Surface Water Ambient Monitoring Program
TM1D3	Techniques and Methods 1-D3
USGS	United States Geological Survey
USL	USGS Sediment Laboratory
YSI	Yellow Springs Instrument

A.4 Distribution List

The final QAPP will be kept on file by the Karuk Tribe Water Program, Yurok Tribe Environmental Program, and the United States Geological Survey (USGS). The following individuals will receive copies of the approved QAPP and any subsequent revisions. Field personnel will have a copy of the QAPP and Health and Safety Plan (HSP) during all field activities:

Table 1. Distribution List

Title	Contact Information
Seth Gentzler **AECOM** **Program Manager**	300 Lakeside Drive, Suite 220 Oakland, CA 94612 Office: (510) 874-3018 Mobile: (415) 722-5129 Seth.gentzler@aecom.com
Benjamin Swann **CDM Smith Inc.** **Program Coordinator**	1755 Creekside Oaks Drive, Ste. 200 Sacramento, CA 95833 Office: (916) 576-7479 Mobile: (916) 2012647 swannbm@cdmsmith.com
Suzanne Wilkins **CDM Smith** **WQ Monitoring Regulatory Compliance Lead**	12313 Soaring Way, Suite 2D Truckee, CA 96161 Office: (530) 582-2224 Mobile: (530) 545-2563 wilkinssm@cdmsmith.com
Stefan Schuster **CDM Smith** **WQ Monitoring Expert Resource**	12313 Soaring Way, Suite 2D Truckee, CA 96161 Office: (530) 582-2221 Mobile: (775) 690-0850 schustersl@cdmsmith.com
Chauncey Anderson **USGS** **KRRP Monitoring Site & Sediment Monitoring Coordinator**	2130 SW 5th Avenue Portland, OR 97201 Office: (503) 251-3206 chauncey@usgs.gov
Scott Wright **USGS – California** **Monitoring Team Leader & Program QA/QC Manager**	USGS California Water Science Center 6000 J Street, Placer Hall Sacramento 95819 Office: (916) 278-3024 Mobile: (916) 862-0163 sawright@usgs.gov
Liam Schenk **USGS – Oregon** **Monitoring Team Leader**	2795 Anderson Avenue, Suite 106 Klamath Falls, Oregon 97603 Office: (541) 273-8689 x208 lschenk@usgs.gov

Title	Contact Information
Alex Etheridge **USGS** **QA/QC and Program Data Manager**	6000 J Street, Placer Hall Sacramento, CA 95819 Office: (916) 995-0784 aetherid@usgs.gov
Dennis O'Halloran **USGS** **QA/QC**	6000 J Street, Placer Hall Sacramento, CA 95819 Office: (916) 278-3168 Mobile: (530) 412-0578 dohall@usgs.gov
Susan Fricke **Karuk Tribe Water Program** **WQ Monitoring Team Coordinator & Monitoring Team Lead**	P.O. Box 282 Orleans, CA 95556 Office: (530) 598-3414 sfricke@karuk.us
Grant Johnson **Karuk Tribe Water Program** **QA/QC**	P.O. Box 282 Orleans, CA 95556 Office: (530) 469-3258 gjohnson@karuk.us
Matt Hanington **Yurok Tribe Environmental Program** **Monitoring Team Leader & QA/QC**	15900 Hwy 101 N P.O. Box 1027 Klamath, CA 95548 Office: (707) 482-1822 ext. 1002 Mobile: (707) 954-7519 mhanington@yuroktribe.nsn.us
Stephen Low **USGS Sediment Lab** **Lab Manager**	2885 Mission Street Santa Cruz, CA 95060 Office: (831) 460-7500 stephlow@usgs.gov

A.5 Project Organization and Schedule

A.5.1 Involved Parties and Roles

The Water Quality Monitoring Program for the Klamath River Renewal Project is being implemented by a multi-agency working group in accordance the Final Oregon Clean Water Act (CWA) Section 401 Water Quality Certification and in preparation for the Final California 401 Water Certification anticipated to be released in 2019. The goal of the program is to gather the necessary scientific information to evaluate the water quality and suspended-sediment transport impacts of implementing the Klamath River Renewal Project (Project) and to comply with federal and state regulatory requirements for water quality monitoring. The Project will remove four dams, including Iron Gate Dam, Copco 1, Copco 2 and J.C. Boyle Dam which impound water on the Klamath River within California and Oregon.

As collaborators and partners with the Klamath River Renewal Corporation (KRRC), the Project Water Quality Monitoring Team comprised of the Karuk Tribe, Yurok Tribe and USGS, will conduct the data

collection activities, perform field and laboratory analysis of samples and data, help to manage the program and contracts, and assist with the development of all reporting documents. The USGS Sediment Laboratory (USL) located in Santa Cruz, CA will perform suspended sediment concentration (SSC) analyses of the water samples. AECOM is the prime consultant to KRRC for the Project and is managing the Water Quality Monitoring Program. CDM Smith Inc., as a subconsultant to AECOM, is providing regulatory compliance oversight and will be managing the monitoring program and reviewing all documents and plans related to the requirements within the California and Oregon 401 Water Quality Certifications for the Project. The Karuk Tribe, Yurok Tribe and the USGS are sharing the monitoring responsibilities of the Water Quality Monitoring Plan based on monitoring site location and the type of monitoring to be conducted as follows:

Table 2. Parties and Monitoring Activities Roles

Monitoring Site	Karuk Tribe	Yurok Tribe	USGS
Keno			Water Quality (including Turbidity)
J.C. Boyle			Water Quality (including Turbidity)
Iron Gate	Water Quality		Turbidity
Seiad Valley	Water Quality, Turbidity & SSC		Turbidity & SSC
Orleans	Water Quality, Turbidity & SSC		Turbidity & SSC
Klamath		Water Quality, Turbidity & SSC	Turbidity & SSC

SSC = Suspended Sediment Concentration

The project team for planning and conducting the study is outlined in (Table 3. Personnel Responsibilities, Figure 1. Organization Chart).

A.5.2 Quality Assurance/Quality Control Manager

The Quality Assurance/Quality Control (QA/QC) Manager role is to establish the quality QA/QC procedures found in this QAPP as part of the sampling, field analysis, and laboratory analysis procedures. The QA/QC Manager will also work with the Laboratory Manager from USL by communicating all quality assurance and quality control issues contained in this QAPP. The QA/QC Manager will also review and assess all procedures during the life of this project against QAPP requirements. The QA/QC Manager will report all findings to the Water Quality Team Coordinator, including all requests for corrective action. The QA/QC Manager may stop all actions, including those conducted by subcontractors if there are significant deviations from required practices or if there is evidence of a systematic failure, (Table 3. Personnel Responsibilities).

A.5.3 Persons Responsible for QAPP Update and Maintenance

The Project will span multiple years and changes and updates to this QAPP shall be made during the different phases of the project to align with schedule and water quality monitoring requirements described within the California and Oregon 401 Water Quality Certifications. The Water Quality Monitoring Team Coordinator will be responsible for making the changes, submitting drafts for review by CDM Smith, preparing a final copy, and submitting the final for signature. The QAPP will be updated as needed for each new monitoring period.

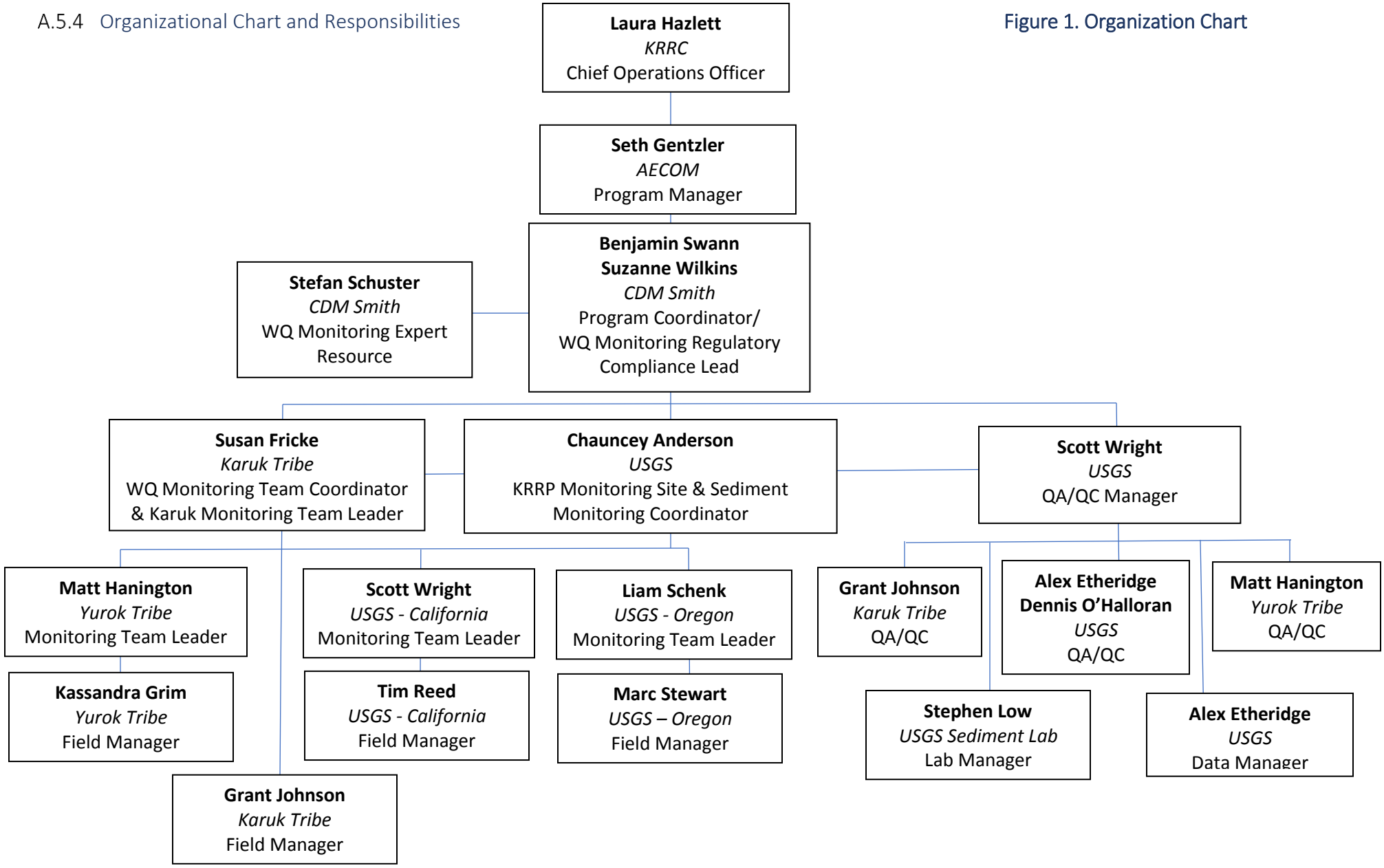
Table 3. Personnel Responsibilities

Program Team Member	Contact information (Telephone number, email)	Responsibility
Program Management/Administration		
Laura Hazlett KRRC	(510) 679-6928 lhazlett@klamathrenewal.org	Chief Operations Officer
Seth Genzler AECOM	(510) 874-3018 seth.gentzler@aecom.com	Program Manager
Benjamin Swann CDM Smith	(916-576-7479) swannbm@cdmsmith.com	Program Coordinator
Suzanne Wilkins CDM Smith	(530) 582-2224 wilkinssm@cdmsmith.com	WQ Monitoring Regulatory Compliance Lead
Stefan Schuster CDM Smith	(530) 582-2221 schustersl@cdmsmith.com	WQ Monitoring Expert Resource
Water Quality Monitoring Team		
Susan Fricke, Karuk Tribe Water Program	(530) 598-3414 sfricke@karuk.us	WQ Monitoring Team Coordinator & Karuk Tribe Monitoring Team Leader
Chauncey Anderson, USGS	(503) 251-3206 chauncey@usgs.gov	KRRP Monitoring Site & Sediment Monitoring Coordinator
Scott Wright USGS - California	(916) 862-0163 sawright@usgs.gov	USGS California Monitoring Team Leader
Liam Schenk, USGS - Oregon	(541) 273-8689 ext. 208 lschenk@usgs.gov	USGS Oregon Monitoring Team Leader
Matt Hanington, Yurok Tribe Environmental Program	(707) 482-1822 ext. 1002 mhanington@yuroktribe.nsn.us	Yurok Tribe Monitoring Team Leader
Grant Johnson Karuk Tribe Water Program	(530) 469-3258 gjohnson@karuk.us	Karuk Tribe Field Manager

Program Team Member	Contact information (Telephone number, email)	Responsibility
Program Management/Administration		
Tim Reed USGS California	(530) 246-5282 treed@usgs.gov	USGS California Field Manager
Marc Stewart USGS Oregon	(541) 776-4258 mastewar@usgs.gov	USGS Oregon Field Manager
Kassandra Grim Yurok Tribe Environmental Program	(707) 482-1822 ext. 1003 kgrimm@yuroktribe.nsn.us	Yurok Tribe Field Manager
Quality Assurance/Quality Control		
Scott Wright USGS	(916) 862-0163 sawright@usgs.gov	QA/QC Manager
Grant Johnson, Karuk Tribe Water Program	(530) 469-3258 gjohnson@karuk.us	Karuk Tribe QA/QC
Alex Etheridge, USGS	(916) 995-0784 aetherid@usgs.gov	USGS QA/QC – Sondes
Denis O'Halloran, USGS	(916) 278-3168 dohall@usgs.gov	USGS QA/QC - Sediment
Matt Hanington, Yurok Tribe Environmental Program	(707) 482-1822 ext. 1002 mhanington@yuroktribe.nsn.us	Yurok Tribe QA/QC
Laboratory Manager		
Stephen Low, USGS Sediment Laboratory	(831) 460-7500 stephlow@usgs.gov	Oversee USL analysis of SCC samples
Data Manager		
Alex Etheridge USGS	(916) 995-0784 aetherid@usgs.gov	Monitoring Data Management and Validation

A.5.4 Organizational Chart and Responsibilities

Figure 1. Organization Chart



A.6 Project Background

Four of the dams in the Klamath River are to be decommissioned beginning in January of 2021, there is a need to evaluate water quality and suspended-sediment transport and water quality before, during and after project implementation. The goal of the program is to gather the necessary scientific information to evaluate the water quality and suspended-sediment transport impacts of implementing the Klamath River Renewal Project (Project) and to comply with federal and state regulatory requirements for water quality monitoring. The Project will remove four dams, including Iron Gate Dam, Copco 1, Copco 2 and J.C. Boyle Dam which impound water on the Klamath River within California and Oregon. The KRRC Technical Team is tasked with establishing and implementing a coordinated monitoring program to accomplish this goal. Information regarding details of dam decommissioning project can be found in The Definite Plan for the Lower Klamath Project (Definite Plan) (KRRC 2018). The Water Quality Monitoring Plan is included in Appendix M of the Definite Plan.

In response to the need for data regarding suspended-sediment transport and water quality, the Monitoring Team will collect data to establish pre-, during and post-dam decommissioning suspended-sediment load and water quality conditions as outlined in Section A.7.1: Work Statement and Produced Products within this QAPP.

As the decommissioning project will result in a discharge to navigable waters of the state of Oregon and California it is subject to Section 401 of the Clean Water Act (CWA) and will be held to conditions set forth in ensuing water quality certifications from both states. For a full description of regulatory criteria and processes ongoing see Section 1.3 of the Definite Plan (KRRC 2018). The scope of the KRRC Technical Team's work will be to evaluate suspended-sediment transport and changes in water quality in accordance with the requirements specified in both the California and Oregon Section 401 Water Quality Certifications (401 WQ Cert). This QAPP reflects conditions stated within the draft California 401 WQ Certification (California State Water Resources Control Board 2018) will be revised once the final California 401 WQ Certification is released and will reflect the final conditions within the certification. The final Oregon 401 WQ Certification has already been released and this QAPP reflects the conditions within the final Oregon 401 WQ Certification (Oregon Department of Environmental Quality 2018).

A.7 Project/Task Description

A.7.1 Work Statement and Produced Products

Six existing USGS stream gage sites along the mainstem of the Klamath River within California and Oregon are being utilized to conduct water quality and suspended-sediment monitoring. Prior to monitoring activities during Water Year 2019, the six existing monitoring sites have been modified, or hardened, during the summer and fall of 2018 to enable water quality data collection during winter and spring high flow periods. Multi-parameter water quality monitoring sondes are operating at all six sites to develop time-series records of water quality data, and water quality sampling for suspended-sediment is being conducted at three of the sites in California (Klamath River near Seiad Valley, Klamath River above Orleans, Klamath River near Klamath). For site descriptions, see Section A.7.4: Geographic Setting. Monitoring activities for all six sites are anticipated to continue during subsequent years, with potential additional sites and analytical constituents.

A.7.2 Constituents to be Monitored and Measurement Techniques

Parameters to be monitored and analyzed with sondes include turbidity, dissolved oxygen (DO), temperature, conductivity, pH, and chlorophyll (summer months in CA only). SSC samples will be collected isokinetically and with automated samplers and delivered to the lab for analysis.

Suspended-sediment transport at individual stream gages will be calculated using techniques described in Rasmussen and others (2009). In summary, continuous (sub-hourly) turbidity data will be used to develop turbidity-SSC regression models to compute continuous SSC at sites where SSC sampling occurs. Those continuous SSC data will then be paired with concurrent streamflow data recorded at the USGS stream gages to calculate continuous suspended-sediment loads (SSL). The SSL data will then be aggregated over desired time frames to produce a total suspended-sediment load for the entire water year, reported in units of tons, kilograms (KG), or metric tons. Computing SSL prior to dam removal provides background data on pre-dam removal sediment transport conditions. Continuing the SSL computations over the course of the drawdowns, dam removals, and post-dam removal time periods will allow for the computation of a sediment budget for the entire Klamath River that will apportion a mass of sediment to the dam removals. The overall sediment budget will help determine how much sediment is transported from behind the dams.

A.7.3 Project Schedule

Table 4 below is the WY 2019 monitoring program schedule for deliverables and activity completions.

Table 4. Project Schedule.

Task/Deliverables	Anticipated date of Completion
Task 1 – Project Administration	
Quarterly Progress Reports	1/15/2019 4/15/2019 7/15/2019 9/15/2019
Draft and Final Meeting Agendas	15 days after meeting
Task 2: Prepare QAPP	
Draft QAPP for Review	12/1/2018
Final QAPP	4/1/2019
Task 3: Install Monitoring Stations	
Equipment list	12/1/2018
Equipment operating instructions	12/1/2018
Equipment Installed and Monitoring Equipment Operational (except for cable way in 2019)	12/1/2018
As-build schematic of all field installations	3/30/2019

Task/Deliverables	Anticipated date of Completion
Task 4: Perform Field Data Collection Activities	
Continuous Time-Series Data Collection	11/1/2018 thru 4/30/2019
Storm Event Sampling	10/1/2018 thru 9/30/2019
Continuous provisional USGS data published in real-time	Ongoing through contract
Final approved USGS records from WY2019	4/1/2020
Task 5: Data Management and Analysis	
Continuous provisional Karuk and Yurok data published in real-time	Ongoing through contract
Final approved USGS records from WY2019	4/1/2020
Laboratory Analysis	2-3 months after sample collection
Task 6: Annual Progress Reporting	
Draft Annual Progress Report	08/01/2019
Final Annual Progress Report	09/30/2019

A.7.4 Geographic Setting

The Klamath River flows 257 miles through Oregon and California to the Pacific Ocean, and is the second largest river in California. It originates in the high desert of south-central Oregon and moves through the Klamath Mountains. Table 5 below provides the six monitoring station locations and descriptions. The six monitoring sites shown below are associated with existing USGS gaging stations. Figure 2. Map of Selected Sites shows the overall geographic location of selected sites. Monitoring site access maps, parking and monitoring equipment locations are included in Appendix A

Table 5. Monitoring Station Location Descriptions

Site Name (USGS Gage No.)	Coordinates*	Operator(s)	Water Data Collected
Klamath River Below Keno (#11509500)	Latitude 42°08'00", Longitude 121°57'40" NAD27	USGS in cooperation with PacificCorp	• Water Temperature • Specific Conductivity • Dissolved Oxygen • pH • Turbidity • Sediment Samples starting WY 2020
Klamath River Below JC Boyle Powerplant (#11510700)	Latitude 42°05'05", Longitude 122°04'20" NAD27	USGS in cooperation with PacificCorp	• Water Temperature • Specific Conductivity • Dissolved Oxygen • pH • Turbidity

Site Name (USGS Gage No.)	Coordinates*	Operator(s)	Water Data Collected
			• Sediment Samples starting WY 2020
Klamath River Below Iron Gate Dam (#11516530)	Latitude 41°55'41", Longitude 122°26'35" NAD27	USGS in cooperation with Karuk Tribe	• Water Temperature • Specific Conductivity • Dissolved Oxygen • pH • Turbidity • Sediment Samples starting WY 2020
Klamath River NR Seiad Valley, CA (#11520500)	Latitude 41°51'14", Longitude 123°13'52" NAD27	USGS in cooperation with Karuk Tribe and USGS – Federal Priority Stream gages (FPS)	• Water Temperature • Specific Conductivity • Dissolved Oxygen • pH • Turbidity • Sediment Samples starting WY 2019
Klamath River Above Orleans (#11523000)	Latitude 41°18'13", Longitude 123°32'00" NAD27	USGS in cooperation with California Department of Water Resources (DWR), Karuk Tribe, and USGS – Cooperative Matching Funds	• Water Temperature • Specific Conductivity • Dissolved Oxygen • pH • Turbidity • Sediment Samples starting WY 2019
Klamath River NR Klamath, CA (#11530500)	Latitude 41°30'40", Longitude 123°58'42" NAD27	USGS in cooperation with Yurok Tribe and USGS – FPS	• Water Temperature • Specific Conductivity • Dissolved Oxygen • pH • Turbidity • Sediment Samples starting WY 2019

*Coordinates taken from USGS National Water Information System (NWIS) website

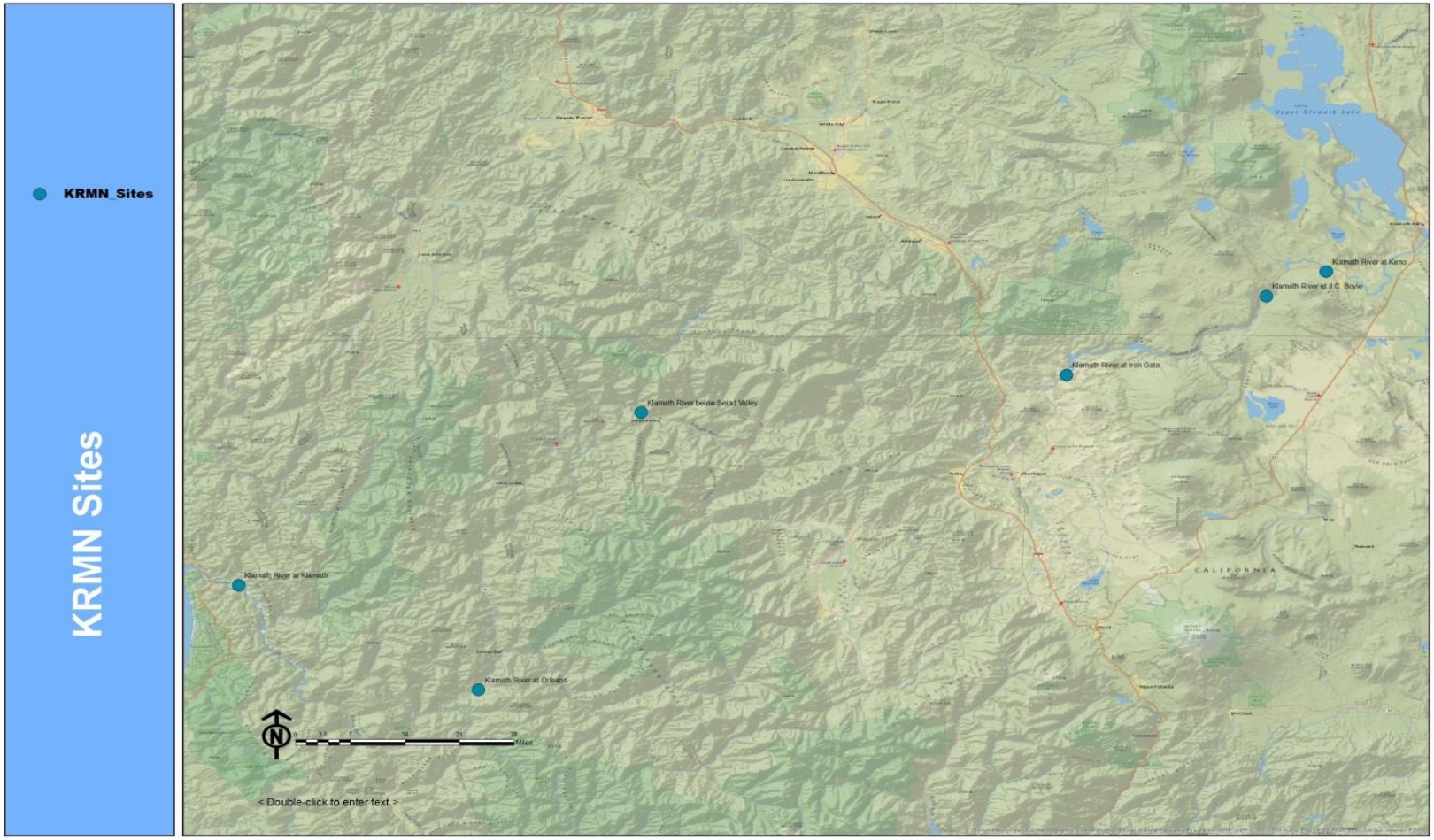


Figure 2. Map of Selected Sites

A.7.5 Constraints

Every effort will be made to collect storm event samples for SSC. Personnel availability may create challenges in collecting samples if multiple sites require sampling at the same time. However, automated pump samplers (ISCO) are deployed to collect samples when the sites cannot be visited. High flow events will be captured to the best of the project teams' ability. Weather conditions will dictate sampling events, and the safety of the crews collecting the samples will be the top priority. If weather conditions create unsafe working environment for sampling crews, the samples will be collected by the automated samplers described above.

A.8 Quality Objectives and Criteria

This section discusses the quality objectives for the project and the performance criteria to achieve those objectives.

For continuous time-series measurements, the data quality criteria to be assessed quantitatively include precision and accuracy alone. These assessments will be different for suspended-sediment samples data. The associated acceptance criteria (types & frequencies of QC checks and acceptance limits) for the project are summarized in Table 6. Measurement Quality Objectives.

A.8.1 Precision

Precision is a measure of agreement among replicate measurements of the same property, under prescribed similar conditions.

Precision will be assessed quantitatively with duplicate samples and expressed as relative percent difference (RPD) by the following equation:

$$RPD(\%) = \frac{\frac{|x1 - x2|}{(x1 + x2)}}{2} X\ 100$$

where,

RPD (%) = relative percent difference

x1 = Original sample concentration

x2 = Duplicate sample concentration

|x1 - x2| = Absolute value of x1 - x2

To assess precision associated with all steps of the project (from sample collection through analysis) field duplicates will be collected and analyzed for SSC samples. Composite (cross-section) samples for SSC will always be collected in duplicate and are referred to as A and B sets in USGS terminology. An A set represents one cross-section sample, and a B set is collected directly after representing a duplicate cross-section sample. To assess laboratory precision alone, the USGS QA Plan for the Analysis of Fluvial Sediment by the USGS California Water Science Center (CAWSC) will be followed (Appendix B)

A.8.2 Accuracy

Accuracy is the degree of agreement of a measurement with the true value. Accuracy includes a combination of random error (precision) and systematic error (bias) that result from sampling and analytical operations. Accuracy of water quality measurements contained in this QAPP are a function of the equipment used during sampling, and of the sampling methods.

For automatic (pump) samples for SSC, single bottle samples collected in conjunction with cross-section samples will be collected at a frequency of 5% (1 duplicate/20 field samples). Collecting a pump sample in conjunction with a cross-section sample allows for accuracy testing of the pump samples, by determining if the pump samples are representative of the cross section as a whole. If the pump samples and cross section samples differ in concentrations, then a box coefficient is applied to the pump samples. The box coefficient is simply a multiplier that is applied to the pump sample to adjust the concentration of that sample to the concentration of the cross-section sample that was collected in conjunction with the pump sample. Applying box coefficients to pump samples is a common practice by USGS, and more documentation can be found in Edwards and Glysson (1999).

Precision of field results will be tested using duplicate samples, with a target of less than 20% RPD, as described previously.

A.8.3 Completeness

Completeness on this project with regards to expected number of collected SSC samples is expected to be approximately 90%. Completeness with regards to continuous water quality data is expected to be as close to a complete record as possible (a complete record is retaining all unit values over a water year), recognizing that data loss can occur for several reasons. These reasons include loss of data during field visits and on-site calibrations, potential issues with data transmission, and other unforeseen circumstances that could result in loss of data.

A.8.4 Representativeness

This is the expression of the degree to which data accurately and precisely represent a characteristic of an environmental condition or a population. Field crews collecting samples will maximize representativeness of samples by selecting sites and employing methodologies to best characterize environmental conditions.

A.8.5 Bias

Bias describes the tendency for under or over prediction of sampled or measured values relative to the true value. Bias is typically assessed using matrix spikes and reference materials. Samples of known sediment concentrations are routinely tested as described in the QA Plan for the Analysis of Fluvial Sediment by the USGS California Water Science Center Sediment Laboratory (Appendix B), and as described in the USGS Office of Surface Water technical memo 98.08, 1998 (https://water.usgs.gov/admin/memo/SW/sw98.05.html). Bias is also assessed in the lab through negative controls (Blanks). Detectable quantities in the blank would indicate positive bias. The CAWSC Santa Cruz Sediment Lab bi-annually participates in the Sediment Lab QA Plan described in (Appendix B).

Table 6. Measurement Quality Objectives

Group	Parameter	Accuracy	Precision	Recovery	Completeness
Conventional Constituents in Fresh Waters	• SSC	Standard Reference Materials (SRM, CRM) within 95% CI stated by provider of material. If not available then with 80% to 120% of true value	Laboratory duplicate, Blind Field duplicate, or MS/MSD 25% RPD Laboratory duplicate minimum.	N/A	Approx. 90%
Continuous Water Quality Data	• dissolved oxygen (DO) • pH • water temperature • specific conductance • turbidity • chlorophyll (CA summer months only)	As described in Wagner and others (2006), Rasmussen and others (2009), and this QAPP	As described in Wagner and others (2006), Rasmussen and others (2009), and this QAPP	N/A	As close to a complete record as possible

A.9 Special Training Needs/Certification

A.9.1 Specialized Training or Certifications

There are no certifications that apply to this work.

A.9.2 Training and Certification Documentation

All relevant training and certification documentation will be stored by respective organization in accordance with their standard operating procedure.

A.9.3 Training Personnel

In July 2018, USGS conducted training for the Karuk and Yurok tribal staff on collection of samples for SSC. Additional SSC sampling training is offered annually through USGS in Castle Rock, WA, which could be attended by new staff within USGS or the Tribes. For operation of continuous monitoring sondes, the USGS California Water Science Center (CAWSC) is planning to offer a water quality data collection training class, which includes turbidity as well as the other water quality parameters, to the relevant Tribal and USGS staff. In November 2018, the Yurok Tribe hosted training on YSI datasonde operation, which was available to all project participants.

The Field Manager for each crew will have the responsibility of overseeing Health and Safety Plan (HSP) compliance by all field staff. Each individual is responsible for their own safety and for following all required HSP policies and procedures. All sampling will be carried out in accordance with USGS job hazard analysis (JHA) documents which will be combined into a packet to serve as a Health and Safety Plan (HSP) for this project and a copy of the HSP will be kept at each monitoring site.

A.10 Documents and Records

All USGS data will be maintained and served publicly through the National Water Information System (NWIS) database. Provisional continuous time series data will be published in real-time on the USGS NWIS website, with final approved records from WY19 available by April 1, 2020. Laboratory results will be provided by the USGS via the NWIS web database. Laboratory results may also be provided electronically for inclusion in a separate project database.

Continuous water quality data collected by the Karuk and Yurok Tribe will be available on the Karuk website and be submitted electronically for inclusion in the project database. The Karuk and Yurok continuous data and associated field data will be stored on their individual servers indefinitely in addition to the project database. Any SSC samples collected by the Karuk and Yurok tribes will be sent to nearest USGS field office under a Chain of Custody (COC) (Appendix C) where a Sediment Laboratory Analysis Request (SLAR) electronic form can be filled out by USGS staff and then sent to USGS Santa Cruz sediment lab, so those records will be available through the USGS NWIS database.

All monitoring entities will provide a summary of data collected each month in quarterly reports to be submitted to CDM Smith for review and then to the KRRC technical team.

Field records will include a written (Appendix C) or electronic record (Aquarius Software) of site visits documenting field observations, site conditions, calibration and maintenance conducted. A field visit summary will be provided in the quarterly reports. Field crews will also collect dated photo documentation of site conditions from each visit showing the condition of equipment and gage and unusual site and river conditions. Additionally, field staff will fill out a Field Inspection Sheet for SSC sampling (Appendix C) including all monitoring sites where SSC samples are collected with information including date, time, number of samples collected, and notes on site conditions.

The Karuk Tribe, Yurok Tribe and USGS will prepare and submit an annual monitoring season summary that covers work completed including: upgrades and development of monitoring locations, samples collected, all other monitoring conducted, photos, and recommendations for program modifications. The annual season summaries will be compiled in an Annual Progress Report that will include site descriptions with photos, mapping, and coordinates, summarize monitoring activities, and provide links to data and results. The report will also present recommendations for program modifications needed to prepare for the required monitoring activities during WY2020 and up to drawdown..

Each sampling entity's QA/QC staff will be tasked with ensuring that all relevant personnel have the most recent version of this QAPP.

Table 7. Document and Record Retention, Archival, and Disposition Information

	Identify Type Needed	Retention	Archival	Disposition
Station Log	Station Description files (record of site visits and conditions – road logs, ownership, equipment, etc.)	Onsite and copy retained in CAWSC and ORWSC (Oregon Water Science Center) Data Program Offices	Archived according to USGS policy SM 502.9 and/or in accordance with this QAPP	Indefinite
Field Visit and Sample Collection Records	Field notes for (1) monitor calibration, (2) SSC Sample collection (3) Autosampler sample collection	Retained in CAWSC and ORWSC Data Program Offices, and Karuk and Yurok Tribal offices.	Archived according to USGS policy and/or in accordance with this QAPP	Indefinite
Analytical Records	Laboratory analyses for SSC and particle sizes	Stored at USL, Santa Cruz, CA	Archived according to USGS policy and in accordance with this QAPP	Indefinite
Data Records	Time Series Data	Retained in CAWSC and ORWSC Data Program Offices, and Karuk and Yurok Tribal offices and project database.	Archived according to USGS policy and in accordance with this QAPP	Indefinite
Assessment Records	Surrogate Model Archives, WQ Station Analyses	Retained in CAWSC and ORWSC Data Program Offices	Archived according to USGS policy	Indefinite

B. Data Acquisition

B.1 Sampling Process Design-Study Design

A total of three sites will be sampled for SSC for this project during WY2019, as summarized in Table 8. Number and Frequency of Suspended-Sediment Samples. Site selection criteria included the use of existing USGS gaging stations, located to enable measurement of changing water quality conditions below project actions. This monitoring project will monitor approximately 240 river miles for continuous water quality data starting at the Klamath River below Keno, and 135 miles for SSC sampling starting at the Klamath River near Seiad in WY 2019. SSC sampling will be conducted at the frequencies shown in Table 8.

B.1.1 Suspended-Sediment Sampling

SSC sampling will occur at each site between November 1, 2018 to September 30, 2019. Sites were selected based on locations of existing USGS gaging stations and to provide a longitudinal profile of SSC and sediment transport from upstream to downstream. Three of the sites (Seiad, Orleans, and Klamath) will each be sampled during four storm events between October 1, 2018 and September 30, 2019. Samples collected will also include 10-12 cross-section composite samples (depth- and width-integrated samples collected from a cableway, bridge, or boat) and 20-30 automated samples (pump samples from an automated sampler. The method chosen to collect individual samples will be determined dependent on weather and hydrologic conditions, and availability of personnel. For events when personnel are not available to collect cross-section composite samples, an automated sampler will be used. Automated (pump) samples will be adjusted to the cross-section samples as described in section A.8.2: Accuracy.

B.1.2 Continuous Monitoring Methods

The KRRC Technical Team will conduct continuous in-situ monitoring as described below. Sites were selected based on locations of existing USGS gaging stations and to provide a longitudinal profile of water quality changes from upstream to downstream. For continuous monitoring, a reading will be taken every 15 minutes by a YSI multi-parameter water quality instrument (sonde). Each reading will include the following parameters: temperature, conductivity (as specific conductance), pH, dissolved oxygen (% saturation and mg/L), turbidity, and chlorophyll. All continuous monitoring will be conducted uniformly and in accordance with the USGS protocols, EPA-approved Karuk and Yurok protocols, and training so data can be validated and analyzed comprehensively (Wagner and others, 2006, Rasumssen and others, 2009, forthcoming USGS techniques and methods on operating fluorescence [e.g. total algae] sensors).

Table 8. Number and Frequency of Suspended-Sediment Samples

Sample Location	Latitude	Longitude	USGS Gage #	Baseline Sampling Nov 2018-Sept 2019	Maximum Number of Storm Sampling Events	Number of Samples per Storm Event	Maximum Number of SSC Samples
Klamath River at Keno	42.133199	-121.962231	11509500	*			
Klamath River at J.C. Boyle	42.084588	-122.073345	11510700	*			
Klamath River at Iron Gate	41.927919	-122.444188	11516530	*			

Sample Location	Latitude	Longitude	USGS Gage #	Baseline Sampling Nov 2018-Sept 2019	Maximum Number of Storm Sampling Events	Number of Samples per Storm Event	Maximum Number of SSC Samples
Klamath River below Seiad Valley	41.853738	-123.232273	11520500	1/month	4	10-12	30
Klamath River at Orleans	41.303460	-123.534504	11523000	1/month	4	10-12	30
Klamath River at Klamath	41.510954	-123.979516	11530500	1/month	4	10-12	30

* These sites will not have sediment sampling in WY19

B.2 Sampling Procedures and Requirements

Suspended-sediment sampling will consist of isokinetic (depth- and width-integrated) sampling, and automated sampling. Appropriately cleaned and weighed sample containers for isokinetic sampling will be obtained from the analyzing laboratory or USGS. Sample bottles and other field equipment will be protected from contaminants.

In the event a sample cannot be collected the project leads will be notified to decide if a backup or alternate option exists.

B.2.1 Suspended-Sediment Sampling

Composite sampling (depth- and width-integrated sampling) requires the manual collection of isokinetic samples by direct bottle filling using USGS techniques described in Edwards and Glysson (1999) and Gray and others (2008). SSC samples may be collected by cableway, from a bridge, or from a boat, depending on the site and streamflow conditions. The complete Suspended Sediment Sampling SOP appears in Appendix D. Suspended sediment. SSC sampling will occur monthly at the three sampling sites as either composite or automated samples from November 1, 2018 to September 30, 2019 as described in the Table 8. Number and Frequency of Suspended-Sediment Samples.

Table 9. Samples Handling

Analyte	Bottle Type/Size	No. Bottles per Sample	Preservative	Minimum Holding Time
Depth-width integrated Suspended-sediment concentration (SSC)	Plastic, either 1-L or 3-L bottles or glass 1-pint bottles	10 each (5 per set)	None	30 days
Autosampler Pumped Suspended-sediment concentration (SSC)	Plastic 1-L bottles	1	None	30 days

B.2.2 Automated Samplers

Automated pump samplers are included to allow for high-frequency sampling and to capture events that might be missed when personnel are not available. Teledyne ISCO 6712 portable samplers or similar automated samplers will be set to trigger at either a specified time or a specified turbidity threshold that will be determined once the project team has evaluated recent turbidity data from the Yurok and Karuk Tribes at the three sampling sites. Once the turbidity threshold is reached, the automated samplers will collect SSC samples at a specified interval based on the site and hydrologic conditions. There will be 20-30 automated samples collected per site from October 1, 2018 thru Sept 30th, 2019.

B.2.3 Continuous Monitoring Methods

Continuous water quality monitoring will be conducted with YSI EXO2 data sondes. Data collection by USGS at the Keno and JC Boyle sites will follow protocols detailed in Wagner and others (2006), and Rasmussen and others (2009). The USGS, Karuk and Yurok Tribe will perform all data collection and equipment maintenance as outlined by manufacturer specifications, this QAPP and in accordance with their respective EPA approved QAPPs, and SOPs (Appendices E, F, and G). The sondes will be housed within a protective PVC perforated pipe, which will secure the sondes in the water column to avoid damage to equipment. Communication cables will be attached to the submerged sondes and routed to the gage house where they will be connected to a datalogger. The datalogger will send USGS data to the database through a GOES satellite window. The Karuk and Yurok Tribes sondes are connected to FTS Axiom data loggers with an SDI-12 cable. Once data is recorded by sonde it is sent to data logger. Both the data logger and sonde retain data. The data logger will transmit data via the GOES satellite network and will be available on EDDN servers. In addition, Karuk and Yurok data will be made available on the Karuk water quality web portal in real time. Sondes will record data at a 15-minute interval.

Procedures The procedures for calibrating sondes are in the protocols, SOPs (Appendices E, F, and G) and the Karuk Tribe and Yurok Tribe QAPPs, summarized in Section B.7: Instrument/Equipment Calibration and Frequency. They are also described in Wagner and others (2006) and Rasmussen and others (2009) for the USGS sites at Keno and JC Boyle.

Field Variances As conditions in the field vary; it may become necessary to implement minor modifications to the sampling procedures and protocols described in this QAPP. Modifications will be documented in the Quarterly Progress Reports.

B.2.4 High Range Turbidity Sensor

USGS will deploy and operate high-range continuous turbidity sensors at the JC Boyle, Iron Gate, Seiad, Orleans, and Klamath sites. The sensors will be ANALITE NEP-5000 180-degree backscatter sensors, and will be calibrated and operated by the published protocols referenced in Section B.2.3: Continuous Monitoring Methods.

B.3 Sample Handling and Custody

SSC samples will be delivered to the USGS lab in Santa Cruz, CA within 30 days of sample collection for analysis. SSC samples do not require storage or transport on ice, and can be stored and transported at room temperature, preferably in a dark location. SSC samples collected by Karuk and Yurok Tribes will be either directly shipped to the lab or physically transferred to USGS personnel under a COC, who will then transport the samples to the lab. Analytical service request forms (ASR) will be filled out by USGS personnel using field forms from USGS, Karuk, and Yurok personnel. The sample bottles will be labeled by Site ID, Date, median sample time (the median time between the start and stop time of the samples), gage height at time of sample, and the sample set (A or B). USGS personnel will fill out necessary information into the electronic forms prior to submitting samples to the lab.

B.4 Equipment, Analytical Methods and Field Measurements

Samples will be collected and analyzed as outlined below.

B.4.1 Field Equipment

Isokinetic Suspend-Sediment Sampling

Composite and individual analyses suspended-sediment sampling will be conducted from bridges, boats, cableways, and by wading the stream cross section following methods described in Edwards and Glysson (1999). For bridge, cableway, and boat samples, a USGS D-49, D-96, D-74, D-95, DH-95 or DH-59 sediment sampler with appropriate glass or plastic bottles or plastic bags for the D-96 bag sampler will be used to collect the samples. These samplers will be lowered and raised through the water column using cable and reel devices. For wading samples, a hand-held DH-81 sediment sampler enclosing a 1-L Nalgene plastic bottle, or a DH-48 sediment sampler enclosing a glass pint bottle will be used. These samplers will be manually lowered and raised through the water column during sample collection. Individual sample bottles will be sent to the Santa Cruz lab for analysis. The measurement principle of these samplers follows isokinetic sampling theory, which states that the water approaching and entering the sampler intake does not change velocity while the sampler is being moved through the water column and collecting the sample. Isokinetic samplers are limited to water velocities greater than 1.5 feet per second and depths less than 15-ft for samplers with rigid bottles (D-74, D-95, DH-95, DH-59). The D-96 bag sampler can be used in velocities from 2.0 to 12.5 ft/s and depths up to 110-ft depending on the nozzle diameter.

Two cross-section composite samples will be collected per sampling event generating 10 1-L sample containers. The first sample (A-set) will generate 5 sample bottles that will be analyzed individually for SSC and percent of sample finer than 63 microns (percent fines). The second sample will composite all of the 5 containers resulting in one SSC and percent fines value, and will be analyzed for full particle size distribution.

Automated Samplers

The Teledyne ISCO automated pump samplers function using a peristaltic pump head that is capable of pumping volumes of water up to 26 vertical feet from the point of pumping to the pump head, and at manufacturer-recommended velocities. The sampler can be configured to hold bottles sized from 1-L to 5.5 gallons if needed. No measurement principle is associated with this equipment. Major attributes include the ability to program the sampler to collect samples at specified temporal frequencies and at specified turbidity thresholds. An SDI-12 interface allows connection with the YSI EXO2 sondes via the data logger to trigger the samples at specified turbidity thresholds without disrupting the transmission of continuous water quality data from the sondes.

Continuous Monitoring Methods

The EXO2 sondes contain sensors that continuously record observations of water temperature, pH, dissolved oxygen, specific conductance, turbidity, and chlorophyll. Water temperature and specific conductance are located on the same probe. The temperature thermistor is a calibrated with a NIST-traceable wet calibration and an accuracy specification of 0.01 degrees Celsius and a resolution of 0.001 degrees Celsius. The specific conductance sensor reports water conductance compensated to 25 degrees Celsius and uses four internal pure-nickel electrodes to measure solution conductance. Conductance resolution is 0.0001 to 0.01 ms/cm. The dissolved oxygen sensor is an optical sensor and operates by shining a blue light of a specified wavelength onto a luminescent dye which is immobilized in a matrix and formed to a disk. Accuracy of the dissolved oxygen sensor is increased by irradiating a red light during the measurement cycle to act as a reference in the determination of the luminescence lifetime. Dissolved oxygen resolution is 0.01 mg/L, or 0.1% air saturation. pH is measured using two electrodes combined into the same probe: one for hydrogen ions and one for a reference. The sensor is a glass bulb filled with a solution of stable pH. pH range is 0 to 14 units with a resolution of 0.01 units. The turbidity sensor employs a near-infrared light source and detects scattering at 90 degrees of the incident light beam, also characterized as a nephelometric near-IR turbidimeter, non-radiometric. As such, units are reported as formazin nephelometric units (FNU). The sensor range is 0-4000 FNU with a resolution of 0.01 FNU for 0-999 FNU, and 0.1 FNU for 1000-4000 FNU. The high-range ANALITE NEP-5000 turbidity sensor is a backscatter sensor that detects scattering at 180 degrees of the incident light beam. The units are reported as nephelometric turbidity units (NTUs). The ANALITE NEP-5000 sensor range is 0-30,000 NTU with a resolution of +/- 1.5 NTU for 0-5,000 NTU, +/- 3.0 NTU for 5,000-10,000 NTU, +/- 9.0 NTU for 10,000-30,000 NTU.

For calibration, maintenance, see manufacturer's instructions (Appendix H), and auditing procedures (Appendices E, F). Raw data from sondes will be collected and stored on dataloggers in the USGS gage houses. This data will also be transmitted via the GOES network and made publicly available.

B.4.2 Analytical Methods

Suspend Sediment Concentration is the only laboratory analysis in this study. All samples will be analyzed by the USGS Sediment Laboratory in Santa Cruz, CA.

Chemistry

SSC will be analyzed using method, ASTM D 3977-97, Standard Test Method for Determining Sediment Concentration in Water Samples (ASTM, 1999). This is the USGS standard for determining concentrations of suspended material in surface water samples. This method is used by all USGS sediment laboratories, and by cooperating laboratories certified to provide suspended-sediment data to the USGS. The laboratory will report both concentration in mg/L and percent of sample less than 63 microns, operationally defined as the break between silt and sand.

Table 10. Analytical Methods

Analyte	Project Quantitation Limit (units, wet or dry weight)	Analytical Method	
		Analytical Method/SOP	Modified for Method yes/no
SSC	mg/L, percent of sample less than 63 microns	ASTM D 3977-97	No

Sample Disposal

This section does not apply to any type of sampling conducted under this QAPP.

Corrective Action

The projects QA/QC Manager will be responsible for documenting sampling failures and instituting corrective measures.

B.5 Quality Control

B.5.1 Blanks

Field Blanks will not be collected for this sampling, which is typical for suspended-sediment sampling.

B.5.2 Spikes and Duplicates

A duplicate sample will be collected with each cross-section composite (isokinetic) SSC sample. The primary and duplicate samples are referred to as "A" and "B" sample sets. Collecting two concurrent or sequential duplicate samples for each cross-section sample allows for comparison of sampling methods and helps to determine if a sampling error occurred. For example, if one of the samples reports a high

concentration relative to the other sample, the hydrographer collecting the sample could determine that the high concentration sample possibly over-sampled the bed-sediment, which is not representative of the suspended sediment. In that scenario, the high-concentration sample would be discarded, and the second sample would be retained.

B.6 Instrument/Equipment Testing, Inspection, And Maintenance

B.6.1 Sampling Equipment

Sampling equipment will be inspected regularly prior to use for safety and operational reasons. Cable reels will also be inspected to ensure crew safety during sample collection. The full lists of all sampling equipment are described in the USGS SOPs Appendices D and E.

B.6.2 Automated Samplers

Automated samplers will be inspected regularly, typically when field crews retrieve samples from the sampling units. The pump heads and battery voltage will be inspected to ensure that sample collection will continue at the scheduled frequency.

B.6.3 Continuous Monitoring Methods

Calibration and maintenance of field equipment/instruments will be performed according to the manufacturer's instructions (Appendix H), and sampling organizations SOPs (Appendices E, F, and G) and recorded in an instrument/equipment logbook.

The project-specific criteria for calibration (frequency, acceptance criteria, and corrective actions associated with exceeding the acceptance criteria) are provided in Table 11. Field Equipment Calibration, Maintenance, Testing, and Inspection.

Table 11. Field Equipment Calibration, Maintenance, Testing, and Inspection

Analytical Parameter	Instrument	Calibration Activity	Maintenance & Testing/ Inspection Activity	Frequency	Acceptance Criteria	Corrective Action
Temperature (Sensor)	EXO2 MPS Multi Probe System: YSI Precision ™ Thermistor		According to Wagner and others (2006) Manufacturer's manual Karuk QAPP[1] Yurok QAPP[2]	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	± 0.15°C of true value at both endpoints or as dictated in Wagner and others (2006)	Remove from use and replace with backup sensor if doesn't pass calibration criteria
pH (electrode)	EXO2 MPS Multi Probe System: YSI Glass Combinatio n electrode	Initial: Two-point calibration bracketing expected field sample range (using 7.0 and 10.0 pH buffer) Post: single-point check with 7.0 pH buffer	According to Wagner and others (2006) and Manufacturer's manual Karuk QAPP Yurok QAPP	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	Initial: Two- point calibration done electronically Post: ±0.1 pH units of true value or as dictated in Wagner and others (2006)	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria and replace with backup sensor.
Dissolved oxygen (sensor)	EXO2 MPS Multi Probe Optical Sensor	Initial: One-point calibration with saturated air (need temp, barometric pressure). Post: single-point check at full saturation	According to Wagner and others (2006) and Manufacturer's manual Karuk QAPP Yurok QAPP	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	Initial: One-point calibration done electronically Post: ±0.5 mg/L of true saturated value or as dictated in Wagner and others (2006)	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria and replace with backup sensor.
Turbidity (sensor)	EXO2 MPS Multi Probe System	Initial: 2 or 3-point calibration using 0, 124, 1010 FNU copolymer beads Post: same calibration as pre-deployment	According to Wagner and others (2006) and Manufacturer's manual Karuk QAPP Yurok QAPP	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	Initial: One-point calibration done electronically Post: ±1 NTU of true value or as dictated in Wagner and others (2006) and Rasmussen and others (2009)	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria and replace with backup sensor.

Analytical Parameter	Instrument	Calibration Activity	Maintenance & Testing/ Inspection Activity	Frequency	Acceptance Criteria	Corrective Action
Conductivity (sensor)	EXO2 MPS Multi Probe System: YSI 4-electrode cell with autoranging	Initial: One- point calibration at high end of expected field sample range (1000 mS/cm standard)	According to Wagner and others (2006) and Manufacturer's manual Karuk QAPP Yurok QAPP	Initial and bi-weekly (every other week) for Karuk and Yurok sites, once every 4-6 weeks for USGS sites	Initial: one-point calibration done electronically	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria and replace with backup sensor.
		Post: two-point check with high (1000 mS/cm) and low (0 mS/cm) standards			Post: high standard ±5% of true value and low standard ±10% of true value, or as dictated in Wagner and others (2006)	

[1]Karuk Tribe Water Quality Program 2018; [2]Yurok Tribe Environmental Program 2017

B.6.4 Analytical Instruments

The chemistry analytical laboratory maintains its equipment in accordance with its SOPs, which include those specified by the manufacturer and those specified by the method. Problems with the instrumentation during analysis will require repair, recalibration, and re-analysis of the sample.

Table 12. Testing, Inspection and Maintenance of Analytical Instruments

Equipment / Instrument	Responsible Person	Frequency	SOP Reference
Sartorius Analytical Balance LA230S	Lab Manager	Daily during periods of operation	Knott and others (1992)
Sartorius Macro Balance AZ4101	Lab Manager	Daily during periods of operation	Knott and others (1992)
Fisher Scientific Isotemp Premium Oven 700 Series 13247750F	Lab Manager	Weekly during periods of operation	Knott and others (1992)
Filtration Equipment	Lab Manager	Weekly during periods of operation	Knott and others (1992)

B.7 Instrument/Equipment Calibration and Frequency

B.7.1 Suspend-Sediment Sampling

SSC sampling devices do not require calibration before use, with the exception of the D-96 bag sampler, which requires an intake efficiency tests as described in USGS Office of Surface Water technical memo 2013.03, collected before each set of samples for cross-section composite sampling. Intake efficiency tests for D-96 bag samplers will be performed following the protocols described in USGS Office of Surface Water technical memo 2013.03. Resolution of deficiencies will follow protocols described in USGS office of Surface Water technical memo 2013.03.

B.7.2 Automated Samplers

Maintenance and cleaning of equipment will follow manufacturer's guidelines. Calibration of volume delivered will be done according to manufactures specifications. If automated samplers fail to trigger or deliver proper sample volume. Field technicians will notify QA/QC staff and efforts will be made to resolve the issue.

B.7.3 Continuous Monitoring Methods

For a description of equipment, tools, and instruments and the frequency of calibration see Appendices D, E and F for Karuk and Yurok protocols, Table 11. Field Equipment Calibration, Maintenance, Testing, and Inspection and Table 12. Testing, Inspection and Maintenance of Analytical Instruments. Calibration of EXO2 sondes and documentation of the calibrations will follow procedures outlined in Wagner and others (2006) and Rasmussen and others (2009) for the USGS sites at Keno and JC Boyle. At Iron Gate, Seiad Valley and Orleans calibrations will follow the SOPs outlined in Karuk QAPP (Karuk Tribe Water Quality Program 2018) and at the Klamath site procedures will follow the Yurok QAPP (Yurok Tribe

Environmental Program 2017). Any deficiencies in sampling will be documented in quarterly report and resolved by individual sampling entities.

B.8 Inspection/Acceptance for Supplies and Consumables

USGS hydrographers from the Klamath Falls field office will be responsible for the purchase of consumables necessary for the operation and maintenance of continuous water quality sondes at Keno and JC Boyle. Acceptance criteria are addressed by the internal USGS supply store prior to shipping to field offices. Tracking and storing of the materials is conducted by USGS hydrographers at the field office.

The field measurement supplies the Karuk and Yurok Tribe will use, such as calibration solutions, will be acquired from standard traceable sources, such as the instrument manufacturer or reputable suppliers. The Karuk Tribe will obtain calibration standards from Fondriest Environmental, Inc. The lot number and expiration date on standards and reagents will be checked prior to use. Expired solutions will be discarded and replaced. The source, lot number, and expiration dates of all standards and reagents will be recorded in the field log books.

Table 13. Project Inspection/Acceptance Requirements for Supplies and Consumables

Project	Instrument Name/Model	Date Purchased	Inspection Specifications	Acceptance Criteria	Frequency	Responsible Individual
Water Quality Monitoring at Klamath, Orleans, Seiad Valley, Iron Gate	YSI Multiprobe EXO2	10/2018	Karuk, Yurok QAPP	Manufacture specifications (Table 8)	Every 2 weeks	Field Officers

B.9 Data Management

Management of data collected by USGS will follow established protocols, and will be stored in the NWIS database, which is publicly accessible. USGS databases retain all original raw data, and records processing and management follows guidelines detailed in Wagner and others (2006) and Rasmussen and others (2009).

The Karuk Tribe will ensure that all field collected audit and calibration data will be recorded on paper and digitally. All raw continuous monitoring data collected by the Karuk and Yurok Tribe will be stored on their individual servers or the Karuk server and made available to KRRC. Filling of project related documents will follow the guidelines in the Karuk and Yurok Tribes QAPPs (Karuk 2018, Yurok 2017). Raw continuous time series data will be entered into Aquatic Informatics, Inc. Time Series software to be evaluated and corrected based upon procedures outlined in the Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and Data Reporting (Wagner and others, 2006, and Rasmussen and others, 2009) by the USGS. Both real time and corrected data will be made available on the Karuk Tribes Water Quality Web Portal and submitted to the project database.

C. Assessments and Response Actions

During the course of the project, it is important to assess the projects' activities to ensure that the QAPP is being implemented as planned. This helps to ensure that everything is on track and serves to minimize learning about critical deviations toward the end of the project when it may be too late to remedy the situation. For the current project, the ongoing assessments will include:

- Field Oversight,
- Readiness review of the field team prior to starting field efforts,
- Field activity audits,
- Review of field sampling and measurement activities methodologies and documentation at the end of each event, and
- Laboratory Oversight - evaluation of laboratory data generated for each quarterly sampling event.

C.1 Reports to Management

Quarterly progress reports will be prepared and submitted to KRRC. The Yurok Tribe will provide a summary of data collected to the Karuk Tribe for inclusion in the quarterly progress reports. Quarterly progress reports will include respective invoices.

An annual progress report will also be prepared and submitted to KRRC by September 30, 2019. The annual progress report will describe equipment installation and site reinforcement with photos, mapping and site coordinates, all monitoring activities, links to USGS, Karuk and Yurok data results or an established repository with all the results, and recommended QAPP revisions and site modifications for WY2020, as necessary. Note that a detailed report of data trends and analysis will not be included in this report.

D. Data Review, Verification, and Validation

Prior to utilizing data to make project decisions, the quality of the data needs to be reviewed and evaluated to determine whether the data satisfy the projects' objectives. This process involves technical evaluation of the off-site laboratory data, as well as, review of the data in conjunction with the information collected during the field sampling and field measurement activities. This latter, more qualitative review provides for a clearer understanding of the overall usability of the projects' data and potential limitations on their use. Section A.8: Quality Objectives and Criteria outline various criteria that will be used to evaluate project data.

D.1 Verification and Validation Methods

The setting of data review, verification, and validation requirements helps to ensure that project data are evaluated in an objective and consistent manner. For the current project, such requirements have been defined for information gathered and documented as part of field sampling and field measurement activities, as well as for data generated by the off-site laboratory.

Individual monitoring agencies will be responsible for validating various components of project information in accordance with their respective QAPPs (Karuk 2018, Yurok 2017).

D.2 Reconciliation with User Requirements Checklists

The Karuk and Yurok tribes will flag data that does not meet the acceptance criteria outlined in Section A.8: Quality Objectives and Criteria.

Uncertainty for data collected by USGS is reported and quantified as part of the records processing that is required for all USGS data sets. Data limitations are reported by flagging of data and qualitative rating of water quality records. These flags and ratings are retained with the data when retrieved from the USGS database.

Once all the data from the field and laboratory have been evaluated, the QA Officers will make an overall assessment concerning the final usability of the data (and any limitations on its use) in meeting the projects' needs. The initial steps of this assessment will include, but are not necessarily limited to:

- Discussions with the Field Technicians,
- Review of deviations from the QAPP or associated SOPs to determine whether these deviations may have impacted data quality (and determining whether any impacts are widespread or single incidents, related to a few random samples or a batch of samples, and/or affecting a single or multiple analyses),
- Evaluation of the field and laboratory results and QC information,
- Review of any other external information which might influence the results, such as activities up stream, meteorological conditions, wildfires, and data from other sources,
- Evaluation of whether the completeness goals defined in this QA Project Plan have been met,
- Examination of any assumptions made when the study was planned, if those assumptions were met and, if not, how the project's conclusions are affected.

In addition, the Monitoring Management Team will assess the effectiveness of the monitoring program and data collection at the end of each calendar year. Sampling locations, frequency, list of analytical parameters, field measurement protocols, choice of the analytical laboratory, etc. will be modified as needed to reflect the changing needs and objectives of the KRRP. This QAPP will be revised and/or amended accordingly.

E. References

California State Water Resources Control Board. 2018. Draft Water Quality Certification – Klamath River Renewal Corporation's Lower Klamath Project Federal Energy Regulatory Commission Project No. 14803. June 18, 2018.

Edwards, T.K., and Glysson, G.D., 1999, Field methods for measurement of fluvial sediment: Techniques of Water-Resources Investigations of the U.S. Geological Survey, book 3, chap. C2, 89 p.

Gray, J.R., Glysson, G.D., and Edwards, T.E., 2008, Suspended sediment samplers and sampling methods, in, Sediment transport measurements, in, Marcelo Garcia, ed., *Sedimentation Engineering—Processes, Measurements, Modeling, and Practice: American Society of Civil Engineers Manual 110*, Chapter 5.3, p. 320–339.

Karuk Tribe Water Quality Department, *Quality Assurance Project Plan,* KTWQP, CA, 2018.

Klamath River Renewal Corporation. 2018. *Definite Plan for the Lower Klamath Project*. June 2018.

Oregon Department of Environmental Quality. 2018. *Clean Water Act Section 401 Certification for the Klamath River Renewal Corporation License Surrender and Removal of the Lower Klamath Project (FERC no. 14803) Klamath County, Oregon*. September 7, 2018.

Rasmussen, P.P., Gray, J.R., Glysson, G.D., and Ziegler, A.C., 2009, *Guidelines and procedures for computing time-series suspended-sediment concentrations and loads from in-stream turbidity-sensor and streamflow data*: U.S. Geological Survey Techniques and Methods, book 3, chap. C4, 52 p.

Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, *Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods*. 1–D3, 51 p., 8 attachments.

Yurok Tribe Environmental Program, “Quality Assurance Program Plan”, YTEP, CA 2017.

APPENDIX B

Karuk Tribe QAPP 2018

KARUK TRIBE

DEPARTMENT OF NATURAL RESOURCES

P.O. Box 282 * Orleans, California 95556

2018

Quality Assurance Project Plan

For Water Quality Sampling and Analysis

CWA 106 grant identification # BG-97991217

Prepared by

Karuk Tribe Water Quality Program

Karuk Tribe Water Quality Program
Quality Assurance Project Plan

For Water Quality Sampling and Analysis

Water Quality Program
Karuk Tribe Department of Natural Resources
PO Box 282
Orleans, CA 95556

This QAPP has been approved by:

Karuk Water Quality Project Manager _____

Karuk Water Quality QA Officer _____

_____

For EPA use:

Approved by EPA Project Manager: Date:

_____ _____

Expedited Review? ☒ Yes ☐ No

Received by QA Office: Date:

_____ _____

Reviewed by: Date:

_____ _____

Approved: Date:

_____ _____

Region 9 Quality Assurance Manager

Table of Contents

1.0 PROJECT MANAGEMENT

This Quality Assurance (QA) Project Plan has been prepared for the monitoring of surface water by the Karuk Tribe located in Humboldt and Siskiyou County, California. The surface water monitoring program is part of the Tribe's water quality management program developed under Section 319 of the Clean Water Act. This section of the QA Project Plan describes how the project will be managed, organized and implemented.

1.1 Title and Approval Page - See Pages 1-2.

1.2 Table of Contents - See Pages 3 - 8.

1.3 Distribution List

The following is a list of individuals who will receive copies of the approved QAPP and any subsequent revisions or changes.

Susan Fricke Karuk Tribe Water Resources Director Karuk Tribe: Department of Natural Resources P.O. Box 282 Orleans, California 95556 Ph: 530-598-3414 sfricke@karuk.us	**Tim Wilhite** GAP Project Officer USEPA c/o Klamath Nat'l Forest 1312 Fairlane Road Yreka, CA 96097-9549 Ph: 530-841-4577 Fax: 530-841-4571 Wilhite.Timothy@epamail.epa.gov
Karuk Tribal Council PO Box 1016 – 64236 Second Avenue Happy Camp, Ca 96039 Toll Free: (800) 505-2785 (530) 493-1600 – Fax: (530) 493-5322	**Aquatic Research Inc.** 3927 Aurora Ave. N Seattle, WA 98103 Ph: 206-632-2715 info@aquaticresearchinc.com
Jim Sweet Aquatic Analysts 43 Telegraph Ln Friday Harbor, WA 98250 Ph: 503-869-5032 jwsweet@aol.com	**Chesapeake Biological Laboratory** 1 Williams Street Solomons, MD 20688 Ph: 410-326-4281
GreenWater Laboratories 205 Zeagler Drive, Suite 302 Palatka, FL 32177 Ph: 386-328-0882 info@greenwaterlab.com	**Bartholomew Laboratory** Oregon State University 226 Nash Hall Corvallis, OR 97331 Ph: 541-737-1834

Loretta Vanegas CWA 106 Project Officer USEPA REGION 9 75 Hawthorne Street *Mail Code:* WTR-10 San Francisco, CA 94105	**Eugenia McNaughton,** Manager Region 9 Quality Assurance Section U.S. EPA Region 9 75 Hawthorne Street *Mail Code:* MTS-3 San Francisco, CA 94105
Ph: 415-972-3433 Vanegas.Loretta@epa.gov	(415) 972-3411 McNaughton.Eugenia@epa.gov

1.4 Project Organization

Table 1 lists key players and contractors, including those collecting samples, contractors that will process samples and Karuk Tribe Water Quality Program (KTWQP) staff that will oversee quality control (QC) procedures. Laboratories that will process samples are 1) Aquatic Research Inc. in Seattle, Washington, 2) Aquatic Analysts Inc. in Friday Harbor, Washington, 3) the U.S. Environmental Protection Agency Region IX Laboratory in Richmond, California, 4) Chesapeake Biological Laboratory in Solomons, Maryland, 5) GreenWater Laboratories in Palatka, Florida, and 6) Bartholomew Laboratory in Corvallis, Oregon.

The KTWQP is completing this QAPP to define how QC procedures are implemented and to define how the KTWQP and its staff will work together on quality assurance (QA) to insure that data are properly collected and analyzed, managed and stored for on-going use, and results published in a timely fashion. Because of the systematic planning process documented in this QAPP, the KTWQP will supply quality assured data for management decisions related to the aquatic environment within Karuk Ancestral Territory (KAT) and surrounding areas.

The KTWQP is organized as shown in Figure 1. The KTWQP Project Manager has ultimate control over and responsibility for the WQ program. The KTWQP Project Manager is responsible for program coordination, budget management, technical oversight and overall program quality.

The QA Officer will have responsibility and authority for:

- Ongoing review of monitoring methods and equipment calibration,
- Report Preparation,
- Auditing field notebooks, databases, chain of custody forms, and
- Insuring adherence to field and laboratory QA/QC programs.

In short, the QA Officer will insure that QC procedures developed in this QAPP are carried out. The Data Manager and Water Quality Technicians will work under the supervision of the QA Officer and follow procedures as defined in this QAPP.

The Data Manager will:

- Transfer results from the field or laboratory into databases,
- Properly store data and archive to insure against loss,
- Run preliminary analysis of data, and provide charts for reports, and
- Assist with report preparation.

The WQ Technicians will:

- Collect field samples,
- Fill out forms to record results and field conditions,
- Care for and calibrate equipment, and
- Properly fix and ship samples needing laboratory analysis.

Any time there are problems perceived by the Data Manager or the WQ Technician with any part of the WQ Monitoring Program, they are to notify the KTWQP Project Manager so they can work collaboratively on resolving issues. The QA Officer will also periodically conduct audits to detect QA/QC problems or deficiencies.

If any tests of surface water exceed tribally adopted water quality standards, then the KTWQP Project Manager will be notified so that they can inform the Karuk Tribal Council. Following notification of the Tribal Council, the KTWQP would then inform the North Coast Regional Water Quality Control Board staff and work cooperatively with that agency for abatement of problems.

The KTWQP will send water quality samples needing laboratory analysis to Aquatic Research Inc., and to Chesapeake Biological Lab. Phytoplankton and algae samples will be sent to Jim Sweet of Aquatic Analysts to be processed and analyzed. Samples to be tested for microcystin toxins will be sent to the US EPA Region 9 Lab and GreenWater Lab. Samples to be analyzed for ceratonova shasta (c.shasta) will be sent to Bartholomew Lab.

1.5 Background and Problem Definition

This section states background information to provide a historical, scientific, and regulatory perspective for the project, and articulates specific problems to be solved.

1.5.1 Background

The Karuk Tribe is the second largest Tribe in California, with over 3,700 Tribal members currently enrolled. The Karuk Tribe is located along the middle Klamath River in northern California. Karuk Ancestral Territory covers over 90 miles of the mainstem Klamath River and numerous tributaries (Figure 2, Table 2). The Klamath River system is central to the culture of the Karuk People, as it is a vital component of our religion, traditional ceremonies, and subsistence activities. Degraded water quality and quantity has resulted in massive fish kills, increased occurrences of toxic algae, and outbreaks of fish diseases. Impaired water quality conditions also apply extreme limitations and burdens to our cultural activities.

1.5.1.1 Decline of the fishery

What was once a historically productive fishery has now declined to numbers precluding tribal members from utilizing their fishing rights on ancestral waters and limiting their take for sustenance throughout the Klamath River watershed. The Indian people of the Karuk Tribe traditionally depended on the land and waters to provide for their physical and cultural needs. The state of the watershed today prevents this dependency.

Historically, spring-run Chinook salmon were abundant in the rivers of the Klamath Basin, considerably outnumbering the fall Chinook run (Hume in Snyder 1931). "Salmon ascend the river in large numbers, before the waters subside in the spring", remarked Gibbs in 1851 (SRWC SAP 2005). Fall Chinook, winter and summer steelhead were also widespread in the Klamath Basin. (Maria, personal communication in SRWC SAP 2005). Today, the spring Chinook and summer steelhead run is virtually nonexistent in the Klamath River (KRBFTF, 1991. p. 2-87, 2-99, and 4-15; USFS, 2000b, p.3-9; USFS, 2000a).

Coho salmon would have flourished in the numerous ponds created by beavers in Mid-Klamath tributaries and the mainstem Klamath (SRWC SAP 2005 & Belchik, personal communication). Brown et al. (1994) state that California coho populations are probably less than 6% of what they were in the 1940s, and there has been at least a 70% decline since the 1960s. Coho salmon occupy only 61% of the SONCC Coho ESU streams that were previously identified as historical coho salmon streams (CDFG,
2002, p.2)

1.5.1.2 Land Use Factors

Consideration of factors limiting salmon and steelhead production, water quality and attainment of other beneficial uses in Mid-Klamath region must be tiered. Flow depletion in tributaries and water diversions cause secondary water quality problems as transit time increases and stagnation of water occurs. This alteration of timing and flow volume subsequently affects sediment dynamics and the hydro-morphology of these water ways. Limiting factors are most often linked to the land use activities of logging, agriculture, and historical mining.

Historical Mining: Historically, gold was mined in the Mid-Klamath region. The type of mining performed in Northern California during the late 1800s was hydraulic mining, not chemical (like cyanide-leach mining), so less chemical contamination is associated with it. Surface and groundwater in the MidKlamath could potentially be contaminated with heavy metals, such as arsenic, that naturally occur in association with gold but are discarded in mine tailings. The use of mercury to separate gold from concentrates was

common place. Dredge tailings from hydraulic mining can also serve as a source of sediment pollution. Current mining practices are being evaluated by CDFG at present.

Agriculture: Beginning around 1850, ranching became a prevalent use of land on the Klamath River and its tributaries. Grazing of cattle is still performed by landowners adjacent to the Klamath River and its tributaries. This could contribute to erosion of streams and bacterial contamination of surface waters where cattle are permitted access to streams. Agricultural practice near waterways may contribute contaminants such as pesticides, nitrates, and phosphates to the surface water.

In the Shasta River and the Scott River, two major Klamath River tributaries, the flow depletion due to water extraction for agriculture causes warming as the water volume is reduced. Decreasing flows also causes the formation of isolated pools, which can and do strand juvenile fish. Warming water temperatures and nutrient rich agricultural return water increases the amount of periphyton growth on stream substrate, which has been demonstrated in the Shasta River. High rates of photosynthesis by algae in low flow conditions can cause large nocturnal and diurnal fluctuations in pH and dissolved oxygen. The secondary effects related to high photosynthetic activity in stagnant, de-watered reaches are not targeted because loss of flow is an over-riding impact.

Logging: Much of the land in Siskiyou County was logged, beginning in the latter half of the 19th century. Historic timber practices could result in herbicide and pesticide contamination of surface and ground water. Erosion due to clear-cutting and logging roads (whether still used and maintained, or abandoned) contributes significant amounts of sediment to the Klamath River system and has altered the natural hydrograph.

Upland areas of the Klamath River which have been extensively logged have high road densities prompting multiple Regional Water Board TMDLs across the Klamath basin. Compaction of soils and changes in routing of storm water on logged areas and logging roads are known to:

- Increase peak discharge (Montgomery and Buffington, 1993; Jones and Grant, 1996),
- Increase sediment yield (Hagans et al., 1986, de la Fuente and Elder, 1998), and
- Decrease large wood available for recruitment to streams (Reeves et al., 1993; Schuett-Hames et al., 1999).

The potential changes in aquatic conditions related to upland disturbance are described below.

Increased Peak Discharge: Elevated peak discharge can increase median particle size distribution to those greater than optimal for salmonid use, wash out large wood, and trigger bank failures and channel scour. Channel changes can include decreased pool frequency and depth (Buffington and Montgomery, 1993). Wider and shallower channels are also more subject to warming. Although less well-studied, hydrologic changes associated with compaction of a watershed can also lead to decreased summer base flows.

Increased Sediment Yield: Sediment yield is a noted problem in tributaries to the Klamath River mainstem (NCRWQCB, 2003; 2005). Fine sediment comes primarily from surface or gully erosion. Sommarstrom et al. (1990) identified road cuts and road fills on decomposed granitic soils as a major source of fines within the Scott River watershed, a major tributary to the Klamath River.

Fine Sediment: High levels of sand and fine sediment can fill interstitial spaces in stream gravels, decrease salmonid egg and alevin survival and reduce aquatic insect habitat. Decreased aquatic invertebrate production can diminish food resources for juvenile salmonids. Smaller sediment particles are highly mobile and may cause diminished pool frequency and depth, thus reducing salmonid juvenile carrying capacity and adult salmonid holding habitat.

Mass Wasting: The coarse and fine sediment yielded by mass wasting can cause channel aggradation, loss of pool habitat, changes in median particle size, decreased spawning gravel quality and channel adjustments that facilitate stream warming.

Large Wood Depletion: Changes in riparian conditions can increase ambient air temperature over streams and reduce relative humidity, thus leading to stream warming (Bartholow, 1989; Pool and Berman, 2001). Cold air moving down slope from Marble Mountain peaks in winter may also cause elevated risk for the formation of anchor ice along streams where canopy is lacking. Pools formed by large wood are extremely important as nursery areas for coho salmon juveniles (Reeves et al., 1988) that must spend one year in freshwater before migrating to the ocean. Large wood depletion can therefore cause diminished aquatic habitat complexity, reduced pool frequency and lower carrying capacity for juvenile coho. Large coniferous trees in riparian zones may take decades or centuries to grow to sufficient size to be useful in buffering air temperatures and providing wood of sufficient size to provide lasting habitat value (Shuett-Hames et al., 1999).

1.5.1.3 Purpose of Water Quality Investigations

It is the mission of the Karuk Tribe to protect, promote, and preserve the cultural resources, natural resources, and ecological processes upon which the Karuk People depend. This mission requires the

protection and improvement of the quality and quantity of water flowing through Karuk Ancestral Territory and Tribal trust lands. The Karuk Tribe's Department of Natural Resources has been monitoring daily water quality conditions in the Klamath River since January of 2000 and tributaries to the Klamath River since 1998. The Karuk Tribe has been collaboratively involved in maintaining water quality stations along the Klamath River and its tributaries with the United States Environmental Protection Agency (USEPA), the United States Geological Survey (USGS), the Bureau of Reclamation (BOR), the Yurok Tribe, Quartz Valley Indian Reservation, Hoopa Tribe, and Resighini Rancheria, Oregon State University and PacifiCorp.

The data produced is indispensable in monitoring water quality conditions within the Klamath River System. We are building a long-term monitoring data set that allows us to track these conditions and monitor them for improvement. This data is important to state and federal processes currently underway and provides information for Tribal Council and resource managers to make informed decisions. The water quality data the Karuk Tribe collects is essential to providing quality data regarding processes that involve and affect the Karuk Tribe.

The goal of the KTWQP is to provide the Karuk Tribe with a quantitative assessment of water quality effecting KAT, and to further expand the Tribe's scientific knowledge for tribal members, fisheries, future planning, and watershed activities. Additionally, these analyses will help identify any surface water contamination problems that could affect fish habitat, since wild salmon are an important resource to the Karuk Tribe and a vital piece of the Tribe's cultural heritage.

The data was collected in accordance with this QAPP will be used to develop baseline information in order to document water quality changes over time, screen for potential water quality problems, and to provide a scientific foundation in order to actively participate in the management of the Mid-Klamath watershed.

1.5.2 Problem Definition

1.5.2.1 Nutrient and Toxic Algae Pollution

The Klamath River in California is listed as an impaired water body under the Clean Water Act (CWA) Section 303(d) list for temperature, nutrients, dissolved oxygen (DO), sediment, and microcystin (NCRWQCB, 2009). The mid-Klamath River can have elevated water temperatures, low dissolved oxygen levels, elevated sediment loads, loading from organic matter, and high levels of the cyanotoxin microcystin. These detrimental conditions are caused by a variety of factors including hydrological modification, agricultural use, timber harvesting, mining activities, and fire suppression (NCRWQCB, 2009). Some of the beneficial uses that are important to the Karuk Tribe and impacted by poor water

quality conditions are, cultural use, subsistence fishing, cold freshwater habitat, recreation, commercial and sport fishing, shellfish harvesting, rare, threatened, or endangered species, migration of aquatic organisms, spawning, reproduction, and/or early development, and wildlife habitat (NCRWQCB, 2007).

The presence of Microcystis aeruginosa (MSAE) contributes to not only fish health problems, but also to human health problems. As MSAE cells die and decay the hepatoxin microcystin is released, which can cause a range of reactions in humans and/or animals: rash, irritation, conjunctivitis, nausea, vomiting, diarrhea, liver damage, tingling, numbness, paralysis, and death (Chorus and Bartram 1999; Chorus 2001). Once ingested, microcystin is not excreted and instead it bioaccumulates and can cause liver damage, decreased liver function, and eventually mortality (WHO, 1998). Mortality in fish, domestic animals, and humans has been recorded following from both single-dose events and long-term exposure to microcystin (Carmichael 1994).

Nutrient and toxic algae pollution in the Klamath River is causing stressful conditions for Pacific salmonid species and their juveniles and providing an environment that fosters an increase in disease organisms (YTEP, 2006). The reduced salmon production and loss of access to salmon as a food resource has had major health consequences for Native Peoples in the Klamath River basin (Norgaard, 2005).

1.5.2.2 Ceratonova Shasta

Stable river channel conditions, abundant algae beds and deposits of benthic organic matter in the Klamath River just below Iron Gate Dam provide ideal habitat for a polychaete worm that plays host to one of the Klamath River's most deadly fish diseases, *Ceratonova shasta* (Stocking and Bartholomew, 2004; Stocking, 2006). This myxozoan parasite infects the intestine of salmonid fishes, which can lead to enteronecrosis and mortality. *Ceratonova shasta* cycles between two hosts and two spore stages: waterborne actinospores released from freshwater polychaete worms infect salmonids and develop into myxospores, which are then infectious to polychaetes (Bartholomew, 2016). The combination of direct stress to fish from water pollution in combination with increased abundance of pathogens has led to more than 40% of downstream migrant juvenile Chinook salmon dying before they reach the ocean in some years (Foot et al., 2003; Nichols and Foot, 2005). The Bartholomew Lab at Oregon State University has been monitoring the spatial and temporal abundance of the parasite in the Klamath River basin since 2006 using sentinel fish exposures, river water sampling, and polychaete sampling. The KTWQP assists with water sample collection and filtration.

1.5.3 Principal data users/decision makers who will use the data to make decisions

The first step to fulfill the goal of this QAPP is the collection of baseline data for water bodies in the Mid-Klamath watershed. Quality assured water quality data collected by the KTWQP will be used in management decisions regarding the watershed. Data will be shared with the U.S. EPA

and NCRWQCB staff through timely reports on findings, including for use in TMDL updates. Other agencies and entities cooperating in Klamath watershed management, including the U.S. National Forest (Klamath and Six Rivers), may also receive KTWQP data after it has undergone QA/QC and analysis. The KTWQP will also share data with tribal members through annual reports and with the public upon request.

1.5.4 Brief Summary of Existing Information

Klamath River nutrient pollution has been widely recognized since the 1950's (Phinney and Peak, 1962; CH2M Hill, 1985; Kier Associates, 1991). The adult salmon kill in September 2002 (CDFG, 2003; Guillen, 2003), chronic high mortality of juvenile salmon (Nichols and Foot, 2005) and discovery of problems with toxic algae in KHP (Klamath Hydroelectric Project) reservoirs (Kann and Corum, 2006) all point to a water quality crisis. As noted above, sources of pollution include upstream agricultural operations and nitrogen fixing algae in Upper Klamath Lake, Lost River, Lower Klamath Lake and KHP reservoirs.

In 1989 the Karuk Tribe formed the Department of Natural Resources which primarily focused on fisheries work. About ten years later, the KTWQP was started. Water quality data was collected in coordination with USGS and USFWS and generally focused on the KAT but also occurred upstream of the KAT. In 1995, USFWS monitored Klamath River water quality as linkages between water pollution and fish health became more apparent. Data have included grab samples for nutrients and those derived from continuous recording data probes that capture parameters such as pH, D.O., temperature and conductivity.

The Klamath River Water Quality Monitoring Coordination Workgroup that includes Tribes and State and federal agencies was formed after the September 2002 adult salmon kill and coordinated increased water quality sampling. Asarian and Kann (2006) used existing nutrient data to construct a nutrient budget by reach for the Klamath River and their study lists all nutrient related water quality samples collected between 1996 and 2004. They pointed out data gaps for nutrient sampling using adequate laboratory detection limits and the need for more periphyton samples. The Hoopa Tribal Environmental Protection Agency (TEPA, 2008) used existing data to characterize Klamath River nutrient pollution and to set limits on their Reservation waters just upstream of Weitchpec where they have been granted Treatment in the Same Manner as a State (TAS) and set water quality standards.

In 2004, the Yurok Tribe, NCRWQCB, and PacifiCorp conducted a Klamath River periphyton study that included sites above and within the KAT, with results summarized by Eilers (2005) and Hoopa TEPA (2008).

The Karuk Tribe began cooperative water quality sampling, including nutrients, with USFWS in 2001.

The KTWQP has operated continuous water quality datasondes at several locations above and within KAT since that time for temperature, D.O., pH, and conductivity. Monitoring for toxic algae species began in 2005 and is ongoing. Periphyton sampling occurred in 2008 and 2011-2014. The KTWQP has been responsible for all of its sample collection, transportation to applicable laboratories, data storage, and data analysis related to nutrients since 2007. The KTWQP has been assisted by Aquatic Ecosystems for analysis of phytoplankton and toxic algae data. Nutrient data collected from 2001-2006 by KTWQP

underwent extensive QA/QC examination. Starting in 2016 all nutrient data has been submitted to the California Environmental Data Exchange (CEDEN) and then cross walked to EPA's STORET. Data will also be added to the comprehensive TMDL database, which is shared and augmented by the Klamath River Water Quality Monitoring Coordination Workgroup and used by the U.S. EPA and NCRWQCB for the Klamath River TMDL.

1.6 Project/Task Description

This section provides a summary of all work to be performed, products to be produced, and the schedule for implementation. This is most easily discussed in sections: Nutrient Sampling, Public Health Sampling, Continuous Monitoring, and C. Shasta sampling.

1.6.1 Nutrient Sampling

A total of eight sites will be sampled for a complete nutrient suite. Table 3 lists the KTWQP sampling sites for nutrients. The sampling area includes 147 river miles of the mainstem Klamath River upstream and within KAT and the Salmon, Scott, and Shasta Rivers above their confluence with the Klamath River. The Salmon River is within KAT, whereas the Scott and Shasta Rivers are upstream of KAT. Scott and Shasta provide excellent spawning habitat for salmonids that are harvested on the KAT, thereby serving as important tributaries to the tribe's fishery. Although the Klamath River is bordered mostly by forests and wildlands, nutrient pollution and now toxic algae are creating water quality problems in KAT. A map of specific locations of the sampling sites is shown in Figure 3.

The KTWQP will collect biweekly samples (every other week) between May and October and monthly samples between November and April, excluding the months of January and February. This schedule was selected because May-October is when nutrients impair water quality in the mainstem Klamath River. Late spring through fall are important times for juvenile salmonid (Chinook, Coho, steelhead) migration, adult spring and fall Chinook migration into the Klamath basin, and migration and rearing of lamprey and green sturgeon, which are all of great importance to the Karuk People. Water quality conditions may impact these species of importance and may also impact the use of the river for subsistence fishing, ceremonial use, other cultural use, and recreation. Although year-round biweekly sampling is preferred to understand the nutrient dynamics of the Klamath River (Asarian and Kann, 2006; Kann and Asarian, 2007), funding availability limits sampling in certain months.

At the locations previously selected, water samples will be collected with a churn splitter to ensure that the sample is homogeneously mixed before the sample bottles are filled. Depending on location, two collection methods may be used. For all sites except for WA, the churn is fully submerged into the stream

and filled to the lid with flowing water, not stagnant water. For WA, a site sampled from a bridge, a Van Dorn sampler is used to collect 3 samples from across the channel. The samples are poured into the churn and treated the same as all other sites.

Sample bottles and chemical preservatives used will be provided by Aquatic Research Inc. and Aquatic Analysts, and are considered sterile prior to field usage. Sample bottles without chemical preservatives will be rinsed with stream water from the churn three times before filling with sample water. In the case of bottles that contain chemical preservatives, bottles are not rinsed before sample collection and care is taken to avoid over-spillage that would result in chemical preservative loss. Sample bottles used for Chesapeake Biological Laboratory will be cleaned prior to the sampling event using the procedures listed in Appendix E-7. Collected samples are placed in coolers on ice for transport to contracted laboratories for analysis or to KTWQP office for filtering.

Samples being sent to Chesapeake Biological Laboratory will first be filtered at the KTWQP office according to procedures listed in section 11.1.1 of Appendix E-7.

Samples sent to Aquatic Research Inc. will be analyzed for the following parameters: Total Phosphorus, Ortho-Phosphorus, Total Nitrogen, Nitrate+Nitrite, Ammonia, Chlorophyll *a*/Phaeophytin *a*, Dissolved Organic Carbon, Total Suspended Solids, Volatile Suspended Solids, Turbidity, and Alkalinity. Samples sent to Aquatic Analysts will be analyzed for Phytoplankton. Samples sent to Chesapeake Biological Laboratory will be analyzed for Particulate Organic Carbon, Particulate Organic Nitrogen, Particulate Inorganic Phosphorus, and Particulate Organic Phosphorus.

General water quality parameters (temperature, dissolved oxygen, conductivity, and pH) will also be simultaneously measured at each site with a YSI datasonde and the data will be recorded onto the grab sample datasheet. The YSI datasonde will have been calibrated using the procedures in Appendix E-4.

1.6.2 Public Health Sampling

A total of five sites will be sampled for microcystin and one site will be sampled for anatoxin-a. Table 3 lists the KTWQP sampling sites for public health. To best monitor public health risks, water samples are collected at locations used for public access and recreation.

Public health sampling occurs biweekly (every other week) starting in June. Once high levels of microcystin are detected, sampling increases to a weekly interval. MSAE blooms and those of other toxic algae species

occur in late summer and early fall, when fishing for subsistence and ceremonial use is at its peak. Public health sampling is continued through October, or until microcystin is no longer detected.

Samples will be collected as grab samples using the same sampling protocol at all locations. At each sampling location, samplers should conduct an initial visual survey of the public access area to identify where surface grab samples would be collected to represent a reasonable maximum exposure at that public access location. Because cyanobacteria can accumulate and dissipate rapidly, depending on sun and wind conditions, a location having a greater presence of cyanobacteria should be identified within each designated public access area, where the public is likely to come into contact with cyanotoxins. This requires subjective selection by the sampler, but should be limited to locations within the public access area (e.g., roughly 50 meters). When possible, sampling crew field trainings should be conducted before the sampling season begins, and involve comparing where different samplers subjectively select to sample in an effort to normalize the selection process.

Grab samples will be performed using a clean wide-mouth jar (about 8 cm diameter and 10 cm depth) that is turned on its side and then submerged into the upper 10 cm of the water. KTWQP will follow Environmental Sampling of Cyanobacteria for Cell Enumeration, Identification and Toxin Analysis Standard Operating Procedures (Appendix E-2) to complete this sampling.

Sample bottles will be 4 oz. pre-cleaned glass thick-walled jars and are considered sterile prior to field usage. Collected samples will be labeled and promptly placed in a cooler with ice to both protect from sunlight and chill until shipped. Double-bagged wet ice or blue ice is acceptable as long as the maximum threshold temperature (6°C) for samples is not exceeded. Block ice is discouraged to protect sample bottles from breaking during shipping. The ice supply will be replenished as often as needed to maintain samples at or below 6°C, and prior to preparing coolers for shipping to the appropriate laboratories. For shipping, glass samples bottles will be protected from breakage using bubble wrap.

Samples sent to the U.S. EPA Region IX Laboratory will be analyzed for microcystin toxin using the enzyme linked immunosorbent assay (ELISA) method. Samples sent to GreenWater Laboratories will be analyzed for microcystin variants and anatoxin-a using liquid chromatography/mass spectrometry (LCMS/MS).

General water quality parameters (temperature, dissolved oxygen, conductivity, and pH) will also be simultaneously measured at each site with a YSI datasonde and the data will be recorded onto the grab sample datasheet. The YSI datasonde will have been calibrated using the procedures in Appendix E-4.

The Karuk Tribe standard for public health protection and limit of microcystin pollution level is <0.8 µg/L and anatoxin-a pollution level is <90 µg/L. KTWQP will issue warnings and communicate with all appropriate agencies should Klamath River samples exceed these thresholds.

1.6.3 Continuous Monitoring

A total of six sites will be continuously monitored using YSI datasondes. Table 3 lists the KTWQP sonde monitoring sites. Three of these stations are located at fixed points along the mainstem Klamath River (Orleans, Seiad Valley, and Iron Gate) and the other three stations are located at fixed points in tributaries (Shasta River, Scott River, and Salmon River). Figure 3 shows the locations of the sampling stations. These stations create a longitudinal profile of water entering and exiting the Mid-Klamath region. The tributary sites are located near their mouths to highlight their influence on the mainstem Klamath River. These tributaries also support abundant runs of spring and fall chinook, coho, steelhead, lamprey, and sturgeon (Salmon River only).

Water quality parameters to be sampled for each site are Temperature, Specific Conductivity, pH, and Dissolved Oxygen. In addition to these parameters, the mainstem stations will monitor Turbidity and Blue Green Algae (using a phycocyanin probe). Two of the tributary stations, Scott River and Salmon River, will also monitor Turbidity.

All of the stations will continuously monitor using a YSI datasonde. The sondes will be fixed to a cable and protected by a metal pipe which will suspend the probes to avoid damage to equipment. The stations at Orleans, Salmon River, Scott River, and Shasta River will deploy a YSI 6600 V2 datasonde. The stations at Seiad Valley and Iron Gate will deploy a YSI EXO2 datasonde.

This sampling focuses around the summer base flow (the growing season), which is generally from MayOctober. All six sites will be deployed during these months. A reading will be taken every 30 minutes and the data will be available real-time on the KTWQP website. The Iron Gate site and the Salmon River site will be deployed year-round with plans to implement year round monitoring at all Klamath River mainstem site Fall of 2018.

Datasondes will be calibrated at a biweekly (every other week) interval following YSI instructions and other standard procedures for calibration (U.S. EPA, 2001) that are attached as Appendices E-4 and E-5. Every winter the YSI datasondes will be sent back to the factory for preventative maintenance and any defective sensors will be replaced.

This monitoring will help discover whether there are water quality problems with waters within or adjacent to the KAT and the KTWQP will report any findings of action levels of contaminants and work to abate any identified problems.

1.6.4 Ceratonova Shasta

The Karuk Tribe collects c.shasta water samples at five monitoring stations. These sites are termed Orleans (KOR), Seiad Valley (KSV), Kinsman Fish Trap (KMN), Beaver Creek (KBC), and I-5 Bridge (KI5) and their locations are shown in Figure 4. Water collection will occur at the following sites according to the following schedule:

(1) Weekly all year at Beaver Creek and Seiad Valley (to encompass previous and current spring parasite 'hot spots')

(2) Weekly from March through October at I-5 Bridge and Orleans

(3) March through mid-June at Kinsman Fish Trap

Water samples will be collected using an ISCO automatic sampler. The ISCO will be programmed to begin sampling at 8 am and collect 1 L of water from the river every 2 hours for 24 hours. After the completion of the program, the total sample will be mixed manually and 4 x 1 L samples will be poured into clean 1 L sample bottles. All samples will be transported back to the KTWQP office in a cooler with ice. KTWQP will filter the samples within 24 hours of collection according to protocols found in Appendix E-8.

Samples will be sent overnight to Bartholomew Lab at Oregon State University for molecular analysis.

1.7 Quality Objectives and Criteria for Measurement Data

This section discusses the quality objectives for the project and the performance criteria to achieve those objectives.

1.7.1 Project Objectives

The primary goal of this *QAPP* is to ensure that high quality data be generated by the KTWQP that this data can be used to answer questions about the quality of waters within KAT and to foster their protection or improvement over time. Specific questions to be answered through these studies include:

1) What are current in-river conditions?

2) What are current nutrient levels?
3) Are there nutrient levels indicative of pollution in the Klamath River, including reaches within the KAT?
4) What are the levels of MSAE and microcystin toxin in the Klamath River, including reaches within the KAT?
5) Are there other potentially toxic blue-green species present in the Klamath River and algal toxins other than the most common microcystin variant?
6) What is the Ceratonova Shasta parasite density during salmonid spring out-migration and fall inmigration?

KTWQP investigations occur within and above KAT. YTEP and Hoopa will provide data to answer the same questions for downstream reaches. In the longer term, these samples will show pollution variation between water years and provide a basis to judge effectiveness of short-term and long-term management and regulatory actions taken to abate pollution throughout the Klamath River Basin. This will also allow participation of Tribes as resource co-managers and as full partners in adaptive management. Within the KAT specifically, the data may be used as justification for improvement of standards needed to protect Tribal members, the public and other beneficial uses.

Evidence gathered will help regulating agencies make informed decisions off of the 401 certification of the KHP and Klamath TMDL and prompt further action on non-point source pollution from agriculture through mechanisms such as the Klamath River and Lost River TMDL implementation. In the short term, action will be taken immediately to inform appropriate agencies and the public when dangerous levels of blue-green algae cell counts or toxins are discovered.

The Tribe's primary concern with surface water is to minimize the effects of human activity in the watershed, to bolster the health of the ecosystem, to preserve cultural resources, and to return fish populations to a sustainable level enabling tribal members to utilize their fishing rights. Current numbers of returning salmonids will not support a fishery on KAT as it once did.

1.7.2 Decisions to be made using the data

The surface water monitoring program is designed to characterize the surface water resources of MidKlamath. The baseline data generated from 2005-present provides valuable information about the current condition of the Klamath River Basin's water resources. On-going monitoring allows the Tribe to begin to track changes in water quality over time and to assess current and potential future environmental impacts to Klamath River water quality.

Decisions to be made with the data include:

- If data for any analyte or field parameter (from an individual location or single quarterly sampling event) are found to exceed the project action limits, then the Tribal Council will be notified.
- If data are found to exceed the project action limits and appear to be increasing with time, then the Tribal Council will be notified and a plan for future investigations of potential sources will be discussed.
- If waters flowing onto KAT are impaired (i.e., exceed project action limits or the national water quality standards), then the issue will be brought to the attention of the Tribal Council for possible discussion with the US EPA Project Officer.

The Karuk Tribe will determine if any action is needed to reduce surface water pollution from tribal lands. Some examples of actions that could result from findings of poor water quality on KAT are:

- Remediation activities for point sources to stop contamination if a single point source is suspected.
- Stream and watershed restoration activities (e.g. planting native flora for erosion control).
- Pollution prevention planning and establishment of educational programs on KAT to reduce anthropogenic sources of pollution.

The Karuk Tribe will also use this information to act as co-managers in the Klamath River Watershed with federal, state, and local agencies. The information will be shared with these agencies in order to track changes over time and to ultimately improve the quality and quantity of fish populations in the watershed.

1.7.3 Action Limits/Levels

Specific water quality limits and levels are found in tables 5-8.

1.7.4 Measurement Performance Criteria/Acceptance Criteria

Data quality indicators (DQI) include accuracy, precision, comparability, completeness, representativeness, and sensitivity. The quality control criteria established by KTWQP for data gathering, sampling, and analysis activities assures that important data gaps regarding Klamath River nutrient and toxic algae pollution can be filled with scientifically accurate data.

The general approach to assessing each DQI is described below. Some DQIs will be assessed quantitatively, while others will be assessed qualitatively. For quantitative assessments, example calculations have been provided and the QC samples (to assess each DQI) have been identified.

The frequency of the QC samples and the measurement performance criteria for each QC sample for each type of analysis are provided in Table 12. For quantitative assessment of laboratory methodology, the laboratory's QA Manual and analytical SOPs have been reviewed by the Karuk Tribe's project team, and the associated laboratory QC (types & frequencies of QC samples and QC acceptance limits) have been determined to be adequate in meeting the data quality needs of the project. As such, the laboratory QC has been accepted as the project's measurement performance criteria for the analytical component, while project-specific criteria have been defined to assess the field sampling component.

For field measurements, the DQIs to be assessed quantitatively include precision and accuracy alone. The associated acceptance criteria (types & frequencies of QC checks and acceptance limits) for the project are summarized in Table 12 and 13.
Data quality will be assured by:

- Proper study design,
- Following standard methods,
- Using well calibrated equipment,
- Taking and maintaining good field records,
- Following chain of custody procedures for laboratory analysis,
- Prompt data entry in standard programs and formats, Data archiving with back-ups to insure against loss, and Proper oversight of QA/QC procedures.

The primary DQI specific to this project is whether uncertainty associated with each measurement is low enough to provide sufficient resolution to determine values relative to the above references.

Accuracy: *Accuracy* is the degree of agreement of a measurement with the true value. Accuracy includes a combination of random error (precision) and systematic error (bias) that result from sampling and analytical operations. Accuracy of water quality and quantity measurements contained in this QAPP is a function of the equipment used during sampling.

Accuracy/bias will be assessed as related to recovery, as well as in regards to potential contamination sources. Both of these terms will be evaluated quantitatively.

Accuracy/bias related to recovery is an assessment of the laboratory analytical methods alone. For Laboratory Control Samples (LCS), it will be expressed as % Recovery by the following equation:

$$\% \text{ Recovery} = \frac{X}{} \times 100$$

T

where,

X = Measured concentration

T = True spiked concentration

or, for Matrix Spike (MS) samples, by the following equation:

$$\% \text{ Recovery: } \frac{Xms - Xfs}{Xa} \times 100$$

where,

Xms = the amount of target analyte measured in the matrix spike sample

Xfs = the amount of target analyte measured in the corresponding field sample

Xa = the amount of target analyte spiked (into the matrix spike sample)

The frequency of the LCS and/or MS samples associated with the analytical parameters will be one for every 20 samples or 5%. No LCS or MS samples will be analyzed as part of the field measurements.

Accuracy/bias as related to contamination involves both a field sampling and laboratory component. To assess all steps of the project (from sample collection through analysis), field blanks will be collected and analyzed. Field blanks are planned to be collected at a frequency of 5% (or 1 blank/20 field samples) for off-site analysis of metals and anions. To assess potential laboratory contaminant sources alone, laboratory blanks will be prepared and analyzed at a one per batch or 5% frequency. No blanks will be analyzed as part of the field measurements.

Precision of field results will be tested using duplicate samples, taken as field splits, with a target of less than 20% relative percent difference (RPD).

Precision: *Precision* is a measure of agreement among replicate measurements of the same property, under prescribed similar conditions.

Precision will be assessed quantitatively with duplicate samples and expressed as relative percent difference (RPD) by the following equation:

$$RPD\ (\%) = \frac{|X_1 - X_2|}{} \times 100$$

$(X_1 + X_2)/2$

where,

RPD (%) = relative percent difference

X_1 = Original sample concentration

X_2 = Duplicate sample concentration

$|X_1 - X_2|$ = Absolute value of $X_1 - X_2$

To assess precision associated with all steps of the project (from sample collection through analysis) field duplicates will be collected and analyzed. Field duplicates will be collected at a frequency of 10% (1 duplicate/10 field samples) for each analytical parameter and 5% (1 duplicate each of 2 days/10 field samples) for each field measurement parameter. To assess laboratory precision alone, laboratory duplicates will be prepared and analyzed at a 5% frequency.

Comparability: Samples will be taken with comparable methods across the universe of samples on the Klamath River and its tributaries so the results will be comparable within each year. Methods are also consistent with previous samples that make up baseline and trend data for nutrients, phytoplankton, periphyton and algal toxins.

Completeness: Given the high quality of past samples taken by KTWQP, completeness on this project is expected to be over 90%, which is highly desirable because samples will only be taken bi-weekly.

Representativeness: This is the expression of the degree to which data accurately and precisely represent a characteristic of an environmental condition or a population. Field crews collecting samples will ensure representativeness of samples by selecting free-flowing water from established sampling locations and using a churn splitter to mix sample water once collected (Lurry and Kolbe, 2000) and by following protocols for public health sampling and c. Shasta sampling.

See Table 10 for comparability measures and detection limits for nutrient samples, including U.S. EPA or American Public Health Association (APHA) (Eaton et al., 1995) approved sampling methods.

Sensitivity: The ability of a method to detect and quantify an analytical parameter of concern at the concentration level of interest will be assessed semi-quantitatively. No actual QC samples are involved. Instead, the laboratory to perform the analyses has provided their QLs and DLs and demonstrated that these are lower than the project action limits (as shown in Tables 5, 6, 7 and 8) for the majority of the analytical parameters. For field measurements, the sensitivity is defined by the instrument manufacturer (Table 9).

1.8 Special Training Requirements/Certificates

No special training of field personnel is required for this project. The WQPM is an experienced scientist who has been leading and training employees in conducting water quality investigations since 2004. She has been trained by and/or worked with the US Forest Service, the Pacific Southwest Field Station, US Geological Survey, the North Coast Regional Water Quality Control Board, the Klamath Basin Monitoring Program, the Klamath Blue Green Algae Work Group, and the California Harmful Algae Bloom to standardize water quality monitoring protocols. Equipment used includes HOBO temp loggers, flow meters, and hydolabs / data sondes and sampling includes nutrient and phytoplankton grabs, public health monitoring for harmful algae blooms, and periphyton surveys. The KTWQP Project Manager will oversee initial sampling events to ensure that field staff is following the guidelines of this QAPP.

The WQ Technician will keep clear records about how instructions from the Program Manager were followed and make notes about any conditions that might cause anomalies in data. The KTWQP QA Officer will inspect the field and sampling equipment and periodically audit the WQ Technician to make sure that proper maintenance is taking place and is being documented.

The collection of all surface water samples using hand held equipment will use standard field methods as described in this QAPP, which are derived from recognized U.S. EPA (1983; 2004) and U.S. Geologic Survey (USGS, 1998) protocols.

1.9 Documents and Records

This section describes the process and responsibilities for ensuring the appropriate project personnel have the most current approved version of the QA Project Plan, including version control, updates, distribution, and disposition.

1.9.1 QA Project Plan Distribution

It is the responsibility of the KTWQP Program Manager/QA Officer to prepare and maintain amended versions of the QA Project Plan and to distribute the amended QA Project Plan to the individuals listed in Section 1.3. This QAPP, once approved, will be kept in printed form for ease of reference of the WQ Technician, QA Officer and KTWQP Program Manager. When updated plans are approved, one copy of an older version will be retained in the KTWQP library, but clearly stamped to indicate that it is no longer current. In addition, each page of the QAPP will be clearly labeled as to the version and date of revision.

1.9.2 Field Documentation and Records

In the field, records will be documented in several ways, including field logbooks, photographs, preprinted forms (such as labels and chain-of-custody forms), corrective action reports, and field audit checklists and reports. Field activities must be conducted according to this QAPP. All documentation generated by the sampling program will be kept on file in the office of the Karuk Tribe Water Quality Program.

1.9.2.1 Field Notebooks

Bound field logbooks will be used to record field observations, sampling site conditions, and on-site field measurements. These books will be kept in a permanent file in the KTWQP office. At a minimum, information to be recorded in the field logbooks at each sample collection/measurement location includes:

- Sample location and description,
- Sampler's names,
- Date and time of sample collection,
- Designation of sample as composite or grab,
- Type (media or matrix) of sample (for this project, all are surface water samples),
- Type of sampling equipment used,
- Type of field measurement instruments used, along with equipment model and serial number,
- Field measurement instrument readings,
- Field observations and details related to analysis or integrity of samples (e.g., weather conditions, noticeable odors, color),
- Preliminary sample descriptions (e.g., clear water with strong ammonia-like odor),
- Sample preservation,
- Lot numbers of the sample containers, sample identification numbers and any explanatory codes,
- Shipping arrangements (overnight air bill number), and Name(s) of recipient laboratory(ies).

In addition to the sampling information, the following specific information will also be recorded in the field logbook for each day of sampling:

- Team members and their responsibilities,
- Time of arrival/entry on site and time of site departure,

- Other personnel on site,
- Deviations from the QAPP or SOPs required in the field, and
- Summary of any meetings or discussions with tribal, contractor, or federal agency personnel.

Separate instrument/equipment notebooks or logbooks will be maintained for each piece of equipment or instrument. These logbooks will be used to record field instrument calibration and maintenance information. Each logbook will include the name, manufacturer, and serial number of the instrument/equipment, as well as dates and details of all maintenance and calibration activities.

1.9.2.2 Photographs

Digital photographs will be taken at each sampling location and at other areas of interest near the sampling area for every sampling event. The photographs will serve to verify information entered into the field logbook. Photographs will include a date and time stamp on each picture. Digital photographs will be archived in a permanent digital file to be kept in the KTWQP office.

For each photograph taken, the following information will be written in the field logbook or recorded in a separate field photography logbook:

- Time, date, location, and weather conditions
- Description of the subject photographed
- Direction in which the picture was taken
- Name and affiliation of the photographer

1.9.2.3 Labels

All samples collected will be labeled in a clear and precise way for proper identification in the field and for tracking in the laboratory. The Laboratory will provide sample labels (see Appendix A1) for this project. The samples will have pre-assigned, identifiable, and unique numbers. At a minimum, the sample labels will contain the following information:

- Sampling location or name,
- Unique sample number,
- Sample description (e.g., grab, composite),
- Date and time of collection,

- Initials/signature of sampler,
- Analytical parameter(s), and Method of preservation.

Each sample for a given parameter will have a unique identifier. The sample identification numbering scheme is site, date, and method of collection (e.g. open water composite or surface grab).

Example sample label *SA032211-OC*

SA = site identification

032211 = date

OC = Open Channel

1.9.2.4 Field Quality Control Sample Records

Field QC samples (duplicates and blanks) will be labeled as such in the field logbooks. They will be given unique (fictitious) sample identification numbers and will be submitted "blind" to the laboratory (i.e., only the field logbook entry will document their identification and the laboratory will not know these are QC samples). The frequency of QC sample collection will also be recorded in the field logbook.

1.9.2.5 Chain-of-Custody Forms and Custody Seals

Chain-of-custody forms and custody seals (see Appendix A-2) will be provided by the laboratory. The forms will be used to document collection and shipment of samples for off-site laboratory analysis, while the seals will serve to ensure the integrity of (i.e., there has been no tampering with) the individual samples.

All sample shipments will be accompanied by a chain-of-custody form. The forms will be completed and sent with each shipment of samples to the laboratory. If multiple coolers are sent to a laboratory on a single day, forms will be completed and sent with the samples for each cooler. The original form will be included with the samples and sent to the laboratory. Copies will be sent to the KTWQP Program Manager/QA Officer.

The chain-of-custody form will identify the contents of each shipment and maintain the custodial integrity of the samples. Generally, a sample is considered to be in someone's custody if it is either in someone's physical possession, in someone's view, locked up, or kept in a secured area that is restricted to authorized personnel. Until the samples are shipped, the custody of the samples will be the responsibility of the field

personnel, who will sign the chain-of-custody form in the "relinquished by" box and note the date, time, and air bill number.

The shipping containers in which samples are stored will also be sealed with self-adhesive custody seals any time they are not in someone's possession or view before shipping, as well as during shipping. All custody seals will be signed and dated.

1.9.3 Laboratory Documentation and Records

The analytical laboratory will keep a sample receiving log and all completed chain-of-custody forms submitted with the samples collected for this project. The analytical laboratory will also keep records of all analyses performed, as well as associated QC information, including: laboratory blanks, matrix spikes, laboratory control samples, and laboratory duplicates. Hard copy data of the analytical results will be maintained for six years by the laboratory.

The data generated by the laboratory for each sampling event will be compiled into individual data packages/reports. The data packages will include the following information:

- Project narrative including a discussion of problems or unusual events (including but not limited to the topics such as: receipt of samples in incorrect, broken, or leaking containers, with improperly or incompletely filled out chain-of-custody forms, with broken chain-of-custody seals, etc.; receipt and/or analysis of samples after the holding times have expired; summary of QC results exceeding acceptance criteria; etc.),

- Sample results and associated QLs,

- Copies of completed sample receiving logs and chain-of-custody forms, and

- QC check sample records and acceptance criteria (to be included for all QC samples listed in Table 12, including the temperature blank check).

All data packages will be reviewed by the Laboratory QA Officer to ensure the accurate documentation of any deviations from sample preparation, analysis, and/or QA/QC procedures; highlights of any excursions from the QC acceptance limits; and pertinent sample data. Once finalized, the Laboratory QA Officer will

provide the data packages/reports to the Laboratory Project Manager who will sign them and submit them to the KTWQP Program Manager/QA Officer. Laboratories will provide the following QC data for each parameter analyzed; laboratory duplicate results and associated RPD, spike results and associated % recovery, blank results, and QC check information. Any problems identified by the Laboratory QA Officer will be documented in the narrative part of the tribe's report.

Information about the documentation to be provided by the analytical laboratory is also contained in each laboratory's QA Manual (Appendix A-3).

1.9.4 Technical Reviews and Evaluations

As part of the QA efforts for the project, on-going technical reviews will be conducted and documented. These reviews are associated with both field activities and the data generated by the off-site laboratory.

1.9.4.1 Field Audit Reports

The KTWQP Program Manager/QA Officer will observe selected sampling events to ensure that sample collection and field measurements are going according to plan. The results of the observations will be documented in a designated QA Audit Logbook. Once back in the office, the KTWQP QA Officer will formalize the audit in a Field Audit Report to be forwarded to the KTWQP Program Manager and the KTWQP Water Quality Technician/Field Sampler.

1.9.4.2 Corrective Action Reports (following Field Audits)

Corrective action reports will be prepared by the KTWQP Water Quality Technician/Field Sampler in response to findings identified by the KTWQP Program Manager/QA Officer during field visits and audits. The reports will focus on plans to resolve any identified deficiencies and non-compliance issues that relate to on-going activities and problems of a systematic nature, rather than on one-time mistakes. Corrective Action reports do not have a specific format, but will be handled as an internal memorandum.

1.9.4.3 Field Activities Review Checklist

At the end of each sampling event, a technical review will be conducted of field sampling and field measurement documentation to ensure that all information is complete and any deviations from planned methodologies are documented. This review is described in Section 3.1.1.3. The review, as well

as comments associated with potential impacts on field samples and field measurement integrity, will be documented on a Field Activities Review Checklist (as provided in Appendix B-1).

1.9.4.4 Laboratory Review Checklist

Following receipt of the off-site laboratory's data package for each sampling event, The KTWQP QA Officer/Data Manager will conduct a technical review of the data to ensure all information is complete, as well as to determine if all planned methodologies were followed and QA/QC objectives were met. The results of this review, as well as comments associated with potential impacts on data integrity to support project decisions, will be documented on a Laboratory Data Review Checklist (as provided in Appendix B-2).

1.9.5 Project Document Backup and Retention

Hardcopies of field notebooks, checklists, laboratory results and other paperwork will be maintained in the KTWQP office water quality file for six years. After six years, project files will be placed in long term storage. The Tribe's policy is to maintain records indefinitely.

Electronic data will be backed up on two separate external hard-drives. One external hard-drive will be stored in the Karuk Tribe Department of Natural Resources office and the second external hard-drive will be stored in a fireproof safe in the KTWQ office.

1.9.6 Annual Reports

The KTWQP Program Manager/QA Officer is responsible for the preparation of annual reports (summarizing the year's activities) to be submitted to the US EPA Grants Project Officer.

The annual reports should include, at a minimum:

- Description of the project,
- Table summarizing the results (of all project data collected to date, including both laboratory data and field measurements),
- Final laboratory data package (including QC sample results),
- Discussion of the field and laboratory activities, as well as any deviations or modifications to the plans,
- Trends observed as a result of the year's monitoring efforts,
- Copies of Field Audit Reports and any associated Corrective Action Reports,
- Copies of Field Activities Review Checklists and Data Review Checklists,

- Evaluation of the data in meeting the project objectives, including data exceeding Action Levels,
- Recommendations to the Tribal Council regarding exceedance which are occurring on an ongoing basis, and
- Recommendations/changes for future project activities (e.g., adding/deleting sampling locations and/or analyses, modifications to SOPs, amendments to the QA Project Plans, etc.).

2.0 DATA GENERATION AND ACQUISITION

This section of the QA Project Plan describes how the samples will be collected, shipped, and analyzed.

2.1 Sampling Design

2.1.1 Nutrient Sampling Design

A total of eight locations will be sampled for the surface water monitoring program. These locations will be along the Klamath River and at the mouths of major tributaries. Sample sites are in locations that provide a longitudinal profile of the Klamath River from Iron Gate Reservoir to Orleans. Also included are inputs from the Shasta, Scott and Salmon Rivers. Sampling locations are depicted in Figure 3. The sample parameters to be collected at each site are summarized in Table 4. The sample locations, names, and rationale for selecting each site are summarized in greater detail as follows:

- OR (Klamath River at Orleans) – Located just upstream of the USGS gauge. Conditions are indicative of the Klamath River at the downriver end of the KAT.
- SA (Salmon River near mouth) – Conditions of the Salmon River, an important tributary that enters the Klamath River near the center of the world for the Karuk Tribe. Site of a USGS gauge. Major tributary that provides habitat for all Tribal Trust fish species.
- HC (Klamath River below Happy Camp) – About a ¼ mile upstream of Oak Flat Creek.
- SV (Klamath River below Seiad Valley) – This site is just downstream of Seiad Valley but upstream of the USGS gauge. This is near the upstream end of the KAT thereby indicative of water quality conditions entering the KAT.
- SC (Scott River at Johnson's Bar) – This site is about one mile up from the confluence of the Scott and Klamath Rivers. It represents water quality conditions coming out of the lower canyon reach of the Scott River.
- WA (Klamath River at Walker Bridge) – This site is located between two major tributaries, the Scott and Shasta Rivers and is downriver of the town of Klamath River. This site

provides water quality information after the effects of the KHP have been reduced but before entering the KAT where more minor tributaries enter the River.

- SH (Shasta River at USGS Gauge) – This site is located at the USGS gauge and is upstream of the confluence about 300 meters.
- IG formerly KRBI (Klamath River below Iron Gate) – This site is located immediately downstream of Iron Gate dam and upstream of the USGS gauge. It is the start of the free-flowing River below the KHP.

The baseline monitoring program will include monthly to bimonthly analyses throughout the year at 8 locations identified shown in Figure 3. Analyses will include alkalinity, total phosphorus (TP), orthophosphate (SRP), ammonia, nitrate and nitrite, total nitrogen (TN), chlorophyll a, pheophytin, total organic carbon (TOC), dissolved organic carbon (DOC), total dissolved solids (TDS), and volatile suspended solids (VSS). Sample locations will also be field tested for temperature, pH, dissolved oxygen, conductivity (as specific conductance), turbidity in the winter, and BGA in the summer. Additionally, photo documentation will occur at each sampling location during every sampling event.
Site specific analyses are found in Table 4.

Samples will be collected throughout each calendar year. In addition, a parameter may be removed from the monitoring program if the sampling results indicate it is not of concern or added if new land uses develop after the monitoring program begins or the monitoring data indicates other potential parameters to include. If the sample collection changes, this will be noted in the quarterly reports to the US EPA Grants Project Manager and documented in an amendment to the QA Project Plan.

2.1.2 Public Health Sampling Design

A total of five sites will be sampled for microcystin and one site will be sampled for anatoxin-a. Table 3 lists the KTWQP sampling sites for public health and Figure 3 identifies the specific locations. The site specific analyses are listed in Table 4. To best monitor public health risks, water samples are collected at locations used for public access and recreation. The sample locations, names, and rationale for selecting each site are summarized in greater detail as follows:

- OR (Klamath River at Orleans) – Located just upstream of the USGS gauge. Conditions are indicative of the Klamath River at the downriver end of the KAT.
- HC (Klamath River below Happy Camp) – About a ¼ mile upstream of Oak Flat Creek.
- SV (Klamath River below Seiad Valley) – This site is just downstream of Seiad Valley but upstream of the USGS gauge. This is near the upstream end of the KAT thereby indicative of water quality conditions entering the KAT.
- BB (Brown Bear River Access) – Labeled USFS river access sign in the town of Klamath River.

- IB-This site is located at the Colliers rest stop by the I-5 bridge.

Public health sampling occurs biweekly (every other week) starting in June. Once high levels of microcystin are detected, sampling increases to a weekly interval. MSAE blooms and those of other toxic algae species occur in late summer and early fall, when fishing for subsistence and ceremonial use is at its peak. Public health sampling is continued through October, or until microcystin is no longer detected.

2.1.3 Continuous Monitoring Sampling Design

The KTWQP will conduct year round continuous monitoring at three maintstem Klamath River sites (OR, SV, IG) and Salmon River (SA) and six sites during the spring, summer and fall months (OR, SA, SV, SC, SH, and IG). Monitoring locations are summarized in Figure 3. The sample locations, names, and rationale for selecting each site are summarized in greater detail as follows:

- OR (Klamath River at Orleans) – Located at the USGS gauge. Conditions are indicative of the Klamath River at the downriver end of the KAT.
- SA (Salmon River near mouth) – This site is located at a USGS gauge. Conditions of the Salmon River, an important tributary that enters the Klamath River near the center of the world for the Karuk Tribe. Major tributary that provides habitat for all Tribal Trust fish species.
- SV (Klamath River below Seiad Valley) – This site is located at the USGS gauge and is downstream of Seiad Valley. This is near the upstream end of the KAT and is thereby indicative of water quality conditions entering the KAT.
- SC (Scott River at Roxbury Bridge) – This site is about 1/2 mile up from the confluence of the Scott and Klamath Rivers. It represents water quality conditions coming out of the lower canyon reach of the Scott River.
- SH (Shasta River at USGS Gauge) – This site is located at the USGS gauge and is upstream of the confluence about 300 meters.
- IG (Klamath River below Iron Gate) – This site is located at the USGS gauge and is immediately downstream of Iron Gate. It is the start of the free-flowing River below the KHP.

For the continuous monitoring project, a reading will be taken every 30 minutes by a YSI datasonde. Each reading will include the parameters: temperature, conductivity (as specific conductance), pH, dissolved oxygen (% saturation and mg/L), turbidity (at all sites except SH), and BGA (at OR, SV, IG).

2.1.4 Ceratonova Shasta Sampling Design

The KTWQP will conduct C.Shasta monitoring at five sites along the Klamath River. The sites are determined by Bartholomew Laboratory at Oregon State University. These sites are Orleans (KOR), Seiad Valley (KSV), Kinsman Fish Trap (KMN), Beaver Creek (KBC), and I-5 Bridge (KI5) and their locations are shown in Figure 4. Water collection will occur at the following sites according to the following schedule:

(1) Weekly all year at Beaver Creek and Seiad Valley (to encompass previous and current spring parasite 'hot spots')

(2) Weekly from March through October at I-5 Bridge and Orleans

(3) Weekly from March through mid-June at Kinsman Fish Trap

Water samples will be collected using an ISCO automatic sampler. The ISCO will be programmed to begin sampling at 8 am and collect 1 L of water from the river every 2 hours for 24 hours. After the completion of the program, the total sample will be mixed manually and 4 x 1 L samples will be poured into clean 1 L sample bottles. All samples will be transported back to the KTWQP office in a cooler with ice. KTWQP will filter the samples within 24 hours of collection according to protocols found in Appendix E-8. Additionally, temperature loggers (Hobos) attached to each ISCO will record river temperature every 15 minutes.

2.2 Sampling Methods

2.2.1 Nutrient Sampling Methods

KTWQP follows standard water quality grab sample procedures for nutrients sampling using a churn to mix samples and following an appropriate regimen of blanks, duplicates and other steps to assure quality.

Equipment/Materials Field equipment for nutrient samples include a churn splitter, van dorn sampler, bottles provided by laboratories, and a YSI datasonde.
The following are the items on the KTWQP nutrient sampling check list that staff refer to before going into the field to collect nutrient or phytoplankton data:

1. Portable Water Quality instrument = YSI datasonde,
2. Ice (in bottles or packs),
3. Sample Bottles,
4. Camera,
5. Extra labels for sample bottles,
6. Coolers,
7. Churn splitter,
8. Van Dorn sampler,
9. Clip board,
    a. Data sheet
    b. Pencils
    c. Permanent markers
    d. Field notebook
    e. Chain of Custody forms
    f. Protocol Instructions
    g. Shipping forms
10. Watch,
11. Waders and boots,
12. Distilled Water- 5+ gallons, and
13. Shipping boxes, packing material, packing tape.

Decontamination For all samples collected to be sent to Aquatic Research Inc., samples will be collected directly into sample bottles/containers provided from the laboratory. As such, no field decontamination of these bottles (used as the sampling equipment) is necessary. The bottles will be provided and certified clean by the laboratory according to procedures described in the laboratory's QA Manual provided in Appendix A-3.

For all samples collected to be sent to Aquatic Analysts, samples will be collected directly into sample bottles provided from the laboratory. Sample bottles contain a chemical preservative (Lugols Iodine) and are considered sterile prior to field usage.

For all samples collected to be sent to Chesapeake Biological Laboratory, samples will be collected directly into sample bottles which have previously been cleaned in the KTWQP office. As such, no field decontamination of these bottles is necessary. The bottles will be cleaned using the following procedure:

- Non-phosphate detergent and tap water wash (using a brush, if necessary),
- Tap-water rinse,
- 10 % HCl rinse (twice), and
- Deionized/distilled water rinse (three times).

Decontamination of the field equipment, churn splitter and van dorn sampler, will be completed in the KTWQP office prior to the sample event. They will be cleaned according to US EPA Region 9 recommended procedures using the following washing fluids in sequence:

- Non-phosphate detergent and tap water wash (using a brush, if necessary),
- Tap-water rinse, and
- Deionized/distilled water rinse (twice).

The churn splitter requires cleaning with distilled water in the field after use at each sampling location (see Churn Cleaning SOP, Appendix E-3).

In the case that there is a need to collect surface water samples by an alternative method, decontamination of reusable sampling equipment coming in direct contact with the samples will be necessary. Decontamination will occur prior to each use of a piece of equipment and after use at each sampling location. Disposable equipment (intended for one-time use) will not be decontaminated but will be packaged for appropriate disposal. All reusable/non-disposable sampling devices will be decontaminated according to US EPA Region 9 recommended procedures using the following washing fluids in sequence:

- Non-phosphate detergent and tap water wash (using a brush, if necessary),
- Tap-water rinse, and
- Deionized/distilled water rinse (twice).

Equipment will be decontaminated in a predesignated area on plastic sheeting. Cleaned small equipment will be stored in plastic bags. Materials to be stored more than a few hours will also be covered.

Procedures

1. Upon arriving at a sampling location, a field measurement will be taken using a YSI datasonde and recorded on the data sheet. The parameters recorded will be temperature, conductivity, pH, dissolved oxygen, and turbidity or BGA.

2. Photos will be taken looking upriver and downriver of the sampling location.

3. Water samples will be collected with a churn splitter to ensure that the sample is homogeneously mixed before the sample bottles are filled. Depending on location, two collection methods may be used. For all sites except for WA, the churn is fully submerged into the stream and filled to the lid with flowing water, not stagnant water. For WA, a site sampled from a bridge, a Van Dorn sampler is used to collect 3 samples from across the channel. The samples are poured into the churn and treated the same as all other sites. Prior to filling the churn for nutrient sampling, the churn will be rinsed three times with distilled water. The goal of rinsing is to remove substances adhering to equipment from previous exposure to environmental and other media (Lurry and Kolb, 2000). After rinsing with distilled water, the churn is rinsed three times with stream water. Samples are collected from uniformly mixed water by wading out into the water channel from the bank and the churn is fully submerged into the stream and filled to the lid with sample water. Completely filling the churn allows for all sample bottles to be filled from one churn; thereby minimizing differences in water properties and quality between samples.

   Proper use of the churn guarantees that the water is well mixed before the sample is collected. The churn should be stirred at a uniform rate by raising and lowering the splitter at approximately 9 inches per second while bottles are being filled (Bel-Art Products, 1993). If filling is stopped for some reason, the stiffing rate must be resumed before the next sample is drawn from the churn. As the volume of water in the churn decreases, the round trip frequency increases as the velocity of the churn splitter remains the same. Care must be taken to avoid breaking the surface of the water as the splitter rises toward the top of the water in the churn.

   Sample bottles without chemical preservatives will be rinsed with stream water from the churn three times before filling with sample water. In the case of bottles that contain chemical preservatives, bottles are not rinsed before sample collection and care is taken to avoid overspillage that would result in chemical preservative loss.

4. Clearly label each sample container so that each sample is uniquely identified and includes the following information: the water body name, station location, date and time collected, sampler's name, type of sample (e.g. open churn), sample depth, and type of analysis.

5. Collected samples are placed in coolers on ice for transport to contracted laboratories for analysis or to KTWQ office for filtering.

Field Variances As conditions in the field vary; it may become necessary to implement minor modifications to the sampling procedures and protocols described in this QA Project Plan. If/when this is necessary; the KTWQP Technician will notify the KTWQP Project Manager/QA Officer of the situation to obtain a verbal approval prior to implementing any changes. The approval will be recorded in the field logbook. Modifications will be documented in the Annual Report to the US EPA Grants Project Officer.

2.2.2 Public Health Sampling Methods

For public health sampling, KTWQP follows the Cyanobacteria Sampling SOP prepared by the Blue Green Algae Working Group (Appendix E-2).

Equipment/Materials The following are the items on the KTWQP public health sampling check list that staff refer to before going into the field to collect algal toxin data:

1. Portable Water Quality instrument = YSI datasonde,
2. Ice (in bottles or packs),
3. Sample Bottles,
4. Camera,
5. Extra labels for sample bottles,
6. Coolers,
7. Wide-mouth sampling jar (about 8 cm diameter and 10 cm depth),
8. Clip board,
    a. Data sheet
    b. Pencils
    c. Permanent markers
    d. Field notebook
    e. Chain of Custody forms
    f. Protocol Instructions
    g. Shipping forms
9. Watch,
10. Waders and boots,
11. Distilled Water- 1 gallon, and
12. Shipping boxes, packing material, packing tape.

Decontamination For all samples collected for public health sampling, sample bottles will be 4 oz. precleaned thick-walled glass jars and are considered sterile prior to field usage. As such, no field decontamination of these bottles is necessary.

Decontamination of the wide-mouth sampling jar will be completed in the KTWQP office prior to the sample event. It will be cleaned according to recommended procedures using the following washing fluids in sequence:

- Non-phosphate detergent and tap water wash (using a brush, if necessary),
- Tap-water rinse, and
- Deionized/distilled water rinse (twice).

The wide-mouth sampling jar requires cleaning with distilled water in the field after use at each sampling location.

Procedures

1. Upon arriving at a sampling location, an initial visual survey of the public access area is conducted. The exact collection location is then identified to best represent the maximum toxic algae exposure.

2. A field measurement will be taken using a YSI datasonde and recorded on the data sheet. The parameters recorded will be temperature, conductivity, pH, dissolved oxygen, and turbidity or BGA.

3. Photos will be taken looking upriver and downriver of the sampling location.

4. Open clean wide-mouth sampling jar. Tip opening of jar towards the water (at approximately a 45 angle) and slowly break water surface and begin to dip jar into the water. Turn the sampling container so that bottom side of jar is 8 cm below and horizontal to the surface. In other words, the jar will fully enter the water, but the top rim and side will not go below the surface. If in flowing water, when turning the bottle upright, turn it so that the opening faces upstream. The sampling bottle should not be moved along the surface to fill. Because of the wide mouth and shallow depth, it will be immediately filled.

5. Tilt the full jar upright as it is slowly removed.

6. Carefully raise the full jar from the water.

7. Cap the container, tightening securely. Invert the jar gently three times, uncap the jar and pour to aliquot a portion into the first sample bottle, re-cap the jar and again gently invert the jar three times. Now uncap the jar and pour to aliquot a portion into the second sample bottle. The second sample bottle may be a replicate for the same lab, a different lab, or a non-replicate for different analyses at the same or a different lab. Any additional sub-dividing of the sample in the jar must be done by recapping and gently reinverting the collection jar three times.

8. Clearly label the sample container, so that each sample is uniquely identified and includes the following information: the water body name, station location, date and time collected, sampler's name, type of sample (e.g. public health shoreline grab), sample depth (for example, 0 to 10 cm), and type of analysis (for example, cyanotoxin by ELISA).

9. Promptly place the labeled sample container in a cooler with ice to both protect from sunlight, and chill, until shipped. Double-bagged wet ice or blue ice is acceptable as long as the maximum threshold temperature (6°C) for samples is not exceeded. Block ice is discouraged to protect sample bottles from breaking during shipping.

10. Replenish ice supply as often as needed to maintain samples at or below 6°C, and prior to preparing coolers for shipping to the appropriate laboratories.

Field Variances As conditions in the field vary; it may become necessary to implement minor modifications to the sampling procedures and protocols described in this QA Project Plan. If/when this is necessary; the KTWQP Technician will notify the KTWQP Project Manager/QA Officer of the situation to obtain a verbal approval prior to implementing any changes. The approval will be recorded in the field logbook. Modifications will be documented in the Annual Report to the US EPA Grants Project Officer.

2.2.3 Continous Monitoring Methods

The continuous monitoring will be done using a YSI datasonde. The sondes will be fixed to a cable and protected by a metal pipe which will suspend the probes to avoid damage to equipment. The stations at Orleans, Salmon River, Scott River, and Shasta River will deploy a YSI 6600 V2 datasonde. The stations at Seiad Valley and Iron Gate will deploy a YSI EXO2 datasonde.

Each field datasonde will be calibrated every two weeks according to the procedures in Appendix E-4 and Appendix E-5. The calibration standards will be supplied by Aurical Company and Fondriest Environmental for turbidity standards.

Equipment/Materials The following are the items on the KTWQP datasonde calibration check list that staff refers to before going into the field to calibrate:

1. 1L 1,000 uS/cm Conductivity Standard,
2. 1L pH 7 Standard,
3. 1L pH 10 Standard,
4. 1L 12.4 FNU Turbidity Standard (April – October),
5. 1L 124 FNU Turbidity Standard,
6. 1L 1000 FNU Turbidity Standard (Nov – March),
7. Clipboard,
    a. Data sheet
    b. Pencils
8. Towel for DO calibration,
9. Reference Sonde,
10. Handheld,
11. 1 Gallon Distilled Water,
12. Sonde Tool Kit, 13. 5 Gallon Bucket, and
14. Crate.

Procedures The procedures for calibrating are in the SOPs in Appendix E-4 for the YSI 6600 V2 datasondes and Appendix E-5 for YSI EXO2 datasondes.

Field Variances As conditions in the field vary; it may become necessary to implement minor modifications to the sampling procedures and protocols described in this QA Project Plan. If/when this is necessary; the KTWQP Technician will notify the KTWQP Project Manager/QA Officer of the situation to obtain a verbal approval prior to implementing any changes. The approval will be recorded in the field logbook. Modifications will be documented in the Annual Report to the US EPA Grants Project Officer.

2.2.4 Ceratonova Shasta Sampling Methods

For C. Shasta sampling, KTWQP follows the C. Shasta SOP (Appendix E-8). All samples are collected using an ISCO automatic sampler.

Equipment/Materials The following are the items on the KTWQP C. Shasta sampling check list that staff refer to before going into the field to collect C. Shasta water samples:

1. 4 clean 1L bottles per site, and
2. Clipboard.

a. Data sheet
b. Pencils

Decontamination Decontamination of the 1L sample bottles will be completed in the KTWQP office prior to the sample event. They will be cleaned according to recommended procedures by rinsing three times with tap water and using a brush if necessary.

Decontamination of the ISCO collection bottle will be completed in the field by rinsing three times with tap water.

Procedures

1. Upon arriving at a sampling location, remove the top of the ISCO and verify that the screen reads Sample Complete. If so, continue to step 2. If not, scroll through the menu to determine why the previous sampling event did not occur correctly. Record on datasheet.

2. Reprogram the ISCO to start the next program at 8 am for the following week.

3. Secure the top of the ISCO taking care not to press any more buttons.

4. Open the middle part of the ISCO to reveal the large collection bottle.

5. Remove the lids of the 4 clean 1L sample bottles.

6. Manually mix the water in the large collection bottle and carefully pour into the 4 1L sample bottles, mixing between each pour. Tighten the lids on each of the 4 1L sample bottles.

7. Dump out the remaining water from the large collection bottle.

8. Rinse the large collection bottle three times with tap water.
9. Return the large collection bottle to the ISCO and secure the sampler by restacking the ISCO and hooking all three latches.

In the event that the previous sampling event did not occur correctly, a surface grab must be taken. This is recorded on the datasheet. The following steps are for collecting a surface grab:

1. Remove the lid of the clean 1L sample bottle.

2. Fill from the surface of the water by tilting the bottle.

3. Tighten the lid on the 1L sample bottle and repeat the process for the remaining 3 clean 1L sample bottles. All four samples should be taken from the same location.

Field Variances As conditions in the field vary; it may become necessary to implement minor modifications to the sampling procedures and protocols described in this QA Project Plan. If/when this is necessary; the KTWQP Technician will notify the KTWQP Project Manager/QA Officer of the situation to obtain a verbal approval prior to implementing any changes. Modifications will be documented and approved by the Bartholomew Laboratory at Oregon State University.

2.3 Field Health and Safety Procedures

A brief tail-gate safety meeting will be held the first day of each sampling event to discuss emergency procedures (e.g., location of the nearest hospital or medical treatment facility), local contact information (e.g., names and telephone numbers of local personnel, fire department, police department), as well as to review the tribe's contingency plan.

When wading, care will be taken to avoid slipping on rocks and algae. Also, due to weather conditions during the sampling events and the possibility of health concerns (e.g., heat stress) from working in high temperatures, field personnel will be advised to drink plenty of water and wear clothing (e.g., hat, longsleeved shirt) that will cover and shade the body.

Potential routes of exposure related to field sampling and measurement activities are through the skin (e.g., from direct contact from the surface water) and/or by ingestion (e.g., from not washing up prior to eating).

2.4 Disposal of Residual Materials

This section does not apply to any type of sampling conducted under this QAPP.

2.5 Quality Assurance for Sampling

Detailed instructions for collection of all field QC samples are discussed in Section 2.8 and listed in Table 12.

Additional deviations from the QA Project Plan may be implemented as field variances or modifications. These deviations will be communicated to the KTWQP Program Manager/QA Officer by the KTWQP Technician/Field Sampler for approval. Documentation any deviations is the responsibility of the KTWQP

QA Officer. Deviations noted during the field audit will be documented in the QA Audit Logbook, recorded in the Field Audit Reports, and discussed in the annual reports.

2.6 Sample Handling and Custody

This section describes the sample handling and custody procedures from sample collection through transport and laboratory analysis. It also includes procedures for the ultimate disposal of the samples. All samples will be fully documented and complete notes will accompany every sampling event, including photo monitoring.

2.6.1 Field Notes and Logbooks

Sampling from each day of data collection will be recorded in the field notebook, which includes:

1. Survey crew identification,
2. Date and time,
3. Station ID,
4. Sample ID,
5. Ambient water quality measurements (temperature, pH, D.O., conductivity)
6. Number of bottles collected of each sample type (nutrients, phytoplankton, and toxins),
7. Sample collection device,
8. Details of undocumented sample locations, and
9. Note fields for recording site conditions.

All ambient water quality information is recorded with a YSI datasonde that is calibrated prior to going in the field. Since this is the only source of field-recorded water quality data, YSI instrument calibration is not noted on sampling data sheets.

2.6.2 Photographs

Photographs will be taken at each sampling location during each sampling event. They will serve to verify information entered in the field logbook. For each photograph taken, the following information will be written in the logbook:

- Time, date, location, and weather conditions, • Description of the subject photographed, and

- Name of person taking the photograph.

2.6.3 Labeling

All samples collected will be labeled in a clear and precise way for proper identification in the field and for tracking in the laboratory. At a minimum, the sample labels will contain the following information: station location, date of collection, analytical parameter(s), and method of preservation. Every sample, including samples collected from a single location but going to separate laboratories, will be assigned a unique sample number

2.6.4 Chain of Custody

All sample shipments for analyses will be accompanied by a KTWQP Nutrient, Phytoplankton, or Algal Toxin Chain of Custody Form (Appendix A2). These forms will be completed and sent with each sample for each laboratory and each shipment (i.e., each day). If multiple coolers are sent to a single laboratory on a single day, duplicate forms will be completed and sent in each cooler.

Until the samples are shipped, the custody of the samples will be the responsibility of KTWQP staff assigned to collection and shipment of samples and the Project Manager. The chain of custody form includes date and time of transfer to carrier and carrier shipping number. Each laboratory listed above will be responsible for chain of custody once they have received the cooler from the shipping company.

2.6.5 Sample Packaging and Shipment

Sturdy coolers suitable for secure sample transit are provided by the laboratories and KTWQP staff makes sure that packing materials and ice are supplemented to protect samples in transit. The KTWQP Algal Toxin Chain of Custody Form supplies U.S. EPA staff at the Region 9 Richmond Laboratory with a Regional Analytical Program (RAP) number. Shipment of samples will not include a copy of the KTWQP field notebook, so that labs cannot introduce bias because locations are unknown to them.

1. All samples are removed from coolers
2. Place bubble wrap around the inside edge of the cooler to prevent breakage during shipment, and/or wrap bottles individually.
3. Prepare bags of ice to be used to keep the samples cool during transport when wet ice is used.

Pack the ice in doubled, zip-locked plastic bags.

4. Check the sample bottle screw caps for tightness.
5. Ensure sample labels are affixed to each sample container and protected by a cover of clear tape.
6. Wrap all glass sample containers in bubble wrap to prevent breakage.
7. Samples are placed in cooler and entered on COC
8. Place the bagged ice or blue ice on top and around the samples to chill them to the correct temperature.
9. Fill the empty space in the cooler with bubble wrap, Styrofoam peanuts, or any other available inert material to prevent movement and breakage during shipment.
10. Enclose the appropriate chain-of-custody(s) in a zip-lock plastic bag 1. Close the lid of the cooler. Tape the cooler shut

Daily, the KTWQP Field Samplers will notify the Laboratory Project Manager of the sample shipment schedule. The laboratory will be provided with the following information:

- Sampler's name,
- Name and location of the site or sampling area,
- Names of the tribe and project,
- Total number(s) and matrix of samples shipped to the laboratory,
- Carrier, air bill number(s), method of shipment (e.g., priority next day),
- Shipment date and when it should be received by the laboratory,
- Irregularities or anticipated problems associated with the samples, and
- Whether additional samples will be shipped or if this is the last shipment.

2.6.6 Sample Custody

The field sampler is responsible for custody of the samples until they are delivered to the laboratory or picked up for shipping. (Note: As few people as possible will handle the samples to ensure sample custody.) Chain-of-custody forms must be completed in the field. Each time one person relinquishes control of the samples to another person, both individuals must complete the appropriate portions of the chain-of-custody form (see Appendix A2) by filling in their signature as well as the appropriate date and time of the custody transfer.

During transport by a commercial carrier, the air bill will serve as the associated chain-of-custody. Once at the laboratory, the sample receipt coordinator will open the coolers and sign and date the chain-ofcustody form. The laboratory personnel are then responsible for the care and custody of samples. The analytical laboratory will track sample custody through their facility using a separate sample tracking form, as discussed in the laboratory QA Manual included in Appendix A3.

A sample is considered to be in one's custody if:

- The sample is in the sampler's physical possession,
- The sample has been in the sampler's physical possession and is within sight of the sampler,
- The sample is in a designated, secure area, and/or
- The sample has been in the sampler's physical possession and is locked up.

2.6.7 Sample Disposal

Following sample analysis, each laboratory will store the unused portions for an established length of time (see lab QA/QC Manual's in Appendix A-3). At that time, the laboratory will properly dispose of all the samples (if applicable). Sample disposal procedures at the laboratory are discussed in the laboratory's QA Manual included in Appendix A-3.

2.7 Analytical Methods

The field measurement and off-site laboratory analytical methods are listed in Tables 9, 10, and 11 and discussed below.

2.7.1 Field Measurement Methods See Section 2.2

2.7.2 Laboratory Analysis Methods

Surface water samples will be analyzed at Aquatic Research Inc., Chesapeake Bay Laboratory, EPA Region 9 Lab, Aquatic Analysts, GreenWater Laboratories, and Bartholomew Laboratory. Analyses will be performed following either EPA-approved methods or methods from *Standard Methods for the*

Examination of Water and Wastewater, 20 Edition, as summarized in Tables 10 and 11. SOPs for the analytical methods are included in Appendix A-3. The Laboratory QA/QC Officer must notify the Laboratory Project Manager if there is any knowledge of the SOPs not being followed.

Both the laboratory and consultant will summarize the data and associated QC results in a data report, and provide this report to the KTWQP Program Manager. The KTWQP Program Manager/QA Officer will review the data reports and associated QC results to make decisions on data quality and usability in addressing the project objectives.

2.8 Quality Control Requirements

This section identifies the QC checks that are in place for the sample collection, field measurement, and laboratory analysis activities that will be used to access the quality of the data generated from this project.

2.8.1 Field Sampling Quality Control

Field sampling QC consists of collecting field QC samples to help evaluate conditions resulting from field activities. Field QC is intended to support a number of data quality goals:

- Combined contamination from field sampling through sample receipt at the laboratory (to assess potential contamination from field sampling equipment, ambient conditions, sample containers, sample transport, and laboratory analysis) - assessed using field blanks;
- Sample shipment temperature (to ensure sample integrity and representativeness that the sample arriving at the laboratory has not degraded during transport) - assessed using temperature blanks; and
- Combined sampling and analysis technique variability, as well as sample heterogeneity - assessed using field duplicates.

For the current projects, the types and frequencies of field QC samples to be collected for each field measurement and off-site laboratory analysis are listed in tables 12. These include field blanks, temperature blanks (as included in a footnote to the table), and field duplicates.

Field Blanks

Field blanks will be collected to evaluate whether contaminants have been introduced into the samples during the sample collection due to exposure from ambient conditions or from the sample containers themselves. Field blank samples will be obtained by pouring deionized water into a sample container at the sampling location. Field blanks will not be collected if equipment blanks have been collected during the sampling event. If no equipment blanks are collected (and none are planned because samples will be collected directly into sample containers), one field blank will be collected for every 10 samples or a frequency of 10%. Field blank frequency is outlined in Table 12.

Field blanks will be preserved, packaged, and sealed in the same manner described for the surface water samples. A separate sample number and station number will be assigned to each blank. Field blanks will be submitted blind to the laboratory for invalidation of results, greater attention to detail during the next sampling event, or analysis of metals, hardness, and anions. No field blanks are planned for phytoplankton identification/enumeration. Field duplicates will be used to assess laboratory results.

If target analytes are found in field blanks, sampling and handling procedures will be reevaluated and corrective actions will be taken. These may consist of, but are not limited to, obtaining sampling containers from new sources, training of personnel, discussions with the laboratory, or other procedures deemed appropriate.

Field Duplicate Samples

Field duplicate samples will be collected to evaluate the precision of sample collection through analysis. Field duplicates will be collected at designated sample locations by alternately filling two distinct sample containers for each analysis. Field duplicate samples will be preserved, packaged, and sealed in the same manner described for the surface water samples. A separate sample number and station number will be assigned to each duplicate. The samples will be submitted as “blind” (i.e., not identified as field duplicates) samples to the laboratory for analysis.

For the current projects, field duplicates will be collected for each analytical parameter, and field measurement parameter, at the frequencies shown in Table 12. The duplicate samples will be collected at random locations for each sampling event. Criteria for field duplicates for the analytical and field measurement parameters are provided in Table 12. If criteria are exceeded, field sampling and handling

procedures will be evaluated, and problems will be corrected through greater attention to detail, additional training, revised sampling techniques, or whatever appears to be appropriate to correct the problems.

2.8.2 Field Measurement Quality Control

Quality control requirements for field measurements are provided in Table 12.

2.8.3 Laboratory Analyses Quality Control (off-site)

Laboratory QC is the responsibility of the personnel and QA/QC department of the contracted analytical laboratories. Each laboratory's Quality Assurance Manuals detail the QA/QC procedures it follows. The following elements are part of standard laboratory quality control practices:

- Analysis of method blanks,
- Analysis of laboratory control samples,
- Instrument calibration (including initial calibration, calibration blanks, and calibration verification),
- Analysis of matrix spikes, and
- Analysis of duplicates.

The data quality objectives for Aquatic Analysts, Aquatic Research Inc, EPA Region 9 Lab, GreenWater Laboratories, and Chesapeake Bay Laboratory (including frequency, QC acceptance limits, and corrective actions if the acceptance limits are exceeded) are detailed in the QA Manuals and SOPs (as in Appendix A-3). Any excursions from these objectives must be documented by the laboratory and reported to the Project Manager/QA Officer.

The Karuk Tribe has reviewed each laboratory's control limits and corrective action procedures and feels that these will satisfactorily meet tribal project data quality needs. A summary of this information is included below. These include laboratory (or method) blanks, laboratory control samples, matrix spikes, and laboratory duplicates.

Method Blanks

A method blank is an analyte-free matrix, analyzed as a normal sample by the laboratory using normal sample preparation and analytical procedures. A method blank is used for monitoring and documenting

background contamination in the analytical environment. Method blanks will be analyzed at a frequency of one per sample batch (or group of up to 20 samples analyzed in sequence using the same method).

Corrective actions associated with exceeding acceptable method blank concentrations include isolating the source of contamination and re-digesting and/or re-analyzing the associated samples. Sample results will not be corrected for blank contamination, as this is not required by the specific analytical methods. Corrective actions will be documented in the laboratory report's narrative statement.

Laboratory Control Samples

Laboratory control samples (LCS) are laboratory-generated samples analyzed as a normal sample and by the laboratory using normal sample preparation and analytical procedures. An LCS is used to monitor the day-to-day performance (accuracy) of routine analytical methods. An LCS is an aliquot of clean water spiked with the analytes of known concentrations corresponding to the analytical method. LCS are used to verify that the laboratory can perform the analysis on a clean matrix within QC acceptance limits. Results are expressed as percent recovery of the known amount of the spiked analytical parameter.

One LCS is analyzed per sample batch. Acceptance criteria (control limits) for the LCS are defined by the laboratory and summarized in their associated QA Manuals (Appendix A-3). In general, the LCS acceptance criteria recovery range is 70 to 130 percent of the known amount of the spiked analytical parameter. Corrective action, consisting of a rerunning of all samples in the affected batch, will be performed if LCS recoveries fall outside of control limits. Such problems will be documented in the laboratory report's narrative statement.

Matrix Spikes

Matrix spikes (MS) are prepared by adding a known amount of the analyte of interest to a sample. MS are used as a similar function as the LCS, except that the sample matrix is a real-time sample rather than a clean matrix. Results are expressed as percent recovery of the known amount of the spiked analytical parameter. Matrix spikes are used to verify that the laboratory can determine if the matrix is causing either a positive or negative influence on sample results.

One MS is analyzed per sample batch. Acceptance criteria of the MS are defined by the laboratory and summarized in each QA Manual (Appendix A-3). In general, the MS acceptance criteria recovery range is

of 70 to 130 percent of the known amount of the spiked analytical parameter. Generally, no corrective action is taken for matrix spike results exceeding the control limits, as long as the LCS recoveries are acceptable. However, the matrix effect will be noted in the laboratory report's narrative statement and documented in the Karuk Tribe's reports for each sampling event.

Laboratory Duplicates

A laboratory duplicate is a laboratory-generated split sample used to document the precision of the analytical method. Results are expressed as relative percent difference between the laboratory duplicate pair.

One laboratory duplicate will be run for each laboratory batch or every 10 samples, whichever is more frequent. Acceptance criteria (control limits) for laboratory duplicates are specified in the laboratory QA Manual and SOPs, Appendix A-3. If laboratory duplicates exceed criteria, the corrective action will be to repeat the analyses. If results remain unacceptable, the batch will be rerun. The discrepancy will be noted in the laboratory report's narrative statement and documented in the Tribe's reports for each sampling event.

2.9 Instrument/Equipment Testing, Inspection, and Maintenance

2.9.1 Field Measurement Instruments/Equipment

Sampling equipment under the care of the KTWQP will be maintained according to the manufacturer's instructions. Maintenance logs will be kept in the office of the KTWQP Program Manager/QA Officer. Each piece of equipment will have its own maintenance log. The log will document any maintenance and service of the equipment. A log entry will include the following information:

- Name of person maintaining the instrument/equipment,
- Date and description of the maintenance procedure,
- Date and description of any instrument/equipment problem(s),
- Date and description of action to correct problem(s),
- List of follow-up activities after maintenance (i.e., system checks), and
- Date the next maintenance will be needed

2.9.2 Laboratory Analysis Instruments/Equipment

Inspection and maintenance of laboratory equipment is the responsibility of the Aquatic Analysts, Aquatic Research Inc, U.S. EPA Region 9 Lab, Chesapeake Bay Laboratory, and GreenWater Laboratories and is described in each laboratory's QA Manual included as Appendix A-3.

2.10 Instrument/Equipment Calibration and Frequency

2.10.1 Field Measurement Instruments/Equipment

Calibration and maintenance of field equipment/instruments will be performed according to the manufacturer's instructions (see Appendices E-4 and E-5) and recorded in an instrument/equipment logbook. Each piece of equipment/instrument will have its own logbook.

The project-specific criteria for calibration (frequency, acceptance criteria, and corrective actions associated with exceeding the acceptance criteria) are provided in Table 13.

2.10.2 Laboratory Analysis Instruments/Equipment

Laboratory instruments will be calibrated according to the appropriate analytical methods. Acceptance criteria for calibrations are found in each of their QA Manuals included as Appendix A-3.

2.11 Inspection and Acceptance of Supplies and Consumables

2.11.1 Field Sampling Supplies and Consumables

Sample containers and preservatives will be provided by the analytical laboratories and the Karuk Tribe. Containers will be inspected for breakage and proper sealing of caps. Other equipment such as sample coolers and safety equipment will be acquired by the Karuk Tribe. For reusable sampling equipment, materials/supplies necessary for equipment decontamination will be purchased by the Karuk Tribe. Any equipment deemed to be in unacceptable condition will be replaced.

2.11.2 Field Measurement Supplies and Consumables

Field measurement supplies, such as calibration solutions, will be acquired from standard sources, such as the instrument manufacturer or reputable suppliers. Chemical supplies will be American Chemical Society reagent grade or higher. The lot number and expiration date on standards and reagents will be checked prior to use. Expired solutions will be discarded and replaced. The source, lot number, and expiration dates of all standards and reagents will be recorded in the field log books.

2.11.3 Laboratory Analysis (off-site) Supplies and Consumables

Each of the laboratory's requirements for supplies and consumables are described in its QA Manual which is provided in Appendix A-3.

2.12 Data Acquisition Requirements (Non-Direct Measurements)

To supplement field measurements and laboratory analytical activities conducted under these projects, other potential "external" data sources will be researched. These sources include, but are not limited to, the U.S. Geological Survey, the North Coast Regional Water Quality Control Board, the California Department of Water Resources, the U.S. Environmental Protection Agency, the United States Forest Service, the Hoopa Tribe, and the Yurok Tribe. The primary use of this external data will be to help focus the Karuk Tribe's data collection efforts (for example, the information may be used to identify new sites in the Klamath River watershed for future sampling).

If it appears that the "external" data might facilitate water body evaluation, the data will first be reviewed to verify that they are of sufficient quality to meet the needs of the project by examining:

1. the sample collection and location information;
2. the data to see whether they are consistent with known tribally-collected data from the same general vicinity; and
3. the QA/QC information associated with the data.

If the data are of insufficient or unknown quality, limitations will be placed on its use in supporting project decisions. In general, it is anticipated that decisions for the current project will be based on data collected by the Karuk Tribe following this current QA Project Plan.

3.0 ASSESSMENT AND OVERSIGHT

This section describes how activities will be checked to ensure that they are completed correctly and according to procedures outlined in this QA Project Plan.

3.1 Assessment/Oversight and Response Actions

During the course of the project, it is important to assess the projects' activities to ensure that the QA Project Plan is being implemented as planned. This helps to ensure that everything is on track and serves to minimize learning about critical deviations toward the end of the project when it may be too late to remedy the situation. For the current project, the ongoing assessments will include:

- Field Oversight,
- Readiness review of the field team prior to starting field efforts,
- Field activity audits,
- Review of field sampling and measurement activities methodologies and documentation at the end of each event, and
- Laboratory Oversight - evaluation of laboratory data generated for each quarterly sampling event.

Details regarding these assessments are included below.

2.13 Data Management

All data collected by the KTWQP will be maintained in appropriate bound notebooks and electronic databases. Data from the laboratory will be requested in both hard copy and electronic form. The electronic and hard copy results will be compared to ensure that no errors occurred in either format. If discrepancies are noted, the laboratory will be contacted to resolve the issues.

3.1.1 Field Oversight

3.1.1.1 Readiness Reviews

Sampling personnel will be properly trained by qualified personnel before any sampling begins and will be given a brief review of sampling procedures and equipment operation by the KTWQP Program Manager/QA Officer before each sampling event. Equipment maintenance records will be checked to

ensure all field instruments are in proper working order. Adequate supplies of all preservatives and bottles will be obtained and stored appropriately before heading to the field. Sampling devices will be checked to ensure that they have been properly cleaned (for devices which might be reused) or are available in sufficient quantity (for devices which are disposable). Proper paperwork, logbooks, chain of custody forms, etc. will be assembled by the sampling technician. The KTWQP Project Manager/QA Officer will review all field equipment, instruments, containers, and paperwork to ensure that all is in readiness prior to the first day of each sampling event. Any problems that are noted will be corrected before the sampling team is permitted to depart the Karuk Tribe's facilities.

3.1.1.2 Field Activity Audits

Once a month, the KTWQP Project Manager/QA Officer will assess the sample collection methodologies, field measurement procedures, and record keeping of the field team to ensure activities are being conducted as planned (and as documented in this QA Project Plan). Any deviations that are noted will be corrected immediately to ensure all subsequent samples and field measurements collected are valid. (Note: If the deviations are associated with technical changes and/or improvements made to the procedures, the KTWQP QA Officer will verify that the changes have been documented by the KTWQP Technicians in the Field Log Book and addressed in an amendment to this QA Project Plan.) The KTWQP QA Officer may stop any sampling activity that could potentially compromise data quality.

The KTWQP QA Officer will document any noted issues or concerns in a QA Audit Logbook and discuss these items informally and openly with the KTWQP Water Quality Technicians while on site. Once back in the office, they will formalize the audit findings (for each event) in a Field Audit Report which will be submitted to the KTWQP Program Manager and the KTWQP Technicians.

The KTWQP Technician will prepare a Corrective Action Report to address any audit findings discussed in the Field Audit Report. The Corrective Action Report will be issued as an internal memorandum the KTWQP Program Manager/QA Officer in response to problems noted during on-site audits and will document steps taken to reduce future problems prior to the next sampling event.

3.1.1.3 Post Sampling Event Review

Following each sampling event, the KTWQP Data Manager will complete the Field Activities Review Checklist (Appendix B-1). This review of field sampling and field measurement documentation will help ensure that all information is complete and any deviations from planned methodologies are documented. This review will be conducted in the office, not in the field. The results of this review, as well as comments associated with potential impacts on field samples and field measurement integrity will be forwarded to the KTWQP Program Manager to be used in preparing the reports for each event and also to be used as a guide to identify areas requiring improvement prior to the next sampling event.

3.1.2 Laboratory Oversight

Following receipt of the off-site laboratory's data package for each sampling event, the KTWQP QA Officer will review the data package for completeness, as well as to ensure that all planned methodologies were followed and that QA/QC objectives were met. The results of the review will be documented on the Laboratory Data Review Checklist (Appendix B-2). (Note: The KTWQP Program Manager/QA Officer has the authority to request re-testing or other corrective measures if the laboratory has not met the project's QA/QC objectives and/or has not provided a complete data package.)

Due to the scope and objectives of the current projects, the Karuk Tribe is not planning any laboratory audits at this time. However, the Karuk Tribe will check periodically with the state of California certification agency to make sure that the laboratory remains in good standing for those methods that the Karuk Tribe is requesting.

The laboratories' QA Manuals describe the policies and procedures for assessment and response in the laboratory.

3.2 Reports to Management

Annually, the KTWQP Program Manager will prepare and submit a report on that year's sampling activities. Contents of this report have been described previously in Section 1.9.6. The prepared report will show any data trends that have occurred. The report will also discuss how any actions taken during the year may have affected the trends. This report will be submitted to the Tribal Council for approval. After approval, the report will be submitted to the US EPA Grants Project Officer.

4.0 DATA REVIEW AND USABILITY

Prior to utilizing data to make project decisions, the quality of the data needs to be reviewed and evaluated to determine whether the data satisfy the projects' objectives. This process involves technical evaluation of the off-site laboratory data, as well as review of the data in conjunction with the information collected during the field sampling and field measurement activities. This latter, more qualitative review provides for a clearer understanding of the overall usability of the projects' data and potential limitations on their use. This section describes the criteria and procedures for conducting these reviews and interpreting the projects' data.

4.1 Data Review, Verification, and Validation Requirements

The setting of data review, verification, and validation requirements helps to ensure that project data are evaluated in an objective and consistent manner. For the current project, such requirements have been defined for information gathered and documented as part of field sampling and field measurement activities, as well as for data generated by the off-site laboratory.

4.1.1 Field Sampling and Measurement Data

Any information collected during sample collection and field measurements is considered field "data." This includes field sampling and measurement information documented in field logbooks (as listed in Section 1.9.2.1), photographs, and chain of custody forms.

Once the KTWQP Technician returns to the office following a sampling event, they turn in the field data to the KTWQP Data Manager who is responsible for conducting a technical review of the field data to ensure that all information is complete and any deviations from the planned methodologies are documented. For the purpose of this project, the review will be documented using the Field Activities Review Checklist provided in Appendix B-1. This checklist comprehensively covers the items to be reviewed and leaves room to capture any comments associated with potential impacts on field samples and field measurement integrity based on the items listed.

4.1.2 Laboratory Data

For the data generated by an off-site laboratory, the laboratory is responsible for its own internal data review and verification prior to submitting the associated data results package to the KTWQP QA Officer. The details of the review (including checking calculations, reviewing for transcription errors, ensuring the

data package is complete, etc.) are discussed in the laboratory's QA Manual included as Appendix A3. Details of the information that will be included in each data package are listed in Section 1.9.3 of this QA Project Plan.

Once the laboratory data are received by the Karuk Tribe, the KTWQP QA Officer is responsible for further review and validation of each data package. For the purpose of this project, data review and validation will be conducted using the Data Review Checklist provided in Appendix B-2 in conjunction with the QC criteria (i.e., frequency, acceptance limits, and corrective actions) defined in Tables 10, 11 and 12. This review will include evaluation of the field and laboratory duplicate results, field and laboratory blank data, matrix spike recovery data, and laboratory control sample data pertinent to each analysis. The review will also include ensuring data are reported in compliance with the project action limits and quantification limits defined in Tables 5-8; the sample preparation/analytical procedures were performed by the methods listed in Table 10; sample container, preservation, and holding times met the requirements listed in Table 11; the integrity of the sample (ensuring proper chain of custody and correct sample storage temperatures) is documented from sample collection through shipment and ultimate analysis, and the data packages. The Data Review Checklist comprehensively covers the review of all these items.

The KTWQP QA Officer will further evaluate each data package's narrative report and summary tables to see whether the laboratory "flagged" any sample results based on poor or questionable data quality and to ensure that any exceedances of the laboratory's QC criteria (as listed in Table 12) are documented. If a problem was noted by the laboratory, the KTWQP QA Officer will evaluate whether the appropriate prescribed corrective action was taken by the laboratory, the action successfully resolved the problem, and the process and its resolution were accurately documented.

An effort will be made to identify whether any data quality problem is the result of laboratory issues and/or if it may be traced to some field sampling activity. If the laboratory is determined to be responsible, the KTWQP QA Officer will request information from the laboratory documenting that the problem has been resolved prior to submitting future samples. If some aspect of the field operation (e.g., sample collection, sample containers and/or preservation, chain-of-custody, sample shipment, paperwork, etc.) is identified as the possible problem, efforts will be made to retrain the KTWQP's field staff to minimize the potential of the problem recurring. If the problem is believed to be due to the sample matrix, the KTWQP Program Manager/QA Officer will discuss the use of alternative analytical methods with the

laboratory; and, if an alternative method is available that might minimize the problem, the QA Project Plan will be modified and/or amended accordingly.

If any of the QC criteria and/or the project requirements (as discussed above) is exceeded, the associated data will be qualified as estimated and flagged with a "J". If grossly exceeded, the associated data will be rejected and the need for re-sampling will be considered. However, since the data are being generated for a baseline assessment, it is generally felt that paying special attention to some troublesome sample collection or analytical concern during the next sampling event will be sufficient and re-sampling will not be necessary.

4.2 Verification and Validation Methods

Defining the data verification and validation methods help to ensure that project data are evaluated in an objective and consistent manner. For the current projects, such methods have been described for information gathered and documented as part of the field sampling and field measurement activities, as well as the data generated by the off-site laboratories.

4.2.1 Field Sampling and Measurement Data

The methods associated with verification and validation of the field sampling and measurement data are included within the discussion provided in Section 4.1.1.

4.2.2 Laboratory Data

The methods associated with verification and validation of the laboratory data are included within the discussion provided in Section 4.1.2.

4.3 Reconciliation with User Requirements

The purpose of the continued monitoring of the KAT is to assess the surface water resources and determine whether analytes of concern exceed national and tribal water quality standards. This also provides the Karuk Tribe with the opportunity to begin efforts of co-management in the Mid-Klamath watershed. Data must fulfill the requirements of this QA Project Plan to be useful for the overall project. Information needed to support decision making under the surface water monitoring program is contained in this QA Project Plan, field documentation, the laboratory "data package" report, the Field Activities Review Checklist, the Laboratory Data Review Checklist, and the Field Audit Report and associated

Corrective Action Report. This section describes the steps to be taken to ensure data usability (after all the data have been assembled, reviewed, verified, and validated) prior to summarizing the information in the Annual Report.

Once all the data from the field and laboratory have been evaluated (as described in Sections 4.1 and 4.2), the KTWQP Program Manager/QA Officer will make an overall assessment concerning the final usability of the data (and any limitations on its use) in meeting the projects' needs. The initial steps of this assessment will include, but are not necessarily limited to:

- Discussions with the KTWQP Water Quality Technician,
- Review of deviations from the QA Project Plan or associated SOPs to determine whether these deviations may have impacted data quality (and determining whether any impacts are widespread or single incidents, related to a few random samples or a batch of samples, and/or affecting a single or multiple analyses),
- Evaluation of the field and laboratory results and QC information,
- Review of any other external information which might influence the results, such as activities up stream, meteorological conditions (such as storm events proceeding sampling that might contribute to high turbidity readings), and data from other sources,
- Evaluation of whether the completeness goals defined in this QA Project Plan have been met,
- Examination of any assumptions made when the study was planned, if those assumptions were met and, if not, how the project's conclusions are affected.

After all this information has been reviewed, the KTWQP Program Manager/QA Officer will incorporate their perspective on the critical nature of any problems noted and, ultimately, identify data usability and/or limitations in supporting project objectives and decision making. All usable data will then be compared to the Project Action Limits (as listed in Table 5 and Table 6) to identify whether these limits have been exceeded. Decisions made regarding exceeding the Project Action Limits will follow the "...if...then..." statements included in Section 1.7.2.

In addition, the KTWQP Program Manager/QA Officer will assess the effectiveness of the monitoring program and data collection at the end of each calendar year. Sampling locations, frequency, list of analytical parameters, field measurement protocols, choice of the analytical laboratory, etc. will be

modified as needed to reflect the changing needs and project objectives of the Karuk Tribe. This QA Project Plan will be revised and/or amended accordingly.

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FIGURES

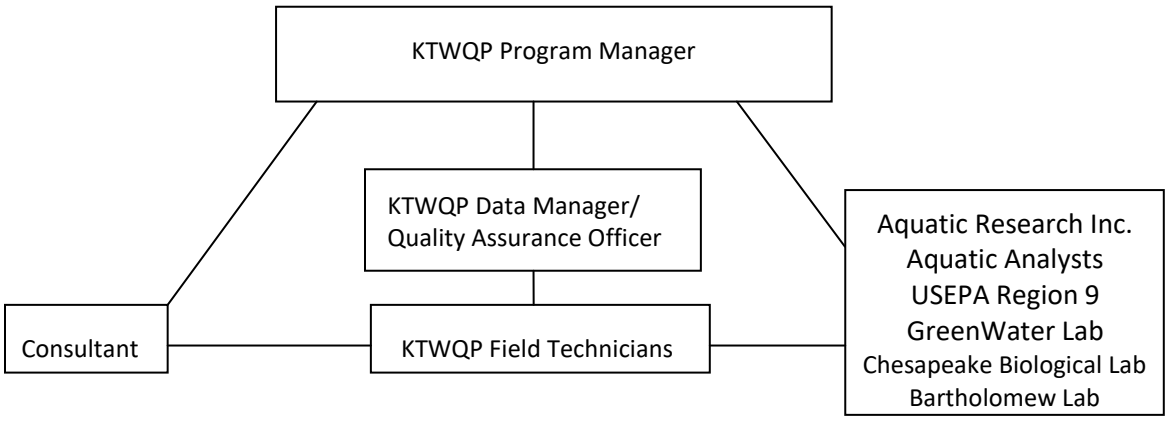


Figure 1. Program Organization.

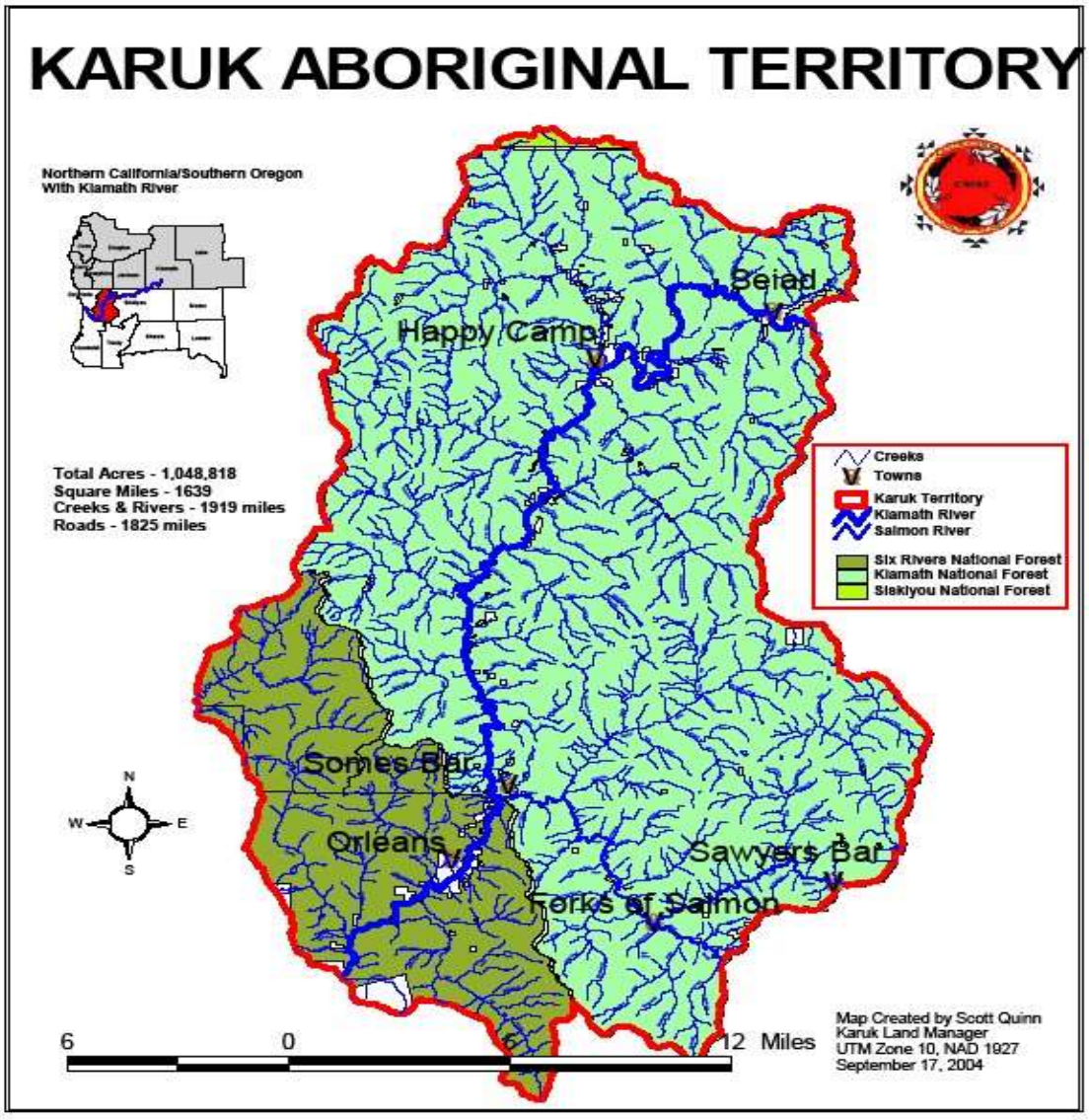


Figure 2. Map of Karuk Aboriginal Territory including towns, counties and where it is relative to the State of California and Oregon. Map from Karuk Tribe.

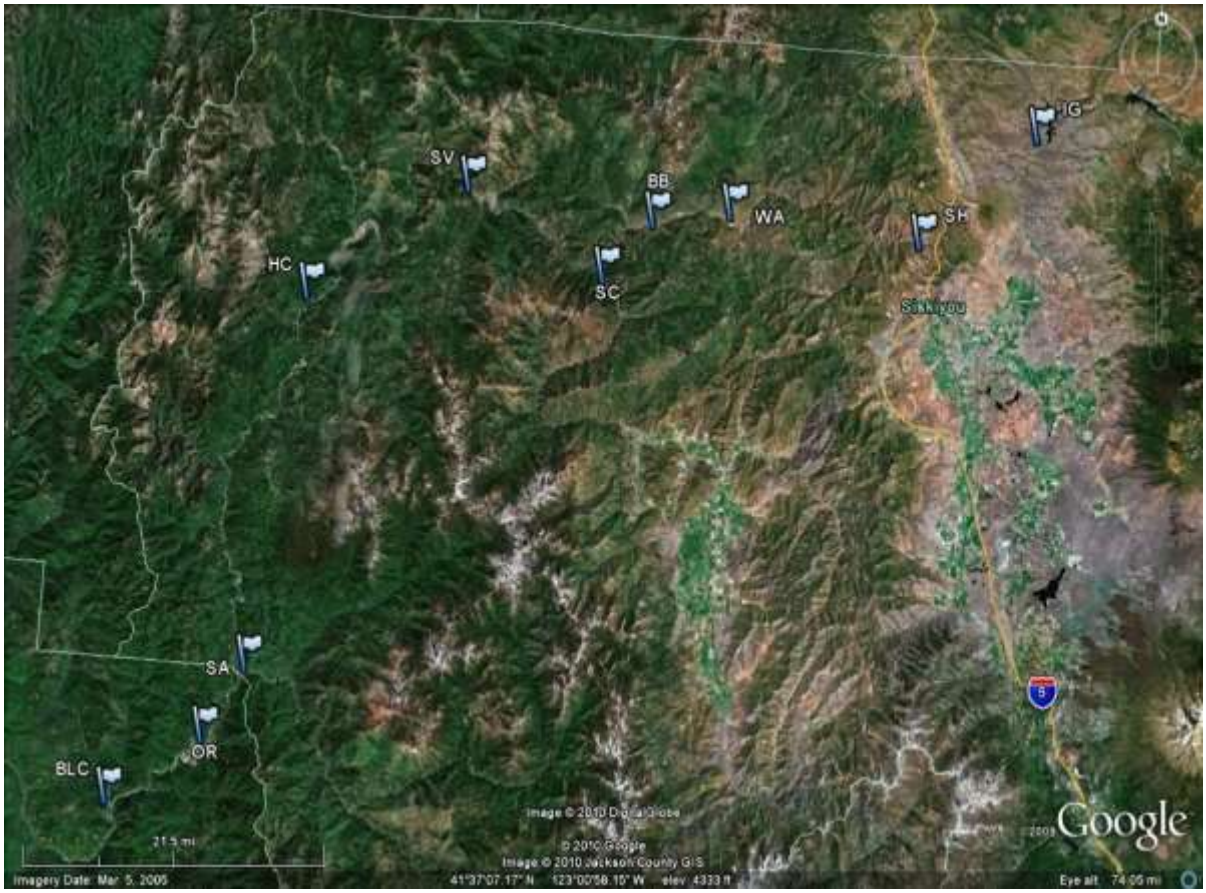


Figure 3. Overview of sampling sites for nutrient sampling, public health sampling, and continuous monitoring.

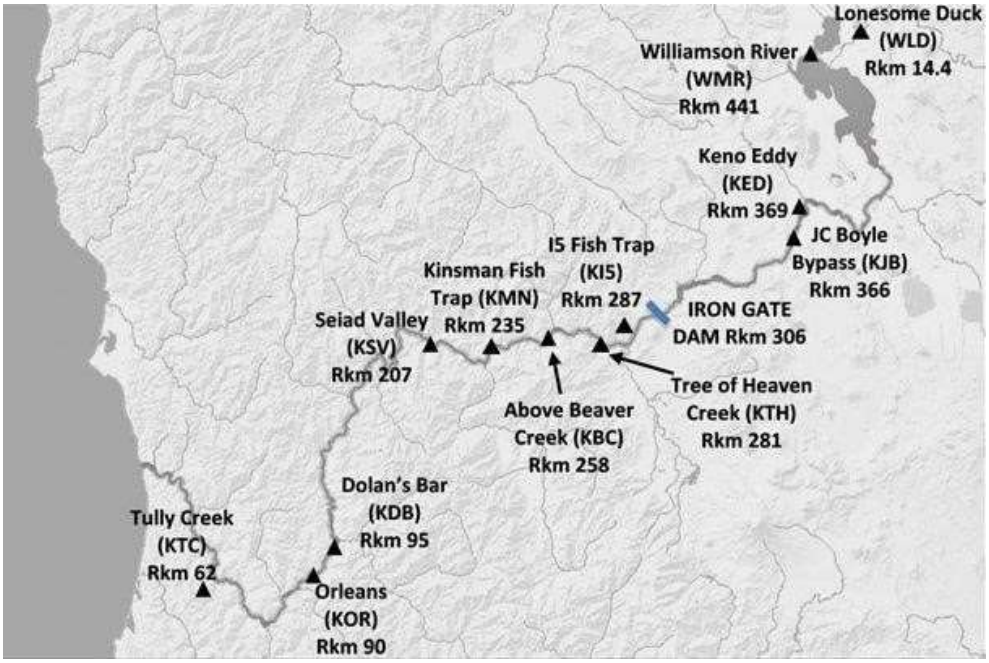


Figure 4. Klamath River Index Sites with site abbreviations and river kilometers (Rkm). Map from Oregon State University Department of Microbiology.

TABLES

Table 1. All parties participating in collection, shipping and handling, analysis of Klamath River nutrient, toxic algae, and c.shasta data by the KTWQP and those responsible for implementation of QA/QC procedures.

Title/Responsibility	Staff/Contractor	Phone Number
EPA Project Manager	Loretta Vanegas	(415) 972-3433
Program Manager	Susan Fricke	(530) 598-3414
Data Quality Manager	Grant Johnson	(530) 469-3258
Field Manager	Grant Johnson	(530) 469-3258
KTWQP Technician	Larry Alameda	(530) 469-3258
Quality Assurance Officer	Grant Johnson	(530) 469-3258
Consultant, Aquatic Ecosystems	Jacob Kann	(541) 482-1575
Consultant, Riverbend Sciences	Eli Asarian	(707) 832-4206
Contractor, Aquatic Research Inc.	Damien Gadomski	(206) 632-2715
Contractor, Aquatic Analysts	Jim Sweet	(503) 869-5032
Contractor, USEPA Region 9 Lab	Andy Lincoff	(510) 412-2389
Contractor, GreenWater Laboratories	Mark Aubel	(386) 328-0882
Contractor, Chesapeake Biological Laboratory	Jerry Frank	(410) 326-4281
Contractee, Bartholomew Laboratory	Sascha Hallet	(541) 737-4721

Table 2. Atlas of Tribal Waters within Ancestral Territory.

Atlas of Tribal Waters Within Ancestral Territory

Total number of Klamath River miles	90
Total number of perennial stream miles	1,900
Total number of lake acres	442
Total number of wetland acres	UNKNOWN

Table 3. Site codes and locations of Karuk sampling stations for nutrients, algal toxins, and Sondes. Nutrient Suite indicates collecting nutrients, algal toxins and phytoplankton. Sonde indicates real time continuous monitoring, and public health designates surface grab sampling for phytoplankton and algal toxins.

Locations and Parameters to be Monitored							
Site ID	Latitude	Longitude	Nutrient Suite	Sonde	Public Health	Winter Turbidity	Location
OR	N 41 18.336	W 123 31.895	X	X	X		Klamath River at Orleans
SA	N 41 22.617	W 123 28.633	X	X		X	Salmon River at USGS Gage
HC	N 41 43.780	W 123 25.775	X		X		Klamath River downstream of Happy Camp
SV	N 41 50.561	W 123 13.132	X	X	X		Klamath River downstream of Seiad Valley
SC	N 41 46.100	W 123 01.567	X	X			Scott River at Johnson's Bar
BB	N 41 49.395	W 122 57.718			X		Brown Bear River Access on Klamath River
WA	N 41 50.242	W 122 51.895	X				Klamath River at Walker Bridge
SH	N 41 49.390	W 122 35.700	X	X			Shasta River at USGS Gage

IG	N 41 55.865	W 122 26.532	X	X		X	Klamath River below Iron Gate Hatchery Bridge

Table 4. Sample locations and parameters for nutrient sampling and public health sampling.

ID	OR	SA	HC	SV	SC	BB	WA	SH	IB	IG
Monitoring Locations	Klamath River near Orleans	Salmon River near mouth	Klamath River near Happy Camp	Klamath River near Seiad Valley	Scott River near mouth	Klamath River at Brown Bear River Access	Klamath River at Walker Bridge	Shasta River near mouth	Klamath River at I-5 bridge	Klamath River below Iron Gate
Photo Points	X	X	X	X	X	X	X	X	X	X
Temp.	X	X	X	X	X	X	X	X	X	X
pH	X	X	X	X	X	X	X	X	X	X
Conductivity	X	X	X	X	X	X	X	X	X	X
Turbidity		X			X					
DO	X	X	X	X	X	X	X	X	X	X
Total Phosphorus	X	X	X	X	X		X	X		X
Dissolved Phosphorus	X	X	X	X	X		X	X		X
Total Nitrogen	X	X	X	X	X		X	X		X
Ammonium Nitrogen	X	X	X	X	X		X	X		X
Nitrate + Nitrite	X	X	X	X	X		X	X		X
Phytoplankton	X	X	X	X	X		X	X		X
Chlorophyll	X	X	X	X	X		X	X		X
Total Organic Carbon	X	X	X	X	X		X	X		X

Dissolved Organic Carbon	X	X	X	X	X		X	X		X
Pheophytin	X	X	X	X	X		X	X		X
Alkalinity	X	X	X	X	X		X	X		X
Volatile Suspended Solids	X	X	X	X	X		X	X		X
Total Suspended Solids	X	X	X	X	X		X	X		X
Orthophosphate	X	X	X	X	X		X	X		X
Microcystin	X	X	X	X	X	X	X	X		X
Anatoxin-A									X	X

Table 5. Specific water quality objectives for Tribal waterbodies.

		Specific Conductance (micromhos) @ 25		Dissolved Oxygen (mg/L)[4]		Hydrogen Ion (pH units)[5]		Hardness (mg/L as CaCO3)	Boron (mg/L as B)	
Hydrologic Area	Waterbody	90% Upper Limit[1]	50% Upper Limit[2]	Min	50% Lower Limit2	Max	Min	50% Upper Limit[2]	90% Upper Limit[1]	50% Upper Limit[2]
Shasta Valley	All Streams	700	400	7	9	8.5	7	200	0.5	0.1
	Groundwaters[3]	800	500	-	-	8.5	7	180	1	0.3
Scott Valley	All Streams	400	275	7	9	8.5	7	120	0.2	0.1
	Groundwaters[3]	500	250	-	-	8	7	120	0.1	0.1
Salmon River	All Streams	150	125	9	10	8.5	7	60	0.1	0
Middle Klamath River	Klamath R (near Doggett Creek to Orleans)	350	275	*[4]	*[4]	8.5	7	80	0.5	0.2
	Other Streams	300	150	7	9	8.5	7	60	0.1	0
	Groundwaters[3]	750	600	-	-	8.5	7.5	200	0.3	0.1

1 90% upper and lower limits represent the 90 percentile values for a calendar year. 90% or more of the values must be less than or equal to an upper limit and greater than or equal to a lower limit.

2 50% upper and lower limits represent the 50 percentile values of the monthly means for a calendar year. 50% or more of the monthly means must be less than or equal to an upper limit and greater than or equal to a lower limit.

3 Value may vary depending on the aquifer being sampled. This value is the result of sampling over time, and as pumped, from more than one aquifer.

4 The Site Specific Objectives (SSOs) for dissolved oxygen (DO) for the mainstem Klamath River are presented separately in Table 6.

Table 6. Dissolved oxygen objectives for the mainstem Klamath River.

Location	Percent DO Saturation Based On Natural Receiving Water Temperatures[1]	Time Period
Klamath River from near Doggett Creek to the Scott River	90%	October 1 through March 31
	85%	April 1 through September 30
Klamath River from Scott River to Orleans	90%	Year round

1 Corresponding DO concentrations are calculated as daily minima, based on site-specific barometric pressure, site-specific salinity, and natural receiving water temperatures as estimated by the T1BSR run of the Klamath TMDL model and described in Tetra Tech, December 23, 2009, Modeling Scenarios: Klamath River Model for TMDL Development. The estimates of natural receiving water temperatures used in these calculations may be updated as new data or method(s) become available.

A		B Freshwater Aquatic Life		C Human Health (10-6 risk for carcinogens) For consumption of:	
# Compound	CAS Number	Criterion Maximum Conc. (c) (ug/L) B1	Criterion Continuous Conc. (c) (ug/L) B2	Water & Organisms (ug/L) D1	Organisms Only (ug/L) D2
1. Antimony	7440360			5.6 a	640 a
2. Arsenic	7440382	340 h,l,r	150 h,l,r		

3. Beryllium	7440417				
4. Cadmium	7440439	4.3 d,h,l,r	2.2 d,h,l,r		
5a. Chromium (III)	16065831	570 d,h,l,r	74 d,h,l,r		
5b. Chromium (VI)	18540299	16 h,l,r	11 h,l,r		
6. Copper	7440508	13 d,h,l,r	9.0 d,h,l,r	1,300 k	
7. Lead	7439921	65 d,h,l	2.5 d,h,l		
8a. Mercury	7439976	1.4 h,l,r	0.77 h,l,r		

Table 7. Water quality objectives for aquatic life & organism consumption.

A		B Freshwater Aquatic Life		C Human Health (10-6 risk for carcinogens) For consumption of:	
8b. Methylmercury	22967926				0.3 mg/kg i
9. Nickel	7440020	470 d,h,l,r	52 d,h,l,r	610	4,600
10. Selenium	7782492	o,p	5.0	170 a	4,200 a
11. Silver	7440224	3.4 d,f,h,l			
12. Thallium	7440280			0.24 a	0.47 a
13. Zinc	7440666	120 d,h,l	120 d,h,l,r	7,400 a	25,000 a
14. Cyanide	57125	22 r,s	5.2 r,s	140 a	16,000 a,j
15. Asbestos	1332214			7 million fibers/L k	
16. 2,3,7,8-TCDD (Dioxin)	1746016			5.0 E-9 b	5.1 E-9 b
17. Acrolein	107028			190	290
18. Acrylonitrile	107131			0.051 a,b	0.25 a,b

19. Benzene	71432			0.61 - 2.2 a,b	14 - 51 a,b
20. Bromoform	75252			4.3 a,b	130 a,b
21. Carbon Tetrachloride	56235			0.23 a,b	1.6 a,b
22. Chlorobenzene	108907			130 a	1,600 a,j
23. Chlorodibromomethane	124481			0.40 a,b	13 a,b
24. Chloroethane	75003				
25. 2-Chloroethylvinyl Ether	110758				
26. Chloroform	67663				
27. Dichlorobromomethane	75274			0.55 a,b	17 a,b
28. 1,1-Dichloroethane	75343				
29. 1,2-Dichloroethane	107062			0.38 a,b	37 a,b
30. 1,1-Dichloroethylene	75354			0.056 a,b	1.2 a,b
31. 1,2-Dichloropropane	78875			0.50 b	15 b
32. 1,3-Dichloropropene	542756			0.34 a,b	21 a,b
33. Ethylbenzene	100414			530 a	2,100 a
34. Methyl Bromide	74839			47 a	1,500 a
35. Methyl Chloride	74873				

A		B Freshwater Aquatic Life		C Human Health (10-6 risk for carcinogens) For consumption of:	
36. Methylene Chloride	75092			4.6 a,b	590 a,b

37. 1,1,2,2-Tetrachloroethane	79345			0.17 a,b	4.0 a,b
38. Tetrachloroethylene	127184			0.69 b	3.3 b
39. Toluene	108883			1,300 a	15,000 a
40. 1,2-Trans-Dichloroethylene	156605			140 a	10,000 a
41. 1,1,1-Trichloroethane	71556				
42. 1,1,2-Trichloroethane	79005			0.59 a,b	16 a,b
43. Trichloroethylene	79016			2.5 b	30 b
44. Vinyl Chloride	75014			0.025 a,b	2.4 a,b
45. 2-Chlorophenol	95578			80 a	150 a
46. 2,4-Dichlorophenol	120832			77 a	290 a
47. 2,4-Dimethylphenol	105679			380 a	850 a
48. 2-Methyl-4,6-Dinitrophenol	534521			13	280
49. 2,4-Dinitrophenol	51285			69 a	5,300 a
50. 2-Nitrophenol	88755				
51. 4-Nitrophenol	100027				
52. 3-Methyl-4-Chlorophenol	59507				
53. Pentachlorophenol	87865	19 e,r	15 e,r	0.27 a,b	3.0 a,b,j
54. Phenol	108952			21,000 a	1,700,000 a,j
55. 2,4,6-Trichlorophenol	88062			1.4 a,b	2.4 a,b
56. Acenaphthene	83329			670 a	990 a
57. Acenaphthylene	208968				
58. Anthracene	120127			8,300 a	40,000 a

59. Benzidine	92875			0.000086 a,b	0.00020 a,b
60. Benzo(a)Anthracene	56553			0.0038 a,b	0.018 a,b
61. Benzo(a)Pyrene	50328			0.0038 a,b	0.018 a,b
62. Benzo(b)Fluoranthene	205992			0.0038 a,b	0.018 a,b
63. Benzo(ghi)Perylene	191242				

A		B Freshwater Aquatic Life		C Human Health (10-6 risk for carcinogens) For consumption of:	
64. Benzo(k)Fluoranthene	207089			0.0038 a,b	0.018 a,b
65. Bis(2-Chloroethoxy)Methane	111911				
66. Bis(2-Chloroethyl)Ether	111444			0.030 a,b	0.53 a,b
67. Bis(2-Chloroisopropyl)Ether	108601			1,400 a	65,000 a
68. Bis(2-Ethylhexyl)Phthalate (x)	117817			1.2 a,b	2.2 a,b
69. 4-Bromophenyl Phenyl Ether	101553				
70. Butylbenzyl Phthalate (w)	85687			1,500 a	1,900 a
71. 2-Chloronaphthalene	91587			1,000 a	1,600 a
72. 4-Chlorophenyl Phenyl Ether	7005723				
73. Chrysene	218019			0.0038 a,b	0.018 a,b
74. Dibenzo(a,h)Anthracene	53703			0.0038 a,b	0.018 a,b
75. 1,2-Dichlorobenzene	95501			420 a	1,300 a
76. 1,3-Dichlorobenzene	541731			320	960

77. 1,4-Dichlorobenzene	106467			63	190
78. 3,3'-Dichlorobenzidine	91941			0.021 a,b	0.028 a,b
79. Diethyl Phthalate	84662			17,000 a	44,000 a
80. Dimethyl Phthalate	131113			270,000	1,100,000
81. Di-n-Butyl Phthalate	84742			2,000 a	4,500 a
82. 2,4-Dinitrotoluene	121142			0.11 b	3.4 b
83. 2,6-Dinitrotoluene	606202				
84. Di-n-Octyl Phthalate	117840				
85. 1,2-Diphenylhydrazine	122667			0.036 a,b	0.20 a,b
86. Fluoranthene	206440			130 a	140 a
87. Fluorene	86737			1,100 a	5,300 a
88. Hexachlorobenzene	118741			0.00028 a,b	0.00029 a,b
89. Hexachlorobutadiene	87683			0.44 a,b	18 a,b
90. Hexachlorocyclopentadiene	77474			47 a	1,300 a,j
91. Hexachloroethane	67721			1.4 a,b	3.3 a,b

A		B Freshwater Aquatic Life		C Human Health (10-6 risk for carcinogens) For consumption of:	
92. Ideno(1,2,3-cd)Pyrene	193395			0.0038 a,b	0.018 a,b
93. Isophorone	78591			35 a,b	960 a,b
94. Naphthalene	91203				
95. Nitrobenzene	98953			17 a	690 a,j

96. N-Nitrosodimethylamine	62759			0.00069 a,b	3.0 a,b
97. N-Nitrosodi-n-Propylamine	621647			0.0050 a,b	0.50 a,b
98. N-Nitrosodiphenylamine	86306			3.3 a,b	6.0 a,b
99. Phenanthrene	85018				
100. Pyrene	129000			830 a	4,000 a
101. 1,2,4-Trichlorobenzene	120821			35 a	70 a
102. Aldrin	309002	3.0 f		0.000049 a,b	0.000050 a,b
103. alpha-BHC	319846			0.0026 a,b	0.0049 a,b
104. beta-BHC	319857			0.0091 a,b	0.017 a,b
105. gamma-BHC (Lindane)	58899	0.95 r		0.012 b	0.023 b
106. delta-BHC	319868				
107. Chlordane	57749	2.4 f	0.0043 f	0.00080 a,b	0.00081 a,b
108. 4,4'-DDT	50293	1.1 f	0.001 f	0.00022 a,b	0.00022 a,b
109. 4,4'-DDE	72559			0.00022 a,b	0.00022 a,b
110. 4,4'-DDD	72548			0.00031 a,b	0.00031 a,b
111. Dieldrin	60571	0.24 r	0.056 r	0.000052 a,b	0.000053 a,b
112. alpha-Endosulfan	959988	0.22 f	0.056 f	62 a	89 a
113. beta-Endosulfan	33213659	0.22 f	0.056 f	62 a	89 a
114. Endosulfan Sulfate	1031078			62 a	89 a
115. Endrin	72208	0.086 r	0.036 r	0.059 a	0.060 a,j
116. Endrin Aldehyde	7421934			0.29 a	0.30 a,j

117. Heptachlor	76448	0.52 f	0.0038 f	0.000078 a,b	0.000079 a,b
118. Heptachlor Epoxide	1024573	0.52 f	0.0038 f	0.000039 a,b	0.000039 a,b
A		B Freshwater Aquatic Life		C Human Health (10-6 risk for carcinogens) For consumption of:	
119. Polychlorinated Biphenyls (PCBs)			0.014 q	0.000064 a,b,q	0.000064 a,b,q
120. Toxaphene	8001352	0.73	0.0002	0.00027 a,b	0.00028 a,b
Total Number of Criteria (g)		23	21	96	95

a. This criterion reflects the Environmental Protection Agency's q1* or RfD, as contained in the Integrated Risk Information System (IRIS) as of August 28, 2000. The fish tissue bioconcentration factor (BCF) from the 1980 Ambient Water Quality Criteria document was retained in each case (unless otherwise noted).

b. This criterion is based on carcinogenicity of 10-6 risk.

c. Criterion Maximum Concentration (CMC) equals the highest concentration of a pollutant to which aquatic life can be exposed for a short period of time without deleterious effects. Criterion Continuous Concentration (CCC) equals the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4 days) without deleterious effects. The term

"ug/L" means micrograms per liter.

d. Freshwater aquatic life criteria for metals are expressed as a function of total hardness (mg/L) in the waterbody. The equations are provided at paragraph (i) through (iv) of section 2. Values displayed in the table correspond to a total hardness of 100 mg/L.

e. Freshwater aquatic life criteria for pentachlorophenol are expressed as a function of pH, and are calculated as follows: Values displayed in the table correspond to a pH of 7.8. CMC = exp(1.005(pH) - 4.869). CCC = exp(1.005(pH) - 5.134).

f. This Criterion is based on 304(a) aquatic life criterion issued in 1980, and was issued in one of the following documents: Aldrin/Dieldrin (EPA 440/5-80-019), Chlordane (EPA 440/5-80-027), DDT (EPA 440/5-80-038), Endosulfan (EPA 440/5-80-046), Endrin (EPA 440/5-80-047),

Heptachlor (EPA 440/5-80-052), Hexachlorocyclohexane (EPA 440/5-80-054), Silver (EPA 440/5-80-071). The Minimum data requirements and derivation procedures used to derive the 1980 criteria were different from those in the 1985 Guidelines. For example, a "CMC" derived using the 1980 Guidelines was derived to be used as an instantaneous maximum. If assessment is to be done using an averaging period, the values given should be divided by 2 to obtain a value that is more comparable to a CMC derived using the 1985 Guidelines.

g. These totals simply sum the number of criteria in each column. For aquatic life, there are 24 priority toxic pollutants with some type of freshwater or saltwater, acute or chronic criteria. For human health, there are 99 priority toxic pollutants with either "water + organism" or "organism only" criteria. Note that these totals count chromium as one pollutant even though EPA has developed criteria based on two valence states. In the matrix, EPA has assigned numbers 5a and 5b to the criteria for chromium to reflect the fact that the list of 126 priority pollutants includes only a single listing for chromium.

h. Criteria for these metals are expressed as a function of the water-effect ratio, WER, as defined in paragraphs (vii) through (ix) of section 2. CMC = (column B1 or C1 value) x WER; CCC = (column B2 or C2 value) x WER.

i. This criterion is a fish tissue residue criterion based on a total fish consumption weighted rate of 0.0175 kg/day. See EPA-823-R-01-001

j. No criterion for protection of human health from consumption of aquatic organisms (excluding water) was presented in the 1980 criteria document or in the 1986 Quality Criteria for Water. Nevertheless, sufficient information was presented in the 1980 document to allow a calculation of a criterion, even though the results of such a calculation were not shown in the document.

k. The CWA 304(a) criterion for this compound is the MCL or drinking water action level.

l. These freshwater criteria for metals are expressed in terms of the dissolved fraction of the metal in the water column. Criterion values were calculated by using EPA's Clean Water Act 304(a) guidance values (described in the total recoverable fraction) and then applying the conversion factors in (v) and (vi) of section 2.

o. The CMC = 1/[(f1/CMC1) + (f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and CMC1 and CMC2 are 185.9 µg/l and 12.82 µg/l, respectively.

p. This water quality criterion is expressed in terms of total recoverable metal in the water column. It is scientifically acceptable to use the conversion factor (0.996 for the CMC, or 0.922 for the CCC) to convert this criterion to a value that is expressed in terms of dissolved metal. (See 40 CFR part 132.)

q. This criterion applies to total PCBs (that is, the sum of all homolog, all isomer, all congener, or all Aroclor analyses).

r. This criterion has been recalculated pursuant to the 1995 Updates: Water Quality Criteria Document for the Protection of Aquatic Life in Ambient Water, Office of Water, EPA-820-B-96- 001, September 1996. See also Great Lakes Water Quality Initiative Criteria Document for the Protection of Aquatic Life in Ambient Water, EPA-80-B-95-004, March 1995.

s. This water quality criterion is expressed as µg free cyanide (as CN)/L.

Table 8. Limits of pollution for various nutrient parameters, MSAE, and microcystin toxins.

Water Quality Parameter	**Recognized Pollution Level**
Total Nitrogen (TN) (mg/L)	0.2 mg/l
Total Phosphorus (TP) (mg/L)	0.035 mg/l
Periphyton Chlorophyll *a* (mg/m^2)	150 mg/m^2
Microcystis aeruginosa cell count	<1,000 cells/ml
Microcystin Toxin	0.8 □g/l

Table 9. Precision of sampling equipment used by KTWQP.

Matrix	**Parameter**	**Measurement Method**	**Precision**	**Accuracy**	**Measurement Range**
Water	Temperature	Onset HOBO Water Temp Pro Loggers	±0.2°C at 0° to 50°C (±0.36°F at 32° to 120°	±0.2°C at 0° to 50°C (±0.36°F at 32° to 120°	0° to 50°C (32° to 122°F) in water (non-freezing)
Water	Temperature	YSI 6600 MPS Multi Probe System: YSI Precision ™ Thermistor	0.1°C	± 0.15°C	-5 to 60°C

Water	Temperature	YSI EXO2 MPS Multi Probe System: YSI Precision ™ Thermistor	0.001°C	±0.01°C at 5° to 35°C and ±0.05°C at 35° to 50°C	-5 to 50°C
Water	pH	YSI 6600 MPS Multi Probe System: YSI Glass Combination electrode	0.01 units	±0.2 units	0 to 14 units

Matrix	**Parameter**	**Measurement Method**	**Precision**	**Accuracy**	**Measurement Range**
Water	pH	YSI EXO2 MPS Multi Probe System: YSI Glass Combination electrode	0.01 units	±0.1 pH units within ±10˚C of calibration temp	0 to 14 units
Water	Dissolved Oxygen	YSI 6600 MPS Multi Probe System Steady state polarographic	0.01 mg/L	±2% @ 0 to 20 mg/L ±6% @ 20 to 50 mg/L	0 to 50 mg/L
Water	Dissolved Oxygen	YSI EXO2 MPS Multi Probe System Steady state polarographic	0.01 mg/L	±1% @ 0 to 20 mg/L ±5% @ 20 to 50 mg/L	0 to 50 mg/L

Water	Conductivity	YSI 6600 MPS Multi Probe System: YSI 4electrode cell with autoranging	0.001 mS/cm to 0.1 mS/cm rangedependent	± 0.5% + 0.001 mS/cm	0 to 100mS/cm
Water	Conductivity	YSI EXO2 MPS Multi Probe System: YSI 4electrode cell with autoranging	0.001 mS/cm to 0.1 mS/cm rangedependent	±0.5% @ 0 to 100 mS/cm ±1% @ 100 to 200 mS/cm	0 to 200mS/cm
Water	Turbidity	YSI 6600 MPS Multi Probe	0.01 NTU	± 2%	0-1000 NTU
Water	Turbidity	YSI EXO2 MPS Multi Probe	.01 FNU @ 0 to 999 FNU 0.1 FNU @	±2% @ 0 to 999 FNU ±5% @ 1000	0-4000 FNU
Matrix	**Parameter**	**Measurement Method**	**Precision**	**Accuracy**	**Measurement Range**
			1000 to 4000 FNU	to 4000 FNU	
Water	Blue Green Algae, Phycocyanin	YSI EXO2 MPS Multi Probe	0.01 µg/L; 0.01 RFU	**Linearity:** R^2 >0.999 for serial dilution of Rhodamine WT solution from 0 to 100 µg/mL BGAPC equivalents	0 to 100 µg/L; 0 to 100 RFU

Table 10. Nutrient, phytoplankton, and algal toxin parameters and the laboratory to which each will be shipped for analysis.

Parameter	Laboratory	Method	Reporting Limit (mg/L)	MDL (mg/L)
Total Phosphorus	AR	SM18 4500PF	0.002	0.002
Soluble Reactive Phosphorus	AR	SM18 4500PF	0.001	0.001
Total Nitrogen	AR	SM204500NC	0.100	0.045
Nitrate + Nitrite	AR	SM 184500NO3F	0.010	0.005
Ammonia	AR	SM 184500NH3H	0.010	0.006
Chlorophyll *a* / Pheophytin *a*	AR	SM1810200H	0.0001	0.0001
Phytoplankton speciation and enumeration	AA	APHA Standards	NA	
Total Organic Carbon	AR	SM205310B	0.250	0.095
Total Suspended Solids	AR	SM20 2540D	0.50	0.30
Volatile Suspended Solids	AR	SM20 2540E	0.50	0.40
Alkalinity	AR	SM182320B	1.00	0.20
Carbonaceous Biochemical Oxygen Demand	AR	SM20 5120B	2.00	1.00
Microcystin-LR	US EPA	ELISA	1.8 □g/l	1.8 □g/l
Microcystin (LR,LA,YR,RR,LF,LW) Anatoxin-a	GreenWater Laboratories	LC-MS/MS	1.0 □g/l	1.0 □g/l

Table 11. Laboratory methodologies, containers, preservatives and holding times.

Parameter	**Method**	**Containers (number, size/volume, type)**	**Preservation Requirements (chemical, temperature, light protection)**	**Maximum Holding Times**
Total Phosphorus	SM18 4500PF	1 X 250ml, polyethylene bottle	4C	28 Days
Soluble Reactive Phosphorus	SM18 4500PF		4C	48 hours
Total Nitrogen	SM204500NC		4C	28 days
Nitrate + Nitrite	SM184500NO3F		4C	48 hours
Ammonia	SM184500NH3H		4C	48 hours
Alkalinity	SM18 2320B		4C	14 days
Chlorophyll *a* / Pheophytin *a*	SM1810200H	1 X 1L, polyethylene bottle	4C	
Total Organic Carbon	SM205310B	1 X 100ml, amber glass bottle	4C	28 day
Dissolved Organic Carbon				
Total Suspended Solids	SM20 2540D	1 X 1L, polyethylene bottle	4C	7days
Volatile Suspended Solids	SM20 2540E			
Microcystin (GreenWater)	Anatoxin, LCMS/MS	1 X 250ml, clear glass bottle	Freeze and ship at <4C	14 days
Microcystin (EPA)	ELISA	1 X 60ml, clear glass bottle	Freeze and ship at <4C	14 days
Carbonaceous Biochemical Oxygen Demand	SM20 5120B	500ml, polyethylene bottle	4C	48 hours

Table 12. Summary of Field and QC Samples for Karuk Tribe Water Monitoring Program.

Matrix/ Media	Analytical Parameter[1]	No. of Sampling Locations	Depth (surface, mid, or deep)[1]	No. of Field Duplicates[2]	Inorganics No. of[4]		No. of Field Blanks[5]	Total No. of Samples
					Dup	MS		
Analysis:								
Surface Water	Total Phosphorus	8	Surface	4	1	1	1	49
Surface Water	Dissolved Phosphorus	8	Surface	4	1	1	1	49
Surface Water	Total Nitrogen	8	Surface	4	0	0	1	47
Surface Water	Ammonium Nitrogen	8	Surface	4	1	1	1	49
Surface Water	Nitrate + Nitrite	8	Surface	4	1	1	1	49
Surface Water	Phytoplankton	8	Surface	4	10% of samples		1	51
Surface Water	Chlorophyll	8	Surface	4	1	1	1	49
Field Measurements:								
Surface Water	Temperature	16	Surface	4			0	46
Surface Water	pH	16	Surface	4			0	46
Surface Water	Conductivity	16	Surface	4			0	46
Surface Water	Turbidity	10	Surface	4			0	46

[1] Samples will be collected at depth of 6-12 inches. If depth of water is less than 12 inches, sample will be collected at mid depth and noted in the field logbook.

[2] Field duplicates will be collected at a frequency of 10% of the samples collected for laboratory analysis. Field duplicates will be collected at a frequency of 10% or one per day, whichever is more frequent, for samples collected for field measurements.

[4] Includes number of associated analytical QC samples if collection of additional sample volume and/or bottles is necessary. If the QC samples listed are part of the analysis but no additional sample volume and/or bottles are needed, include “NAS” (for

Surface Water	Dissolved Oxygen	16	Surface	4			0	46

[1] All analyses will be performed at an off-site laboratory. There will be no field screening analyses. Field measurements will be performed at each sample collection location.

"no additional sample") in the column. (Note: MS=matrix spike, MSD=matrix spike duplicate, dup=laboratory duplicate/replicate.)

[5] Field blanks will be collected at a frequency of 10% of the samples collected, or one per day, whichever is less frequent. Field blanks will not be collected, as they were determined not to be critical, to support laboratory analysis of Total Dissolved Solids, alkalinity, total coliform, e. coli or for field measurements.

Table 13. Field Equipment Calibration, Maintenance, Testing, and Inspectio.n

Analytical Parameter	Instrument	Calibration Activity	Maintenance & Testing/ Inspection Activity	Frequency	Acceptance Criteria	Corrective Action
Temperature (Sensor)	6600 and EXO2 MPS Multi Probe System: YSI Precision ™ Thermistor		See Manufacturer's manual	Initial Post: Once a week check and calibrate as needed	± 0.15°C of true value at both endpoints	Remove from use if doesn't pass calibration criteria
Temperature (Sensor)	Onset HOBO Water Temp Pro Loggers	Water bath calibration against NIST thermometer (US Fish and Wildlife Protocol)	See Manufacturer's manual	Initial	±0.2°C of true value at both endpoints	Remove from use if doesn't pass calibration criteria
pH (electrode)	6600 and EXO2 MPS Multi Probe System: YSI Glass Combination electrode	Initial: Twopoint calibration bracketing expected field sample range (using 7.0 and 10.0 pH buffer)	See Manufacturer's manual	Initial and bi-weekly (every other week)	Initial: Two-point calibration done electronically	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria.

		Post: singlepoint check with 7.0 pH buffer			Post: ±0.1 pH units of true value	
Dissolved oxygen (sensor)	6600 and EXO2 MPS Multi Probe Optical Sensor	Initial: Onepoint calibration with saturated air (need temp, barometric pressure). Post: singlepoint check at full saturation	See Manufacturer's manual	Initial and bi-weekly (every other week)	Initial: Onepoint calibration done electronically Post: ±0.5 mg/L of true saturated value	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria.
Turbidity (sensor)	YSI 6600 and EXO2 MPS Multi Probe System	Initial: Onepoint calibration using 0 NTU (or deionized water) Post: singlepoint check at 0 NTU	See Manufacturer's manual	Initial and bi-weekly (every other week)	Initial: Onepoint calibration done electronically Post: ±1 NTU of true value	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria.
Conductivity (sensor)	YSI 6600 and EXO2 MPS Multi Probe System: YSI 4electrode cell with autoranging	Initial: One-point calibration at high end of expected field sample range (1000 mS/cm standard) Post: two-point check with high (1000 mS/cm) and low (0 mS/cm) standards	See Manufacturer's manual	Initial and bi-weekly (every other week)	Initial: one point calibration done electronically Post: high standard ±5% of true value and low standard ±10% of true value	Recalibrate; Qualify data. Remove from use if doesn't pass calibration criteria.

APPENDIX C

Field Operations and Sampling Forms

ISCO Program - Bottle Retrieval - Field Form

Sample Date	Sample Time	PST / PDT?	Bottle Number

General Notes:

Next Sample Programmed (periodic) Date/Time: _____

Trigger Parameter (episodic) Date/Time: _____

Trigger Level (ft?, FNU? Etc.): _____

Intitials: _____

Field Inspection Sheet - Total Load Sediment

Station Number:		**Date:**			
Station Name:					
Party:		**Weather:**			
Flow:		**H20 Temperature:**		°C	
Meas. Type:		**Stage:**			
Location:			**gage.**		
Sampler Type (84164):					
Nozzle Size:					
		ISOKINETIC SAMPLE?:			

Discharge Measurement Details:									
Width:		**Area:**		**Velocity:**		**Gage Height:**		**Discharge:**	

ONLY FILL OUT SEDIMENT CHANNEL EDGE OF WATER LOCATIONS AND NUMBER OF VERTICALS IF SAMPLING VIA EWI

Sediment Channel REW		**Sediment Channel LEW**		**Sediment Channel Width**		**Number of Verticals**	

SUSPENDED SEDIMENT									
Method (82398)	Station	Start Time	Finish Time	Number of Bottles	Set	Number of Verticals	Recorded GH	WW/OSS	Analysis Requested

Observer Contacted:		**USGS Therm:**		°C	**Cases**		
Thermometer Checked:		**Observer Therm:**		°C			

Remarks: _____

_____

SedLogin Notes:

APPENDIX D

Standard Operation Procedures SSC Plan

Suspended Sediment Sampling – SOP

Klamath River water quality monitoring and SSC sampling

General order of operations at the site

ISCO automated sampler servicing

1. Pause program & collect sample time information
    a. Option 1. Download program / sample log to a computer
    b. Option 2. Fill out ISCO sample history field form as you page through the ISCO or datalogger display
2. Put on gloves as you handle bottles
3. Cap and label bottles with date/time or appropriate information to match sample date/time to bottles back in the office
4. Remove full bottles one by one as you label them with appropriate sample time from log/sheet
5. Replace full bottles with capped empty/clean bottles one by one in tray
6. When done handling all the full / empty bottles, change gloves
7. Uncap empty bottles, store clean caps in ziplock in gagehouse for next visit
8. RESART the program (you may leave it unstarted during EDI sampling so you can get before/after EDI grabs)

Discharge Measurement (if needed)

1. Complete a gage inspection and obtain initial GH readings using SVMAQ
2. Complete a discharge measurement with an ADCP and obtain the EDI stationing information for the EDI sample using QRev
3. Enter the Qm info as you normally would in SVMAQ
4. If an EDI rating has been developed based on rated Q and you are not able to make a Qm, EDI stations can be obtained from the rating.

Equal Discharge Increment (EDI) Sediment Sampling

NOTE: if water temp is <10degC and you are using a bag sampler, see 2013 memo for revised transit rates (policy_memos folder)

"Although a given one-way transit rate must be constant, neither the descending and ascending transit rates in any one vertical need to be equal nor do the transit rates need to be equal among verticals. The number of transits in each vertical can vary if no sample bottle overfills. Although different diameter nozzles for the isokinetic sampler can be used from vertical to vertical, it may complicate the data collection procedure, hence, the practice is discouraged."

"If an equal amount of sample is collected at each vertical, the samples can be composited and analyzed as a single sample. However, to realize the full benefits of the EDI method, samples should be analyzed separately and the resulting SSC values summed and then divided by the number of subsections to derive a mean water discharge-weighted SSC. One advantage of this method is that data describing the cross-sectional variation in SSC are produced. Additionally, a bottle containing an abnormal amount of

sediment – particularly sand – compared to others in the set (because of recirculation or to gouging the nozzle into the bed) can be identified and excluded from the calculated mean cross-sectional SSC to minimize the potential for bias"

1. Collect an ISCO Grab sample prior to the START of sampling
    a. Fill a 3-liter bottle if turbidity is <10 FNU from EXO reading
2. Note the time of the grab on the ISCO bottle
3. Collect the EDI sample (set A & B)
    a. Do an intake efficiency test if you are using a D-96 bag sampler (see tab in this sheet)
    b. Select appropriate transit rate and/or nozzle to fill each bottle for each veritcal with roughly the same volume
        i. See transit rate tables, use rule of thumb = 0.4 x mean velocity = transit rate in sec/ft
        ii. If using transit rate tables in ft/sec, divide 1 by rate to get sec/ft on B reel, e.g., transit rate is 2 ft/sec from table, then 1/2 = 0.5 and transit rate on B reel is 0.5 sec/ft or 1 sec for every two feet as you are reeling/watching on the B-reel dial
        iii. BEGIN SAMPLNG: Lower field-rinsed sampler at the predetermined constant transit rate until slight contact is made with the streambed. **Do not pause** upon contacting the streambed. Raise the sampler immediately until sampler completes the vertical traverse.
            1. Take care not to disturb the streambed by bumping the sampler on it; bed material may enter the nozzle, resulting in erroneous data.
            2. Do not overfill the sampler container.
            3. Inspect each subsample as it is collected, looking for overfilling or underfilling of the sampler container and (or) the presence of anomalously large amounts of particulates that might have been captured because of excessive streambed disturbance during sample collection.
            4. If the sampler is overfilled or the nozzle digs into the streambed, dump sample and re-collect sample starting at the first vertical from the previous sample
            5. Transit rates can vary when lowering and raising through the water column, so long as the transit rate does not exceed the velocity of the water, and that the same volume is collected at each sampling location in the cross section.
        iv. Move sampling equipment to the next vertical. Collect sample.
    c. For A-set samples, retain all containers from each EDI station (minimum 5 locations)
    d. For B-set samples, composite all of the samples from individual EDI stations into 3-L bottles, or whatever size bottle will hold all of the sample
    e. <u>For SedLogin:</u> Analyze the A-set containers individually, Analyze the B-set samples as a composite with particle size distribution
4. Collect an ISCO Grab sample in the ~middle of sampling
5. Note time for each vertical as you are sampling
6. Collect an ISCO Grab sample prior to the END of sampling
    a. Fill a 3-liter bottle if turbidity is <10 FNU from EXO reading

7. Complete sample, and fill out bottle labels and field sheet fully (see “SSC_fieldsheet.pdf”)

Equipment List

1. ISCO form
2. ISCO computer cable
3. Axiom computer cable
4. ISCO labels and pens
5. Ziplocks
6. Gloves
7. Clean ISCO bottles
8. 3L grab sample bottle (<10 FNU EXO Turb)
9. Appropriate sediment sampler for expected conditions
    a. Light samplers: DH-48, DH-59, DH-81, DH-95
    b. Heavy samplers: D-74, D-95, D-96
10. A-reel, B-reel, or E-reel
11. Nozzles (3/16”, ¼”, 5/16”)
12. Appropriate sediment bottles and carrier (3-L, 1-L, glass quart, glass pint)
13. 4-wheel crane and counterweights (if site conditions require)
14. Boom truck and crane (if site conditions require)
15. Boat (if site conditions require)

1. Pre-trip preparation

- Load equipment listed above
- Ensure all manuals are available on tablet
    - ISCO
    - AXIOM
    - SatLink3
    - EXO
    - Analite

Continuous Water Quality Monitors – SOP

Klamath River water quality monitoring and SSC sampling

I. ANALITE high-range turbidity service Protocols

1. Place cal-checked Analite NEP5000 from the office adjacent to deployed sensor
2. Wipe both sensors (field and site)
3. Obtain pre-clean readings, enter in SVMAQ
4. Remove deployed sensor, clean it.
    a. Q-tip on optics face and wiper
    b. Tooth brush or similar on sensor body and cable
    c. Chimney brush to clean deployment tube
    d. Long pool brush or similar to clean outside of deployment tube
    e. Inspect wiper, inspect wiper position ensure it is normal (about 190deg from the optics, or slightly more than 180deg from optics)
    f. Look for scratches on optics face
5. Replace cleaned site sensor in cleaned deployment tube
6. Obtain post-clean readings, enter in SVMAQ
7. Quarterly Cal Checks:
    a. Remove cleaned sensor again from deployment tube
    b. Check in 0 DI water after rinsing 3 times in DI water
        i. Rinse again and check again in DI water if readings are >1.5 FBU above/below zero (FBU = formazin backscatter unit, which is what this sensor measures in, not NTU)
    c. Check in 5000 NTU (really FBU) standard after rinsing 3 times
        i. Use previously used standard to triple rinse, dump out in waste container
        ii. Use new standard to check, and pour out in rinse container for next rinse
    d. Record cal check readings in SVMAQ, cover the range of conditions with polymer (e.g., if conditions <5000 FBU, you do not need to use 10000 or 30000 to check)
    e. DO NOT recalibrate in the field
    f. Swap in the spare sensor if:
        i. >1.5 FBU different from zero DI after several attempts to ensure proper rinsing
        ii. >5% off in 5000 or other polymer standard, will be alerted in SVMAQ by orange data
    g. If spare sensor is swapped in, cal check the old sensor again in the office and recalibrate as necessary.

II. EXO Service Protocols

California sites – Operated by Karuk and Yurok Natural Resources Departments

1. In general, it has been agreed that the Karuk tribal members will perform cal checks on EXOs.
2. Deploy cal-checked field EXO from the office
3. Enter pre-clean readings in SVMAQ for the field and site EXOs
4. Clean the deployed EXO (see below) and re-deploy
5. Enter post-clean readings in SVMAQ

6. Save SVMAQ file and send to Karuk email members
7. Let Karuk know if calibration appears off after cleaning, i.e., there is large disagreement in post-clean readings

Oregon Sites – Operated by U.S. Geological Survey

Cleaning YSI EXO2 sondes in the field

1. Place cal-checked YSI EXO from the office adjacent to deployed sensor
2. Wipe both sensors (field and site)
3. Obtain pre-clean readings for all water quality parameters, enter in SVMAQ
4. Remove deployed sensor, clean it.
    a. Q-tip on optics face and wiper
    b. Tooth brush or similar on sensor body and cable
    c. Chimney brush to clean deployment tube
    d. Long pool brush or similar to clean outside of deployment tube
    e. Inspect wiper, inspect wiper position ensure it is normal (about 190deg from the optics, or slightly more than 180deg from optics)
    f. Look for scratches on optics face
5. Replace cleaned site sensor in cleaned deployment tube
6. Obtain post-clean readings, enter in SVMAQ

Quarterly Calibration checks

Calibration of deployed EXO2 sondes will occur approximately quarterly at USGS-operated continuous water quality monitoring sites. When calibration checks reveal only a small amount of calibration drift, it may not be necessary to recalibrate the instrument. Calibration criteria will be used to determine if sensor require re-calibration (Table 1). In practice, a calibration check of cleaned sensors using calibration standards is compared to the calibration criteria. If calibration drift is within the calibration criterion, the sensor is considered stable and recalibration is not required (Wagner and others, 2006)

[±, plus or minus value shown; °C, degree Celsius; µS/cm, microsiemens per centimeter at 25 °C; %, percent; mg/L, milligram per liter; pH unit, standard pH unit; turbidity unit is dependent on the type of meter used]

Measurement	Calibration criteria (variation outside the value shown requires recalibration)
Temperature	±0.2 ºC
Specific conductance	±5 µS/cm or ±3 % of the measured value, whichever is greater
Dissolved oxygen	±0.3 mg/L
pH	±0.2 pH unit
Turbidity	±0.5 turbidity unit or ±5% of the measured value, whichever is greater

Table 1: Calibration criterion for continuous water-quality monitors (Wagner and others, 2006)

If calibration checks result in re-calibration of sensors, the following procedures will be followed:

Before Calibrating

1. Clean all probes with the correct brushes (Kimwipe for DO and Phycocyanin probe, SC brush for SC probe, pipe cleaner for pH Probe) before calibrating. Clean the body of the probes and any other surfaces inside of the calibration cup with a toothbrush
2. Check that all the probes are tight. They should be tight, **but not torqued.**

Preparation:

1. Use the lab calibration cup and probe guard for all calibrations and checks.
2. Prepare sonde for dissolved oxygen (DO) calibration. Remove the calibration cup, probe guard and the probe guard end-cap with holes, exposing the sensors. Carefully dry the temperature and DO probe surfaces using a Kimwipe, **do not use condensed air to dry the DO probe.**
3. Replace the black probe guard, minus the holy end-cap, over sensors (removing end-cap now will aid in further rinses later on) without wetting the DO or temperature probe tips. (Note the different threads on each end of the probe guard & match accordingly, the finer threads correspond with the sonde body). Be careful not to cross-thread as the plastics are soft.
4. With the calibration cup still detached and resting on the benchtop, add approximately 1 inch of tap water.
5. Mount the sonde vertically (probes pointed downward) by carefully placing the sonde into the water filled calibration cup, but carefully without wetting the DO or temperature probe tips. The sonde's probes should now be hovering above the water in the calibration cup.
6. Loosen the calibration cup almost completely. This will ensure that the barometric pressure inside the cup is the same as the pressure outside of the cup. **It is important to wait at least 15 minutes** for the temperature reading to stabilize and for the air inside the calibration cup to become 100% water-vapor saturated before calibrating the DO probe.

Connecting to EXO Sondes: (Via PC Notebook)

1. Activate the Bluetooth connectivity of the sonde by holding the associated magnetic wand tool (or any magnet) over the magnet symbol on the sonde.
2. The solid Blue LED light on the sonde should now be on, displaying the sonde's Bluetooth is active (a Red LED should also be blinking letting the user know the sonde is now 'awake').
3. Open the KOR-EXO software on the Desktop.
4. Connect to the EXO sonde via Bluetooth (if PC is Bluetooth capable & allows devices to connect) by selecting the "Connections" menu (Green/Blue Circling arrows) and selecting the "Rescan" button on the left. If the computer you are using before has connected to this EXO before it will pop up here. If not, then, select the "Search Bluetooth" button. This will "Discover Devices" and sometimes multiple attempts are required. Select your sonde and "Connect". **Note: The sonde Bluetooth range is rated at 30 feet, but 10 feet is more realistic to prevent problems initially connecting.**
5. If the Bluetooth does not work for some reason, you can connect to the EXO sonde via the USB Signal Output Adapter to the sonde's upper right 6-pin communications port and to the laptop's associated (COM) USB port.
6. Sonde is now connected and it's corresponding model & S/N will now be displayed in a box in the upper right-hand of KOR (sonde connection is also displayed by the sonde symbol having a green check mark). You will also be automatically take you the "Dashboard" screen (Green Runner) with the various sensor parameters displayed. Proceed to calibrations.

Dissolved Oxygen Calibration:

1. After sonde "Preparation" for DO (as described above) and at least 15 minutes, it is time to calibrate.
2. Check that the temperature and DO readings are stable via the Dashboard (Runner Icon). The temperature may change very slowly (e.g. one-hundredth of a mg/L every 10 seconds or so), but this is stable enough.
3. To determine what value to calibrate to, enter in pressure and temperature in CHIMPS or SVMOBILE, where the value will auto populate.
4. Navigate to the Calibration screen (Crosshair symbol) to begin the calibration sequence. Select "Port-3 ODO" and then select "ODO mg/L". A "Device Calibration" window will now appear in a separate window.
5. Select "1 Point" calibration and enter the value from the DO concentrate on table into the "Standard Value" box.
6. "Sal psu" value should be '0'. DO NOT ENGAGE WIPE SENORS.
7. Select "Start Cal". Real time readings will be displayed. Once the values have stabilized (green "Stable Data") Select "Apply" and then "Complete".
8. A "Calibration Summary" for DO will now be provided.
   Record the calibration DO values and also the ODO Gain value from this summary. DO gain should be somewhere between 0.85 and 1.15. If the gain is drastically out of range, or the QC score has a red 'X' or yellow '!' the DO probe may need to be serviced or replaced. Otherwise, go by the QC score in the calibration summary, a 'green check' should be displayed in the summary indicating proper probe function.

9. Verify the calibrated value is equal to the value you entered for the sensor to calibrate to.
10. Next, remove the calibration cup so it's just the probe guard and place the sonde in the 100% air-saturated water bucket.
11. View real time readings by selecting the Dashboard. At the top right of the screen, select "Wipe Sensors" and wait for the sensors to be cleaned. This will remove air bubbles from the ODO probe.

12. After the DO reading has stabilized, record the temperature reading of the water and check that the barometric pressure has not changed.
13. Use the DO table in the lab folder to find the DO mg/L value the sonde should read in the 100% air-saturated water.
14. Record the DO mg/L value the sonde reads in the water in the comments section in CHIMPS or SVMOBILE. If the sonde reads outside the range of ± 0.06 mg/L of the DO concentration table value, the DO sensor needs to be recalibrated.

Notes about the YSI ROX Optical DO probes:

- The Optical Dissolved Oxygen sensor does not require any special sonde setup or burn-in.
- Calibration data is stored in the probe so it can be calibrated in one sonde and then used in another without recalibrating the probe in the new sonde.
- Calibration data are automatically transferred to the host sonde as soon as the sonde powers up the sensor.
- Field DO calibrations should be avoided!
- The DO sensor must remain hydrated at all times.

If you believe that you have calibrated a probe in error, then you can return the probe back to its original factory calibration by using the "uncal" command. At the "Device Calibration" screen where you would type in the "Standard Value" for a DO calibration, press the "Advance" button in the lower left and select the "uncal" button.

Specific Conductance (SC) (Combined with Temperature on same probe):

1. Reinstall the calibration cup onto the sonde body. **Note: Make sure the threads are nice and tight! As this is a compression fitting and sonde could slip loose from cup and crash.**
2. Rinse the calibration cup (accessed via the calibration cup's endcap) and sensors vigorously three times with a small amount of 1000 µS/cm standard solution and discard. Use the bottles labeled "flush" for these rinses. Shake the sonde each time to rinse all surfaces in the cup with the standard flush solution.
3. Put *FRESH* 1000 µS/cm standard solution in the cal cup, **just enough to submerge the SC sensor completely when the sonde is laid on its side. Use the least amount of solution as possible, as this stuff is expensive!!!** The vent holes in the side of the probe must be under the solution. It is important not to have trapped bubbles in the cells. Gently shake the sonde to help dislodge any air bubbles that may be trapped in the conductivity sensor.
4. Navigate to the Calibration screen (Crosshair symbol) to begin the calibration sequence. Select "Port-1 Conductivity" and then select "SpCond µS/cm ". A "Device Calibration" window will now appear in a separate window.
5. Enter the value of 1000 µS/cm as your "Standard Value." Make sure the probe is fully submerged in standard and clear of bubbles to proceed with "Start Cal".
6. Select "Start Cal." Real time readings will be displayed. Once the values have stabilized (green "Stable Data") Select "Apply" and then "Complete".
7. A "Calibration Summary" for SC will now be provided.
8. Record the values, and don't forget the cell constant value which will be listed under "Additional Post Calibration Info."

1. Check the conductivity cell constant is in a somewhat acceptable range of 4.5 - 6.5. Numbers drastically outside of this range may indicate a problem in the calibration process, with the standard that was used or that the sensor needs to be serviced or replaced. Otherwise, mainly go by the QC score in the calibration summary, a 'green check' should be displayed in the summary indicating proper probe function. A red 'X' or yellow '!' indicate the probe may need to be serviced or replaced.
9. If the sonde reports "Out of Range" after the calibration, investigate the cause! Never override a calibration error message without knowing the reason. Typical causes for this error message are incorrect entries, low solution level, fouled probe contacts, air bubbles in the probes cell, calibrating conductivity instead of specific conductance (SpCond), and/or bad standard or the sensor needs to be serviced or replaced.
10. Pour the standard solution used for calibration into the 1000 µS/cm bottle marked "flush."
11. Proceed to the Dashboard menu to check the SC calibration in 180 µS/cm and 50 µS/cm standards. Starting with the 180 µS/cm standard, rinse the probes and calibration cup three times with each standard (flush). Fill the cup to cover the SC probe with *FRESH* solution, and record the measured values.
12. Record the lot numbers of the FRESH standards used.
13. Pour the solution used to check the SC calibration into the appropriate flush bottles. The sonde SC should read within ± 3 µS/cm of the measured value of the check standards. If a check standard is out of range, first try tapping or shaking the sonde to get air bubbles out of the conductivity sensor. If that does not work, try to re-flush with the same standard. If that does not work, clean the SC probe with a conductivity brush and repeat the calibration in the 1000 µS/cm standard solution.
14. Dry the SC probe and record the SC value in air using canned air. This should be between 0 and 1 µS/cm. If a different value is found, try blowing through the probe with compressed air to remove any remaining solution. If the SC reading is 2 µS/cm or less, the probe is acceptable for deployment. If it reads higher than this, try re-calibrating the probe, or try cleaning the SC probe ports with a dilute Liquinox solution and a conductivity brush. If the probe still does not read below 2 µS/cm, replace the probe.

Notes about the SC/Temperature sensors:

- The accuracy of the **reference** temperature probe must be checked by comparison with a traceable thermometer (NIST). Temperature compensation is used in every sonde measurement, so its accuracy should be verified and recorded. These thermistor checks should be done quarterly at 5 temperatures. More verifications may be needed if there is evidence the probe is not working properly.
- Never calibrate with conductivity standards that are less than 1000 µS/cm. You are setting the slope on a linear device, so a good strong conductivity signal will give the best performance.

pH

1. Rinse the calibration cup (accessed via the calibration cup's endcap) and sensors three times with a small amount of pH 7 buffer flush. After the three rinses, fill the calibration cup with just enough *FRESH* pH 7 standard so that the pH and temperature sensors are completely immersed when sonde is laid on its side**. Use the least amount of solution as possible, as this stuff is expensive!!!**. Check that there are no bubbles in contact with the bulb of the pH sensor.
2. Record the lot number of the FRESH pH 7 standard.
3. Make sure before you start the calibration process that the pH value is stable. Usually, 2-3 minutes is needed for the values to become stable, as the values slowly drift.
4. After confirming the pH values are stable, navigate to the Calibration screen (Crosshair symbol) to begin the calibration sequence. Select "Port-2 pH" and then select "pH". A "Device Calibration" window will now appear in a separate window.

5. Select a '2 Point" calibration
6. Wait for the temperature reading near the left to stabilize, and record the temperature. (This will be the temperature used to correct for both pH 7 and pH 10)
7. Enter the temperature information into SVMOBILE or CHIMPS, the program will auto populate the correct value to calibrate to.
8. Begin the calibration sequence for pH by selecting "Start Cal". Real time readings will be displayed for pH 7. Once the values have stabilized (green "Stable Data") Select "Apply" and then "Proceed". **Note: The "Proceed" button actually finalizes the calibration for pH 7. Do not proceed to pH 10 before selecting "Proceed".**
9. A "Proceed to Standard: 10 pH" prompt will appear.
10. **BEFORE YOU CONTINUE** – rinse the probes and calibration cup three times with pH 10 flush solution and fill with FRESH pH 10 standard solution to completely cover the pH probe.
11. Press "Ok"
12. Real time readings will be displayed for pH 10. Once the values have stabilized (green "Stable Data") Select "Apply" and then "Complete".
13. A "Calibration Summary" for pH will now be provided.
2. Record the values, along with pH millivolts for each calibration point via the summary. The acceptable millivolt output for the pH 7 buffer is around 0 ± 35 mv. The acceptable millivolt output for the pH 10 buffer is around -180 ± 35 mv. Otherwise, mainly go by the QC score in the calibration summary, a 'green check' should be displayed in the summary indicating proper probe function. A red 'X' or yellow '!' indicate the probe may need to be serviced or replaced.
3. Record the "Delta Slope" of the sensor from the summary (Delta Slope value will be listed under "Additional Post Calibration Info"). This is the calculated difference (in mv) between the two calibration points that were used. For example, if you record +3 mv for the pH 7 buffer and -177 mv for the pH 10 buffer, the slope would be 180. The acceptable range for the slope is 165 to 180. If the difference is out of this range but the QC score checks out OK then the probe is probably OK, but this is usually a sign that the probe tip needs to be replaced soon.

Notes about the pH sensor:

- Do not use a probe that has given the warnings "Calibration Error" or "Out of Range."

Turbidity

1. Clean the optics of any fouling, fingerprints, etc.
2. Start with the 0 FNU standard (DI Water). Rinse the calibration cup and probes three times with DI water.
3. Fill the calibration cup, very carefully down the side of the cup, with DI water. Be very careful, avoiding aerating the water at all. **THERE SHOULD BE NO BUBBLES!**
4. Replace the 'end cap'. Carefully invert sonde into the upright position, resting it on its 'end cap'. Verify that there are no air bubbles on the probe face and engage the wiper (if applicable). If bubbles remain on the probe surface, engage wipers again (via the Dashboard Menu- Wipe Sensors) or replace with fresh DI water.
5. Navigate to the Calibration screen (Crosshair symbol) to begin the calibration sequence. Select "Port-5 Turbidity" then "Turbidity FNU" and select "2-Point" Calibration.
6. Enter 0 FNU for the first calibration point (DI Water). Also, enter your value of the formazin standard you will be using for the second calibration point, replacing the "NaN" value. (This standard value is up to the user and is typically based on the environmental water conditions that will be expected in the field.)

7. Begin the calibration sequence for turbidity by selecting “Start Cal”. Real time readings will be displayed for the DI value. Once the values have stabilized (green “Stable Data”) Select “Apply” and then “Proceed” to calibration point 2 or 2.
8. BEFORE YOU CONTINUE – rinse the probes and calibration cup three times with your formazin flush solution and then fill with FRESH formazin standard solution to completely cover the pH probe when in the upright right position.
9. Return the sonde to its upright vertical position. Press “Ok”
10. Real time readings will be displayed for your formazin standard. Once the values have stabilized (green “Stable Data”) Select “Apply” and then “Complete”.
11. A “Calibration Summary” for Turbidity will now be provided.
12. Record the “Pre” and “Post” FNU values for both points onto your Calibration Form. Circle Y under Cal? on your Calibration Form.

Notes about the turbidity sensor:

- Never override a calibration error message without understanding the cause of the problem. Error messages indicate that a problem exists that could result in incorrect field readings.
- The calibration of YSI turbidity sensors must be done with either YSI distributed standards, Hach StablCal, diluted Hach 4000 NTU Formazin, or standards that have been prepared according to the instructions in Standard Methods (Section 2130B). Standards from other vendors are NOT approved, and their use will likely result in a bad calibration and incorrect field readings.

- When a sonde is deployed in clean water and it reports negative turbidity data, the cause can usually be traced to the zero calibration. Despite the best practices it is sometimes impossible to clean the sonde and the calibration equipment to a point where the zero standard is not contaminated by some small amount. This is especially true when using previously deployed equipment.

III. Equipment List

- Chimney brush
- Pool brush
- Qtips
- Toothbrush
- Tablet with synced SVMAQ
- Cal-checked reference sensor EXO and/or Analite
- Calibration standards for pH and specific conductance
- 0 DI water from HIF
- 5000 polymer standard (Analite only)
- 10000 polymer standard (Analite only, if needed)
- 30000 polymer standard (Analite only, if needed)
- Cal cup (250 mL brown HDPE wide mouth bottles)
- Waste container (containerize used calibration standards)
- Rinse container for polymer standards (one per standard)

IV. Pre-trip preparation

- Calibrate field EXO/Analite
- Load equipment listed above
- Ensure all manuals are available on tablet
    - ISCO
    - AXIOM
    - SatLink3
    - EXO
    - Analite

APPENDIX E

YSI EXO Datasonde User and Calibration Manual

xylem
Let's Solve Water

USER MANUAL
ITEM# 603789REF
REVISION H

EXO User Manual

ADVANCED WATER QUALITY MONITORING PLATFORM

YSI
a xylem brand

The information contained in this manual is subject to change without notice.

Effort has been made to make the information in this manual complete, accurate, and current.

The manufacturer shall not be held responsible for errors or omissions in this manual.

Consult **YSI.com/EXO** *for the most up-to-date version of this manual.*

THIS IS AN INTERACTIVE DOCUMENT

When viewing this document as an Adobe™ PDF, hovering your cursor over certain phrases will bring up the finger-point icon. Clicking elements of the Table of Contents, website URLs, or references to certain sections will take you automatically to those locations.

Product Components

Carefully unpack the instrument and accessories and inspect for damage. If any parts or materials are damaged, contact YSI Customer Service at 800-897-4151 (+1 937 767-7241) or the authorized YSI distributor from whom the instrument was purchased.

Technical Support

Telephone: 800 897 4151 (USA), +1 937 767 7241 (Globally)

Monday through Friday, 8:00 AM to 5:00 ET

Fax: +1 937 767 9353 (orders)

Email: info@ysi.com

YSI.com

Safety Information

Please read this entire manual before unpacking, setting up or operating this equipment. Pay attention to all precautionary 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.

Precautionary Symbols

NOTE: *Information that requires special emphasis*

NOTICE: Indicates a situation which, if not avoided, may cause damage to the instrument

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

⚠ **WARNING:** Indicates a potentially hazardous situation which could result in death or serious injury

TABLE OF CONTENTS

Bluetooth®

Section 1
EXO Platform Overview

1.1 EXO1 Sonde
Overview

The EXO1 sonde is a multiparameter instrument that collects water quality data. The sonde collects the data with up to four user-replaceable sensors and an integral pressure transducer. Each sensor measures its parameter via a variety of electrochemical, optical, or physical detection methods. Each port accepts any EXO sensor and automatically recognizes its type. Depending upon user-defined settings, the EXO1 will collect data and store it onboard the sonde, transfer the data to a data collection platform (DCP), or relay data directly to a user's PC or the EXO Handheld. See Section 6 for information specific to vented level sondes.

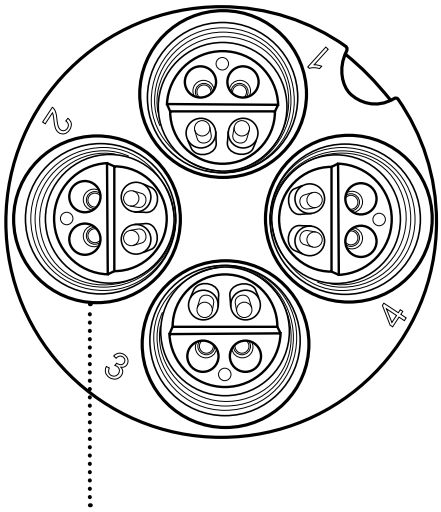
Users communicate with the sonde via a field cable to an EXO Handheld, **Bluetooth**® wireless connection to a PC or EXO Classic Handheld, or a USB connection (via communications adapter) to a PC.

Specifications

Operating Environment *Depth Rating*	 250 meters, 820 feet
Material	Xenoy®, Lexan®, titanium, 316 stainless steel
Internal Logging Memory Capacity	512 MB
Software	KorEXO Software
Communications *Sonde* *Adapters*	 **Wireless:** *Bluetooth* **Field Cable:** RS-485 RS-232, Mod Bus, USB, SDI-12
Power *External* *Internal*	 9-16 VDC (2) D-cell batteries
Temperature *Operating* *Storage*	 -5 to 50°C -20 to +80°C
Battery Life	90 days*
Dimensions *Diameter* *Length* *Weight w/ battery*	 4.70 cm,1.85 in 64.77 cm, 25.50 in 1.42 kg, 3.15 lb

**Battery life will depend on the type of sensors and measurement frequency.*

EXO1 Bulkhead



Universal Sensor Ports

EXO1 Sonde
599501-xx

Removable Bail
599473

6-Pin Cable Connector

Upper Battery Compartment Seal
O-ring kit 599680

Battery Compartment

Battery Cover
599052

Lower Battery Compartment Seal

Pressure Transducer Opening

Red LED Indicator - Sonde Status

Blue LED Indicator - *Bluetooth*

On/Off Magnetic Switch for Power and *Bluetooth*

Bulkhead

Sensors

Port Plug
599475

Calibration Cup
599786

Sensor Guard
599666, 599563

Guard Weight
599471

1.2 EXO2 Sonde
Overview

The EXO2 sonde is a multiparameter instrument that collects water quality data. The sonde collects the data with up to seven user-replaceable sensors and an integral pressure transducer. Each sensor measures its parameter via a variety of electrochemical, optical, or physical detection methods. Each port accepts any EXO sensor and automatically recognizes the type of sensor. Depending on user-defined settings, the EXO2 will collect data and store it onboard the sonde, transfer the data to a data collection platform (DCP), or relay it to a user's PC or EXO Handheld via cable, USB connection, or **Bluetooth®** connection.

In addition to six standard sensor ports, the central port (port 7) can accept either a central wiper or an additional sensor. The auxiliary port on top of the sonde will allow the user to connect the EXO2 to other EXO sondes, making this our most expandable and flexible sonde. See Section 6 for information specific to vented level sondes.

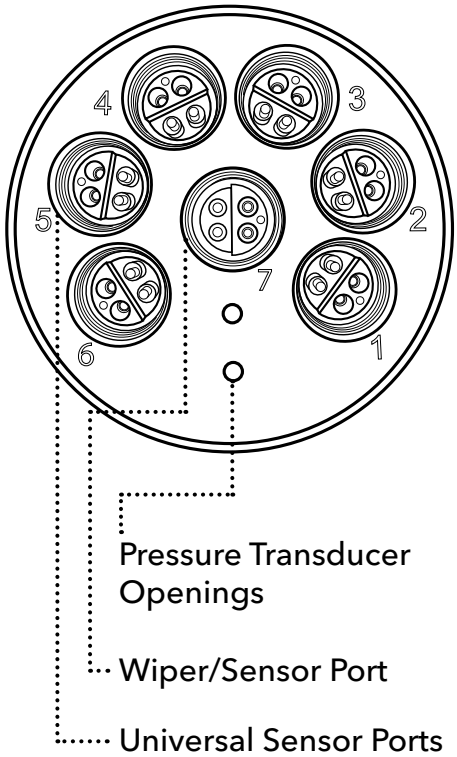
Users communicate with the sonde via a field cable to an EXO Handheld, *Bluetooth* wireless connection to a PC or EXO Classic Handheld, or a USB connection (via communications adapter) to a PC. See Section 2.6 for a communication overview.

Specifications

Operating Environment *Depth Rating*	 250 meters, 820 feet
Material	Xenoy®, Lexan®, titanium, 316 stainless steel
Internal Logging Memory Capacity	512 MB
Software	KorEXO Software
Communications *Sonde* *Adapters*	 **Wireless:** *Bluetooth* **Field Cable:** RS-485 RS-232, Mod Bus, USB, SDI-12
Power *External* *Internal*	 9-16 VDC (4) D-cell batteries
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Battery Life	90 days*
Dimensions *Diameter* *Length* *Weight w/ battery*	 7.62 cm, 3.00 in 71.1 cm, 28.00 in 3.60 kg, 7.90 lb

**Battery life will depend on the type of sensors and measurement frequency.*

EXO2 Bulkhead




EXO2 Sonde
599502-xx
Removable Bail
599474
Auxiliary Port
6-Pin Cable Connector
Battery Cap/Pressure Relief Valve
O-ring kit 599681
Battery Compartment Opening
Battery Compartment
On/Off Magnetic Switch for
Power and *Bluetooth*
Red LED Indicator - Sonde Status
Blue LED Indicator - *Bluetooth*
Bulkhead
Sensors
Port Plug
599475
Sensor Guard
599667, 599564
Calibration Cup
599316
Central Wiper
599090-01
Guard Weight
599472

1.3 EXO2^{S} Sonde
Overview

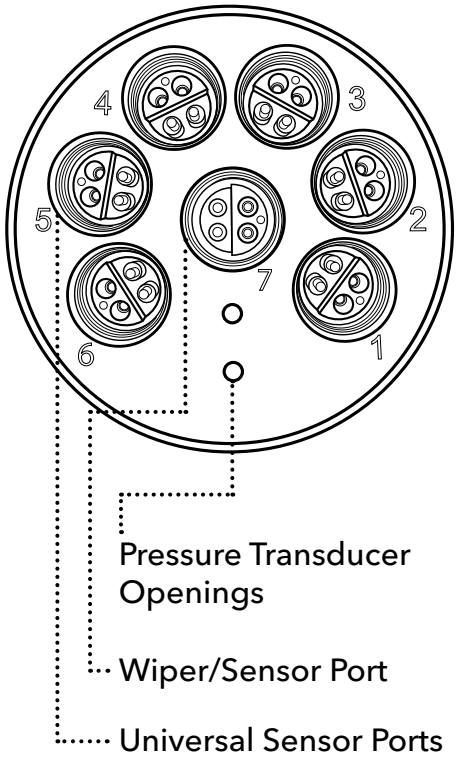
The EXO2^{S} sonde is compact, battery-less, factory-customized version of the EXO2 sonde for use where external power is available. One orders an EXO2^{S} by first selecting the appropriate depth of an EXO2 sonde (599502-xx) and a conversion kit (119077) that is used by our team to convert the EXO2 sonde into an EXO2^{S}. The sonde supports up to seven user-replaceable sensors and an integral pressure transducer. The EXO2^{S} features the same logging and communication options as the standard EXO2; however, an external power source is required. Power can be supplied via a DCP, the EXO handheld or EXO GO. See Section 2.6 for a communication overview.

Specifications

Operating Environment *Depth Rating*	 250 meters, 820 feet
Material	Xenoy®, Lexan®, titanium, 316 stainless steel
Internal Logging Memory Capacity	512 MB
Software	KorEXO Software
Communications *Sonde* *Adapters*	 **Wireless:** *Bluetooth* **Field Cable:** RS-485 RS-232, Mod Bus, USB, SDI-12
Power *External*	 9-16 VDC
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Battery Life	90 days*
Dimensions *Diameter* *Length* *Weight w/ battery*	 7.62 cm, 3.00 in 47.0 cm, 18.50 in 1.10 kg, 2.42 lb

**Battery life will depend on the type of sensors and measurement frequency.*

EXO2^{S} Bulkhead




EXO2S Sonde
599502-xx and 119077
Removable Bail
Auxiliary Port
6-Pin Cable Connector
On/Off Magnetic Switch for
Power and *Bluetooth*
Red LED Indicator - Sonde Status
Blue LED Indicator - *Bluetooth*
Bulkhead
Sensors
Port Plug
599475
Sensor Guard
599667, 599564
Calibration Cup
599316
Central Wiper
599090-01
Guard Weight
599472

1.4 EXO3 Sonde
Overview

The EXO3 sonde is a multiparameter instrument that collects water quality data. The sonde collects the data with up to four user-replaceable sensors and an integral pressure transducer. The EXO3 also has a central port for an EXO wiper (or an additional sensor). Each sensor measures its parameter via a variety of electrochemical, optical, or physical detection methods. Each port accepts any EXO sensor and automatically recognizes the type of sensor. Depending on user-defined settings, the EXO3 will collect data and store it onboard the sonde, transfer the data to a data collection platform (DCP), or relay it to a user's PC or EXO Handheld via cable, USB connection, or **Bluetooth**® connection.

Users communicate with the sonde via a field cable to an EXO Handheld, *Bluetooth* wireless connection to a PC or a USB connection (via communications adapter) to a PC. See Section 2.6 for a communication overview.

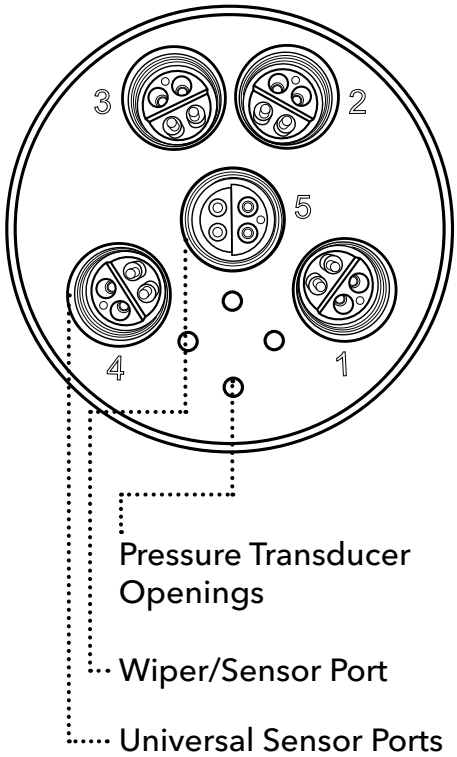
NOTE: *The EXO3 Sonde includes integral SDI-12 communications for use with cables up to 66 meters in length. With EXO3, a 599820 Signal Output Adapter (SOA) is not necessarily required. See Section 2.11 for details.*

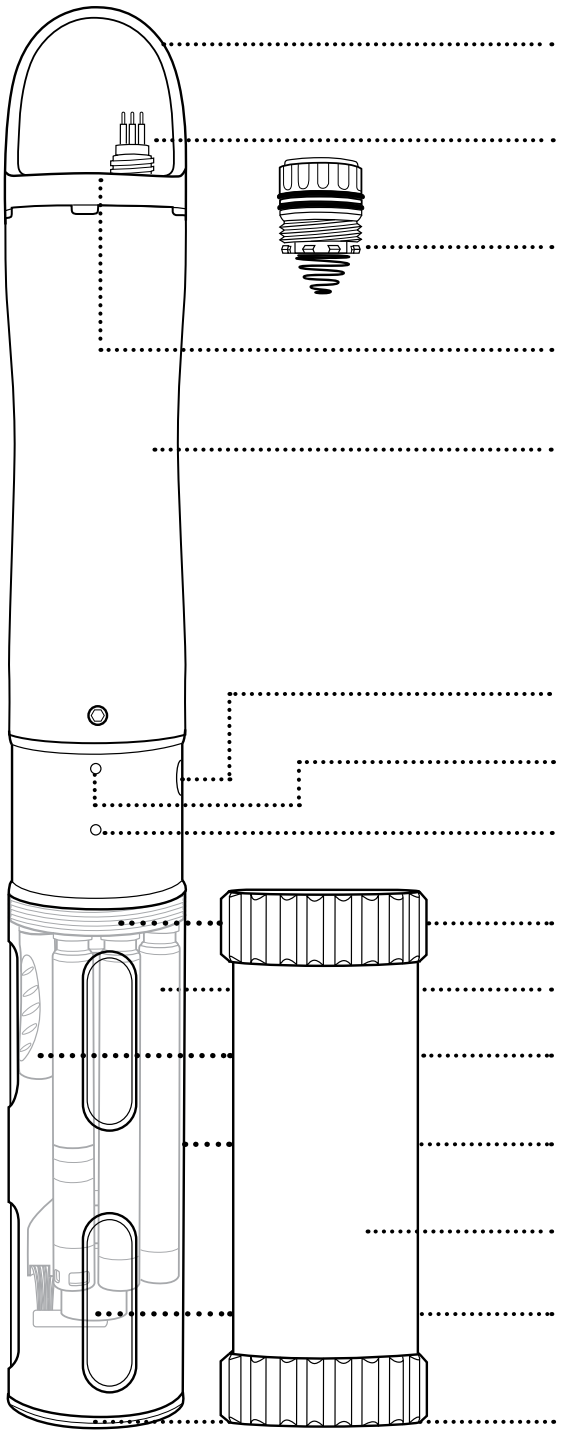
Specifications

Operating Environment *Depth Rating*	 250 meters, 820 feet
Material	Xenoy®, Lexan®, titanium, 316 stainless steel
Internal Logging Memory Capacity	512 MB
Software	KorEXO Software
Communications *Sonde* *Adapters*	 Wireless: *Bluetooth* Field Cable: RS-485, SDI-12 RS-232, Mod Bus, USB, SDI-12
Power *External* *Internal*	 9-16 VDC (2) D-cell batteries
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Battery Life	60 days*
Dimensions *Diameter* *Length* *Weight w/ battery*	 7.62 cm, 3.00 in 58.67 cm, 23.1 in 2.0 kg, 4.41 lb

**Battery life will depend on the type of sensors and measurement frequency.*

EXO3 Bulkhead





EXO3 Sonde
599503-xx

Removable Bail
599474

6-Pin Cable Connector

Battery Cap/Pressure Relief Valve
O-ring kit 599681

Battery Compartment Opening

Battery Compartment

On/Off Magnetic Switch for Power and *Bluetooth*

Red LED Indicator - Sonde Status

Blue LED Indicator – *Bluetooth*

Bulkhead

Sensors

Port Plug
599475

Sensor Guard
599667, 599564

Calibration Cup
599316

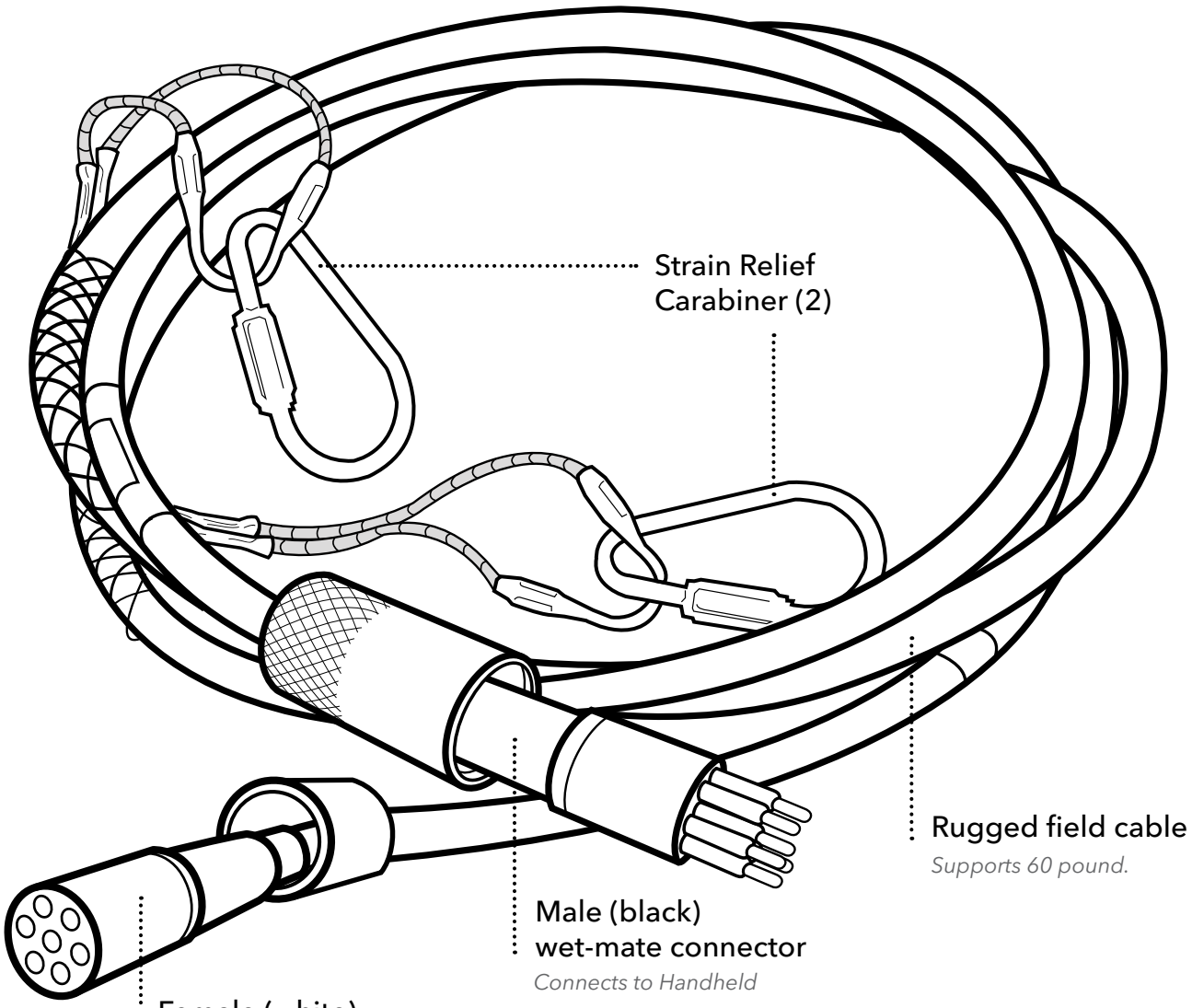
Central Wiper
599090-01

Guard Weight
599472

1.5 EXO Field Cables

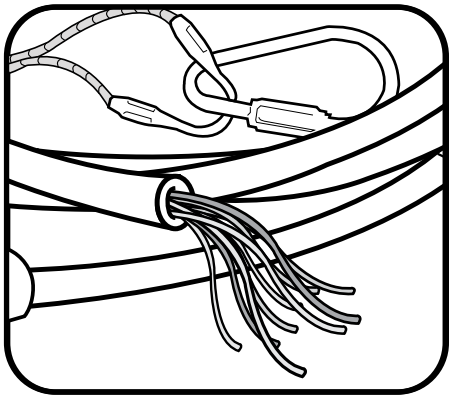
Overview

The EXO rugged field cable comes in many different lengths and options to meet the needs of your specific application. Selecting the correct cable length and coupler will ensure the best quality data for your project. For a full list of cable options and precautions for extended cables, please see Cable Options on the following page.



Flying Lead Cable Vented and Non-Vented

A flying lead cable option is available which is intended for wiring to a data collection platform (DCP) or a data logger. A vented flying lead option is for use with a vented sonde only. See Section 6 for more information.



Cable Options

599431-01	EXO Cable Coupler, Titanium
599431-02	EXO Cable Coupler, Brass
599040-2	EXO 2 meter Field Cable
599040-4	EXO 4 meter Field Cable
599040-10	EXO 10 meter Field Cable
599040-15	EXO 15 meter Field Cable
599040-33	EXO 33 meter Field Cable
599040-66	EXO 66 meter Field Cable
599040-100	EXO 100 meter Field Cable
599040-150	EXO 150 meter Field Cable
599040-200	EXO 200 meter Field Cable

599040-250	EXO 250 meter Field Cable
599040-300	EXO 300 meter Field Cable
599008-10	EXO 10 meter Flying Lead Cable
599008-15	EXO 15 meter Flying Lead Cable
599008-33	EXO 33 meter Flying Lead Cable
599008-66	EXO 66 meter Flying Lead Cable
599008-100	EXO 100 meter Flying Lead Cable
599210-4	EXO 4 meter VENTED Flying Lead Cable
599210-10	EXO 10 meter VENTED Flying Lead Cable
599210-15	EXO 15 meter VENTED Flying lead Cable
599210-33	EXO 33 meter VENTED Flying Lead Cable

Extended Field Cables Precaution

There are some limitations for applications using EXO cable lengths greater than 100 meters - whether by extended cables, or by means of cable-coupling.

NOTICE: To prevent system problems related to power and signal integrity, make sure you understand the system limitations if you plan to use cable couplers or extended cables.

Voltage drop through long cables can adversely affect the available power at the sonde.
Here are some techniques to prevent such problems:

•Use Alkaline or high-capacity NiMH batteries in the sonde. This serves a dual purpose of adding weight in the sonde for profiling applications, as well as preventing system reboots during period of high current demand.

•Do not use EXO's USB SOA or Handheld as the sole power source for systems with large payloads (many optical or high power sensors). These devices do not provide a voltage high enough for use with extended cables.

•Limit use of EXO's auxiliary port to lower power devices.

•Power the sondes with a regulated power supply (12V-14V) capable of supplying 1A. This will ensure sufficient power is reaching the sonde.

1.6 EXO Handheld
Overview

The EXO Handheld is a rugged, microcomputer-based instrument that allows the user to display sonde readings, configure sondes, store and retrieve data, and transfer data from sondes to a computer. Equipped with GPS and an integrated barometer, the Handheld communicates via field cable or USB connector.

The unit also utilizes an adjustable backlit screen for easy day or night viewing. The handheld features a built-in rechargeable Lithium-Ion battery, integrated help menus, a simplified user interface, and a more ergonomic design than the Classic handheld.

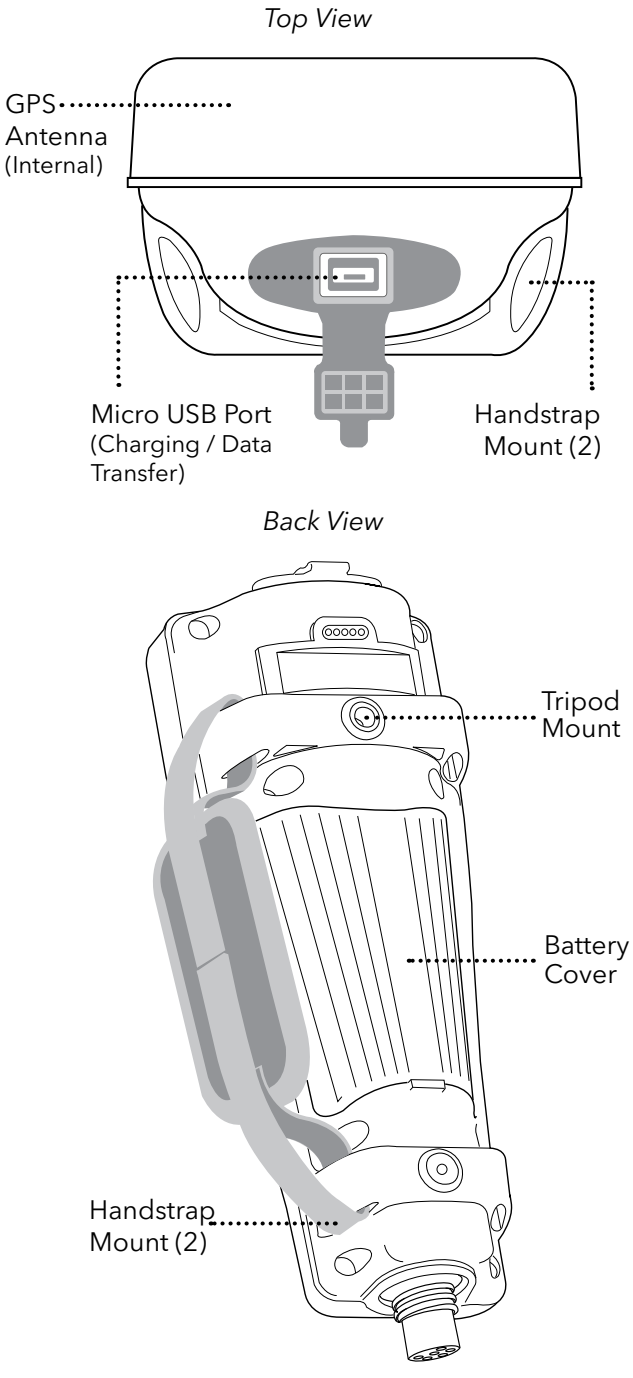
NOTE: *For operating instructions, please see the EXO Handheld Mini-Manual.*

Specifications

GPS	Yes
Display	IP-67 rated, Color-LCD graphic display
Memory	>100,000 data sets
Software	KorEXO Software
Communications	Field Cable, USB
Power *Internal*	 Rechargeable Lithium-Ion Pack
Temperature *Operating* *Storage*	 0°C to 50°C 0°C to 60°C (no battery) 0°C to 45°C (battery installed)
Barometer *Range* *Accuracy* *Resolution*	*Built-in with User Calibration* 375 to 825 mmHg ±1.5 mmHg from 0 to 50°C 0.1 mmHg
Dimensions *Width* *Length* *Depth* *Weight w/ battery*	 8.3 cm, 3.27 in 21.6 cm, 8.5 in 5.6 cm, 2.21 in 0.57 kg, 1.25 lb

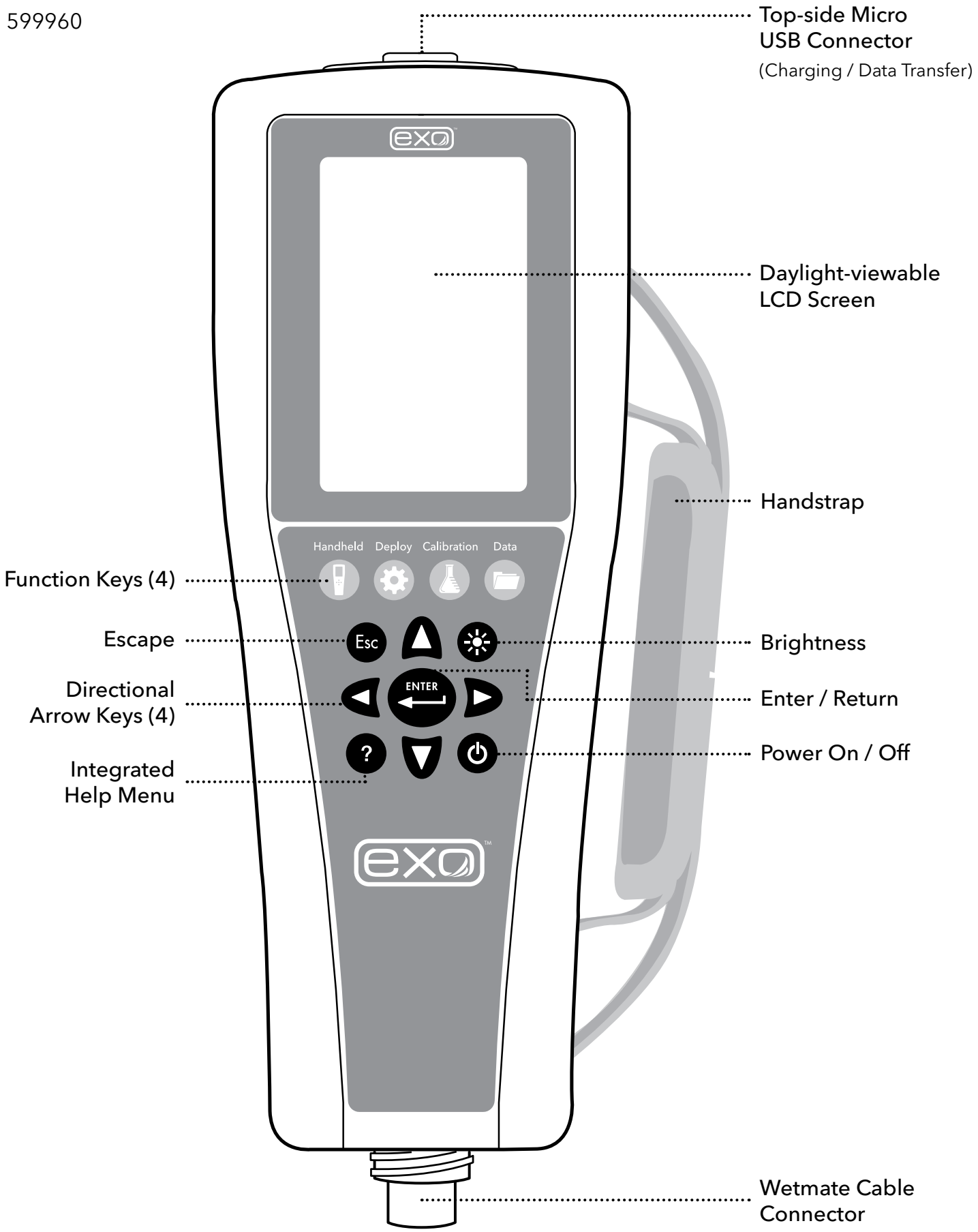
NOTE: *Barometer vent located under battery cover.*

EXO Handheld



EXO Handheld

599960



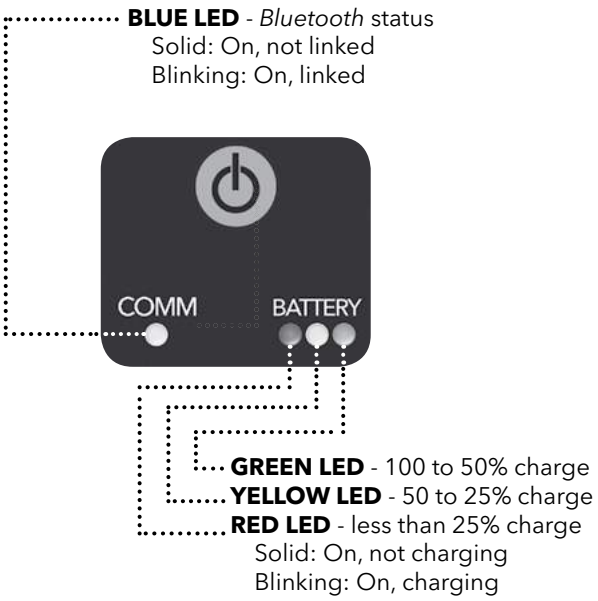
1.7 EXO GO
Overview

The EXO GO is a compact, rugged device that enables **Bluetooth**® communication between a submerged EXO sonde and a device running KorEXO Software. The EXO GO remains topside while connected to a sonde via the field cable. Pair with a tablet or laptop running KorEXO to form a complete sampling system.

With an integral barometer and GPS, the EXO GO provides barometric pressure and location data in addition to the connected sonde data. The built-in, rechargeable Lithium-Ion battery will power an EXO Sonde for a full day of sampling. LED indicators represent battery level, charge status, and *Bluetooth* status, as shown in the diagram below.

NOTE: *EXO GO is not compatible with earlier versions of KorEXO Software (prior to 2.0).*

LED Descriptions



Specifications

Communications	*Bluetooth*, USB 2.0
Bluetooth *Range*	Class 2 10 m
Barometer *Range* *Accuracy* *Resolution*	*Built-in with User Calibration* 375 to 825 mmHg ±1.5 mmHg 0.1 mmHg
GPS *Accuracy*	 2.5 m CEP (dependent on site conditions)
Battery *Operating Time* *Charge Time*	Rechargeable Lithium-Ion > 15 hours (powering full EXO3) 9 hours (from 0 to 100%)
Enclosure *Rating*	Xenoy IP-67
Temperature *Operating* *Storage*	 -5 to 50°C 0 to 45°C
Dimensions *Width* *Length* *Depth* *Weight*	 5.2 cm 17.4 cm 3.5 cm 240 g

EXO GO

577400

Section 2
Operation

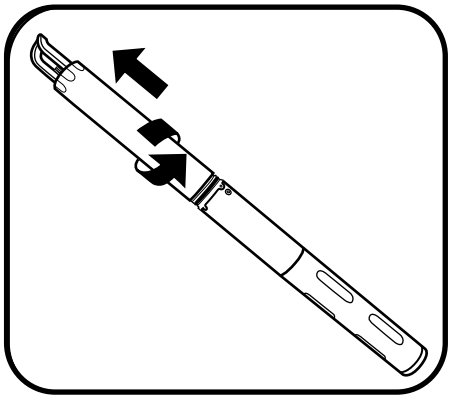
2.1 Sonde

Install / Replace EXO1 Batteries

EXO1 water quality sondes use two (2) D-cell batteries as a power source. Using alkaline batteries, users can expect approximately 90 days of deployment from a fully loaded sonde that samples once every 15 minutes. However, deployment times may vary greatly depending on water temperature, sampling rate, sensor payload, and brand of battery.

See Battery Life Specification on the next page.

NOTICE: Do not use Ni-Cad or 3.6V Lithium batteries in the EXO1 sonde.



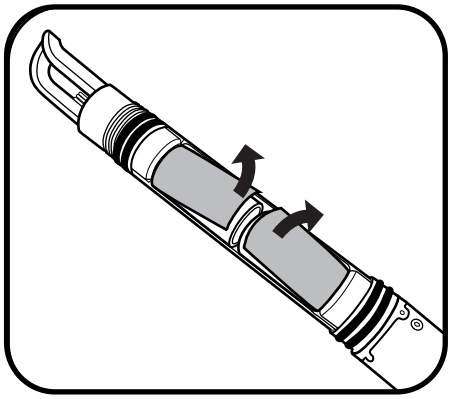
1 Remove battery cover

Start with a clean and dry sonde. Hold the sonde horizontally with the bail up and twist the battery cover counterclockwise until free. If necessary, slide the sonde tool's larger opening over the end of the battery compartment and use it as a lever to break the compartment free. Then slide off the battery cover.

NOTICE:

Do not remove the screws on the sonde.

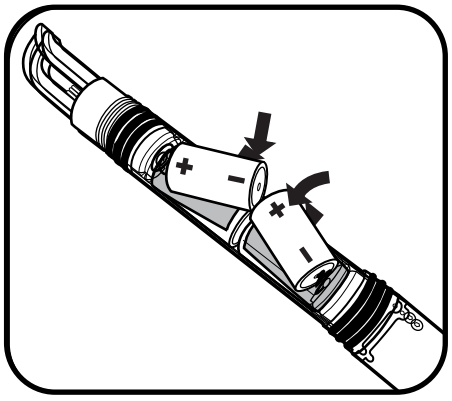
Do not clamp the sonde in a vise.



2 Remove old batteries

Expose the batteries by flipping the isolation flap up away from the batteries, and pull the batteries free of their compartment. Always dispose of used alkaline batteries according to local requirements and regulations.

Clean the inside of the battery compartment with a lint-free cloth.



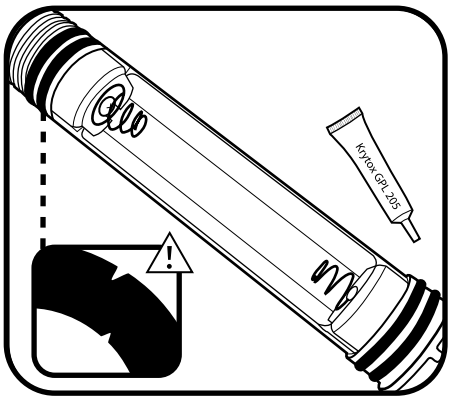
3 Install new batteries

Install the new batteries so that the positive terminals point towards the bail (away from the sensor bulkhead). Replace the isolation flap over the batteries.

NOTICE:

Do not use Ni-Cad or 3.6V Lithium batteries in the sondes.

Damage to the circuit board is not covered under warranty.

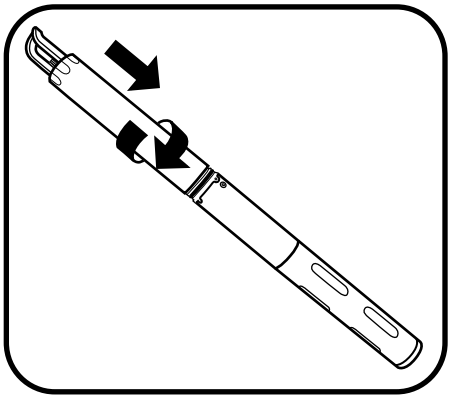


4 Check and service o-rings

NOTE: *Before replacing the battery cover, check and service the four o-rings.*

Ensure that the o-rings are not nicked or torn and that there are no contaminants or particles on them or the sealing surfaces inside the battery cover. Clean the o-rings with a lint-free cloth. Then apply a thin coat of Krytox® lubricant to each o-ring.

EXO1 replacement o-ring kits are available, part #599680.



5 Replace battery cover

Twist the battery cover clockwise until it stops at the rubber gasket. The gasket does not provide a seal and does not need to be compressed.

NOTICE: Do not overtighten; overtightening will not create a strong seal and may damage the sonde.

The EXO1 sonde has a resealing pressure relief valve; no maintenance is required.

If a battery failure occurs that results in battery acid leakage into the battery compartment, the sonde must be returned to a service center for evaluation.

Battery Life Specification (Example)

When using alkaline batteries: Estimated battery life is approximately 90 days for EXO1 at 20˚C at a 15-minute logging interval, with temperature/conductivity, pH/ORP, Optical DO, and turbidity sensors installed. Battery life is heavily dependent on sensor configuration and is given for a typical sensor ensemble. Battery life is reduced in cold-water applications.

When using rechargeable nickel metal hydride (NiMH) batteries: Estimated battery life is not available because NiMH batteries vary greatly in manufacturer capacity and discharge curves. We recommend a NiMH D-cell battery with a minimum rating of 10,000 milliamp hours that is fully charged each time it is used.

2.2 Sonde

Install / Replace EXO2 and EXO3 Batteries

EXO2 sondes use four (4) D-cell batteries as a power source. Using alkaline batteries, users can expect approximately 90 days of deployment from a fully loaded sonde that samples once every 15 minutes. However, deployment times may vary greatly depending on water temperature, sampling rate, sensor payload, wiper frequency, and brand of battery.
See Battery Life Specification on the next page.

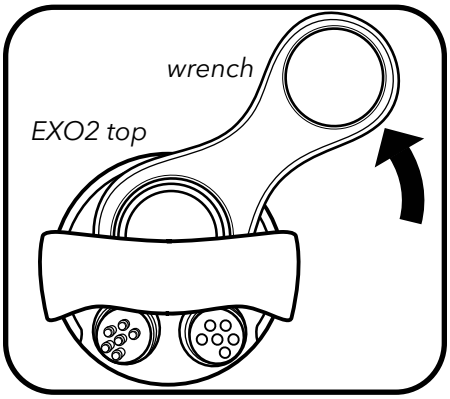
EXO3 sondes use two (2) D-cell batteries as a power source and can expect 60 days of deployment with an average sensor payload while sampling once every 15 minutes.

NOTICE: Do not use Ni-Cad or 3.6V Lithium batteries in the EXO sondes.

Pressure in Battery Compartment

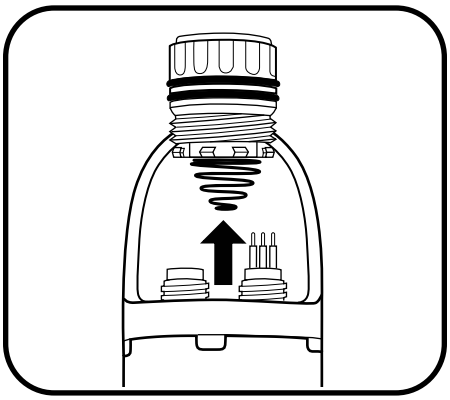
The EXO2 and EXO3 sondes are equipped with a pressure relief valve to protect against catastrophic battery failure. If the valve is open (indicating an over-pressure situation), the battery cap must be replaced. Significant water leakage into the battery compartment requires that your instrument be evaluated by the manufacturer or Authorized Service Center before the next deployment.

⚠ **WARNING:** Do not paint over or cover the pressure release valve in any way.
Blocking the pressure release valve can lead to dangerously high internal pressure.



1 Loosen battery cap

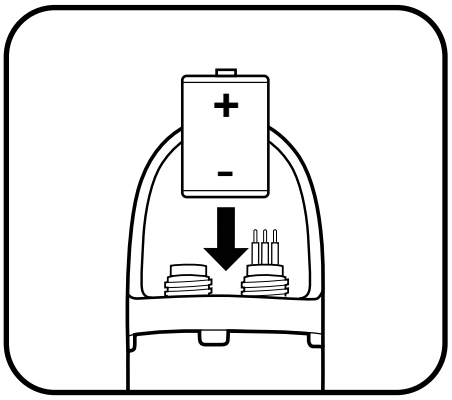
Start with a clean and dry sonde. Slide the sonde tool's smaller opening over the battery cap on top of the EXO2 or EXO3. Using the tool as a lever, firmly turn the tool counterclockwise until the battery cap is loose.



2 Remove battery cap and old batteries

Once the cap is sufficiently loose, remove the cap and old batteries from the well. Always dispose of used alkaline batteries according to local requirements and regulations.

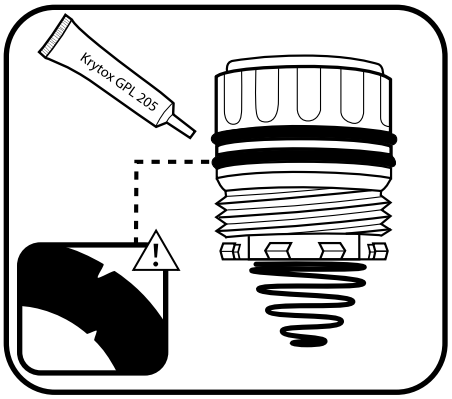
Clean the o-ring sealing surfaces of the cap with a lint-free cloth.
Inspect down into the battery tube to make sure it is clean and dry.



3 Insert new batteries

With the positive terminal facing up, insert four (4) new D-cell batteries into the battery well for EXO2 sondes, or two (2) new D-cell batteries for EXO3 sondes.

NOTICE:
Do not use Ni-Cad or 3.6V Lithium batteries in the sondes.
Damage to the circuit board is not covered under warranty.

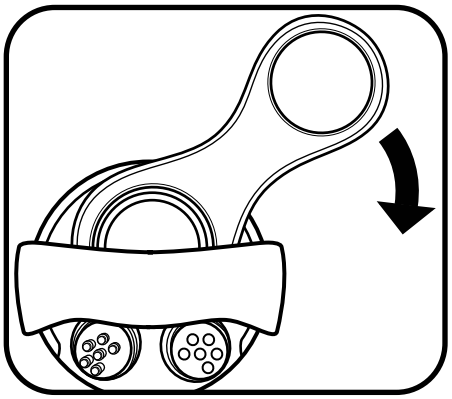


4 Check and service o-rings

NOTE: *Before replacing the battery cover, inspect and service the four o-rings.*

Ensure that the o-rings are not nicked or torn and that there are no contaminants or particles on the o-rings or the sealing surfaces inside the battery cover. Then apply a thin coat of Krytox® lubricant to each o-ring and sealing surface.

EXO2 replacement o-ring kits are available, part #599681.



5 Replace battery cap

After servicing the cap's o-rings, insert the cap in its recess. Then, using your thumb, press down on the pressure relief valve while turning the cap clockwise. Once the cap threads are engaged, use the tool to tighten until snug.

NOTICE: Do not overtighten; overtightening will not create a strong seal and may damage the sonde. When completed, the top o-ring of the cap must be below the battery compartment opening.

If a battery failure occurs that results in battery acid leakage into the battery compartment, the sonde must be returned to a service center for evaluation. Some battery acid will damage the plastic in the battery compartment.

Battery Life Specification (Example)

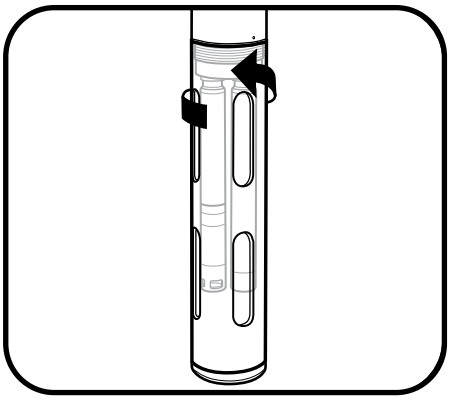
When using alkaline batteries: Estimated battery life is approximately 90 days for EXO2, and 60 days for EXO3, at 20˚C with a 15-minute logging interval, with temperature/conductivity, pH/ORP, Optical DO, turbidity, and Total Algae-PC sensors installed along with a central wiper which rotates once every logging interval. Battery life is heavily dependent on sensor configuration and is given for a typical sensor ensemble. Battery life is reduced in cold-water applications.

When using rechargeable nickel metal hydride (NiMH) batteries: Estimated battery life is not available because NiMH batteries vary greatly in manufacturer capacity and discharge curves. We recommend a NiMH D-cell battery with a minimum rating of 10,000 milliamp hours that is fully charged each time it is used.

2.3 Install / Remove Guard or Cal. Cup

Sensor guards protect EXO sensors from impact throughout deployment. Users must install the guard prior to data collection. The calibration cup (cal cup) is used for storage and calibration.

NOTE: *We recommend using two guards: one for field deployments and a second used exclusively for calibrations. Using a second guard will minimize calibration solution contamination (especially for turbidity).* EXO calibration cups install over an installed sensor guard. This configuration reduces the amount of standards required for calibration and protects the sensors during calibration.

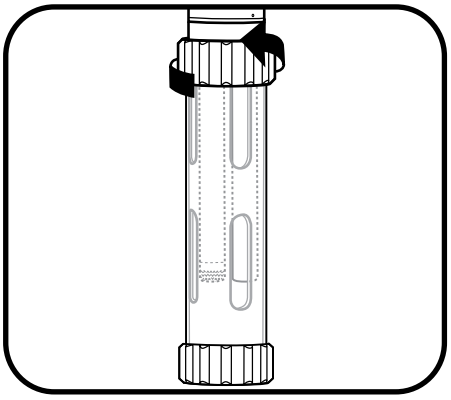


1 Install/remove sensor guard

Install guard by threading it onto the sonde bulkhead threads. Rotate the guard clockwise on the bulkhead to install, taking care not to pinch your fingers. Rotate it counterclockwise to remove. Always use one guard for deployment/storage and a second guard for calibration only.

Additional EXO sensor guards can be purchased:
EXO1 Guard Assembly Kit, part #599666
EXO2/3 Guard Assembly Kit, part #599667

NOTICE: Take care not to let the guard damage unguarded pH or pH/ORP sensors when installing and removing.



2 Install/remove calibration cup

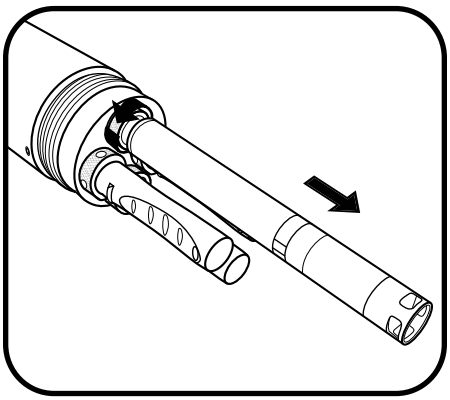
Before installation, loosen (but do not remove) the cup's clamping ring. Then, with the sonde guard already installed, slide the cal cup over the guard until the bottom of the guard rests against the bottom of the cal cup. Tighten the ring until snug. To remove the cal cup, loosen the ring by 1/4 turn and pull the guard free from the cup.

Additional EXO calibration cups can be purchased:
EXO1 Calibration / Storage cup, part #599786
EXO2/3 Calibration / Storage cup, part #599316

2.4 Install / Remove Sensors

EXO sensors have identical connectors and identify themselves via onboard firmware; therefore, users can install any probe into any universal sonde port. The exception is the wiper for the EXO2 and EXO3 sondes, which must be installed in the central port 7. Individual ports are physically identified by an engraved number on the sonde bulkhead. Although the probes are wet-mateable, users should clean, lubricate, and dry the sonde and sensor connectors prior to installation or service.

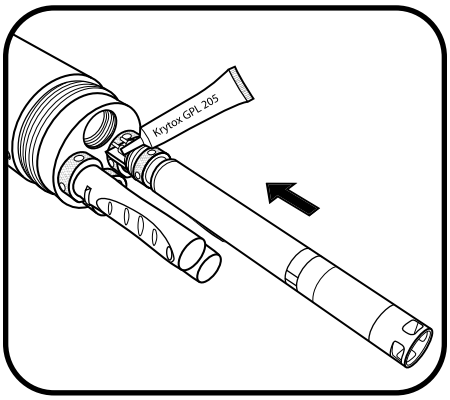
NOTE: *The data displayed on the Handheld / Desktop KorEXO, and the order of the exported data will be in the same order that the sensors are installed (e.g. a turbidity sensor in port 1 will display turbidity values first. The sensor in port 2, second, and so on).*



1 Remove probe or port plug

Remove the calibration cup and sensor guard from the sonde. Place the sonde on a clean, flat surface and prevent it from rolling.

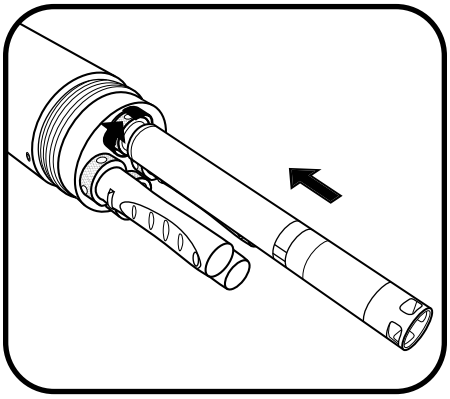
If removing a sensor or port plug, use the probe tool in the locking nut and rotate counterclockwise to loosen. Pull the probe straight out of the port and place on a clean surface. Wipe dry with a clean, lint-free cloth.



2 Clean port and install sensor

Visually inspect the port for contamination. If the port is dirty or wet, clean it with a clean, lint-free cloth or compressed air. Apply a light coat of Krytox grease to the rubber mating surfaces of the connector (not the o-ring) and a small dab of Krytox grease on the threads of the locking nut.

If the sensor is new or being taken out of storage remove any hydration caps or buffer bottles on the probe. Insert the sensor into the port by properly aligning the connectors' pins and sleeves (male and female contacts); then press them firmly together.



3 Tighten locking nut

Taking care not to cross-thread the grooves, finger-tighten the locking nut clockwise. When the nut and o-ring are seated against the bulkhead, tighten the nut with probe tool 1/4 turn until snug. Once sensors or plugs are installed, reinstall the sensor guard to protect sensors from impact damage.

NOTICE: Take care not to twist the probe body when tightening and loosening the locking nut. Excessive twisting of the probe can damage the connector and is not covered under warranty.

2.5 Sonde States and LED Descriptions

States

An EXO sonde is always in one of three operational states: *Off, Awake,* or *Asleep*. These states determine the sonde's power usage and logging potential. When *Off*, the sonde is not powered (no batteries installed, no topside power) and cannot collect data. Users can apply power to the sonde internally, using batteries, or externally with an EXO field cable attached from the topside port to an EXO Handheld, DCP or other approved power source. Once power is applied to a sonde, it is either *Awake* or *Asleep*.

When *Asleep*, the sonde remains in a very low power setting and waits for a user command or its next scheduled logging interval. An *Awake* sonde is fully powered and ready to collect data. Once awakened, a sonde remains *Awake* for five minutes after its last communication via *Bluetooth* or 30 seconds after its last communication via the topside port. The sonde also automatically awakens 15 seconds before its next scheduled logging interval.

Power States

Off: Not powered, no data collection.

Asleep: Low power. Waiting for command.

Awake: Full power. Ready to collect.

LED Indicators

● **Blue LED** – *Bluetooth*

None: Off, not active

On Solid: On, not linked

2 Hz (0.5s Blink): On, linked

● **Red LED** – Sonde State

None: Off or Asleep, with logging disabled

0.1 Hz (10s Blink): Asleep, logging enabled

1 Hz (1s Blink): Awake, sensors are active and may collect data

On Solid: Awake with faults

LED Indicators

Each sonde has two LED indicators that show the sonde's status. The blue LED indicates the *Bluetooth's* wireless connection status. The red LED indicates the sonde's power state.

The *Bluetooth* light (blue) is activated by a magnet swipe at the magnetic activation area. When the blue LED is off, the *Bluetooth* is disabled. When the light is on continuously, the *Bluetooth* is enabled, but no link has been established. When the blue LED blinks at 2 Hz, the sonde's *Bluetooth* is on, and has established a link.

When the red LED is off, the sonde is either *Off* or *Asleep* and not logging. When it blinks at 0.1 Hz (once every 10 seconds), the sonde is *Asleep* and logging is enabled. When the red light blinks at 1 Hz, the sonde is *Awake* and has no faults. If the red light is lit continuously, the sonde is *Awake* and has detected faults that need to be fixed prior to use.

Modes

Within the *Awake* state, the sonde has three modes, which are activated via KorEXO software. When "Inactive (Off)," the sonde does not log any data. In "Real-Time" mode, the sonde continuously collects data at a user-specified interval (default is 2 Hz). "Sample/Hold" mode allows users to easily synchronize data between the sonde's data logger and an external data collection platform.

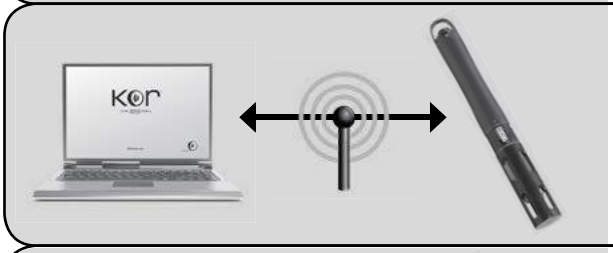
2.6 Connection Methods

Overview

Below is a high level overview of various methods you can use to connect and communicate with your EXO sonde:

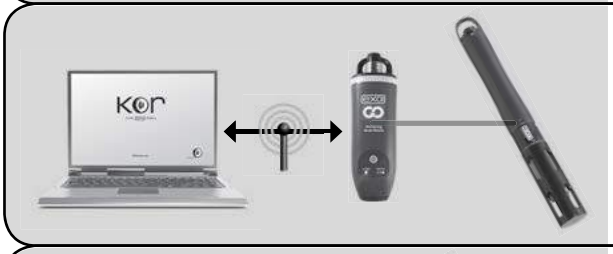
Field Cable, Sonde-to-Handhelds

- Lab Calibration
- Hardware Setup
- Transfer Data from Sonde
- Field Sampling



Wireless *Bluetooth*, Computer-to-Sonde

- Lab Calibration
- Hardware Setup
- Transfer & Export Data

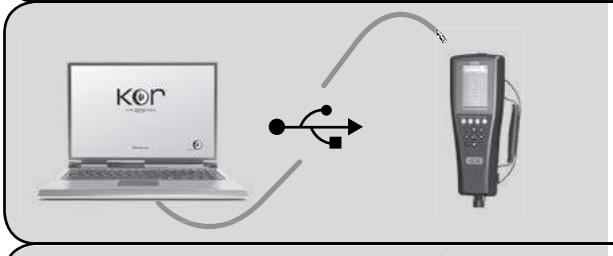


EXO GO *Bluetooth*, Sonde-to-Computer

- Lab Calibration
- Hardware Setup
- Transfer & Export Data
- Field Sampling
- Update Firmware

SOA-USB Adapter, Sonde-to-Computer

- Lab Calibration
- Hardware Setup
- Transfer & Export Data
- Field Sampling
- Update Firmware

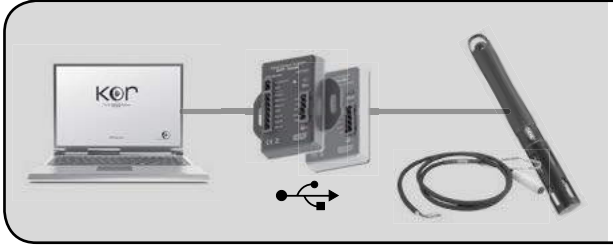


Direct USB, Computer-to-Handhelds

- Transfer & Export Data
- Update Firmware

Flying Lead Cable, Sonde-to-Com. Adapter

- Long-Term Monitoring with a Data Collection Platform or SCADA Modbus



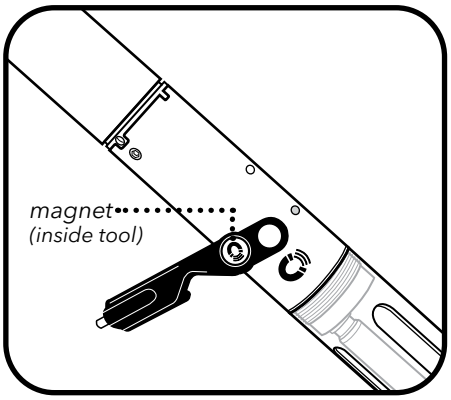
USB Passthrough Mode

- Direct USB communication to sonde, through DCP 2.0 / Modbus using KorEXO software.

2.7 Awaken Sonde

Activate *Bluetooth*

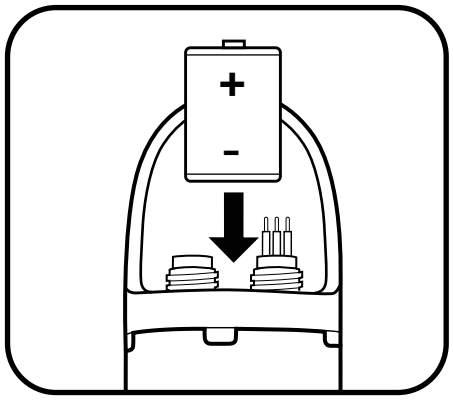
Once power is applied to the sonde, internally or externally, users can awaken their sondes from *Sleep* state using any of several methods. Primarily, users activate EXO sondes and the *Bluetooth* connections via a magnetic switch installed in the sonde's electronics compartment. The sonde will automatically disable the connection and go to sleep if it has received neither a *Bluetooth* signal for 5 minutes, nor a signal from the topside connector for 30 seconds. In order to activate their sondes, users should keep a magnet with them when setting up and deploying sondes. For more information on sonde states and LEDs, see Section 2.5.



1 Awaken sonde with magnet

Users can make their sonde go to the Awake state by holding a magnet at the magnetic activation area on the sonde's bulkhead (identified by the illustrated magnet symbol on the label). Simply hold the magnet within one (1) cm of the symbol until the LEDs activate. EXO Classic Handhelds and sensor removal tools contain embedded magnets identified by the same symbol.

NOTE: *The sensor removal tool was updated in 2014. Item #599469 "EXO Sensor Tool Kit".*

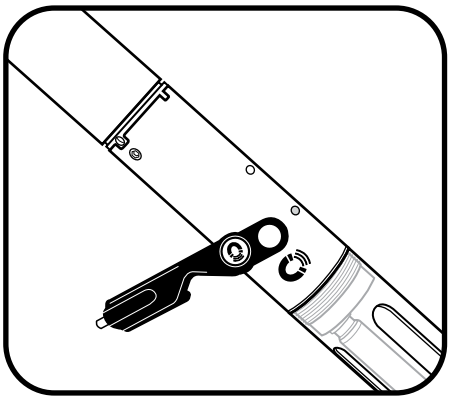


2 Awaken sonde without magnet

Users can also make their sonde go to the Awake state using any of the following methods.

- Cycling power to the sonde (uninstalling/installing batteries).
- Communicating via the topside port.
- Inserting a sensor.

In addition to these manual methods, the sonde also automatically awakens for scheduled unattended logging (programmed in KorEXO).



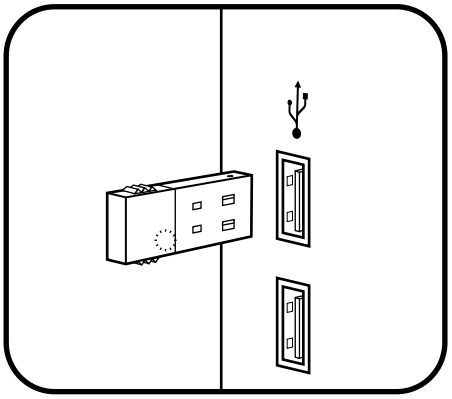
3 Activate sonde's *Bluetooth*

Users activate *Bluetooth* by holding a magnet at the magnetic activation area in the same way as described in Step 1. In addition to magnetic activation, users can also activate *Bluetooth* by:

- Cycling power to the sonde (uninstalling/installing batteries).
- Enabling *Bluetooth* via a connection at the topside port using KorEXO.

2.8 Connect Sonde
Bluetooth

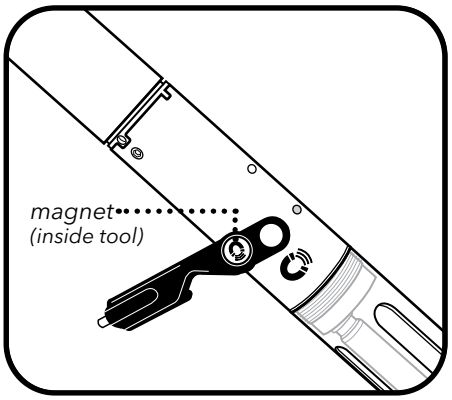
Before users can communicate wirelessly with their EXO sondes, they must establish a *Bluetooth* link. All EXO sondes are equipped with *Bluetooth*. This technology provides a secure, two-way, reliable communication channel with which users can communicate with their sondes above water without cables. Many new computers are equipped with *Bluetooth* wireless installed internally; those without *Bluetooth* can use a *Bluetooth* dongle (not included). Follow the manufacturer's instructions for installing the dongle's software and hardware.



1 Install *Bluetooth* dongle (optional)

If your computer is not equipped with internal *Bluetooth* radio, insert a *Bluetooth* dongle (not provided) into any of the computer's USB ports. Wait for the computer to automatically install the device and its drivers. Once the installation is complete, the computer should indicate that the device is installed and ready to use.

The preferred *Bluetooth* configuration is Windows 7 with native Windows *Bluetooth* drivers and software.



2 Activate sonde's *Bluetooth*

Users activate *Bluetooth* wireless by holding a magnet at the magnetic activation area. In addition to magnetic activation, users can also activate *Bluetooth* by:

- Cycling power to the sonde (uninstalling/installing batteries).
- Enabling *Bluetooth* via a connection at the topside port using KorEXO.

3 Establish *Bluetooth* Connection

1. Launch KorEXO Software.
2. Click the Scan for *Bluetooth* Devices button in thte Instrument Connection Panel.
3. This might need to be repeated several times before the software finds the sonde.
4. Once the EXO Sonde appears, simply click the Connect button to establish communications.

An option to Automatically Connect to Instrument is available in the General Settings.

2.9 Communication Adapters

Overview

The EXO platform now offers expanded communication adapter (com. adapter) options. Below is a high level overview of the com. adapter options available to you. Choosing the right adapter for your application, based on the desired communication protocol, will be a key factor in the success of your project.

NOTE: *Each communication adapter requires its own USB driver update, go to* **YSI.com/KorEXO** *to download the latest software and drivers.*

EXO USB Signal Output Adapter (599810)

This adapter supports a connection between an EXO sonde and a PC through a wired USB interface with the top-side connector. Transfer files and make changes to the sonde from your laptop or other USB ready smart device.

See Section 2.10 for EXO SOA connection instructions.

EXO DCP Signal Output Adapter 2.0 (599820)

The DCP-SOA is intended for use in long term monitoring applications and requires an EXO sonde, data logger, and flying lead cable to function. This adapter converts an EXO sonde signal into either SDI-12 or RS-232.

See Section 2.11 for more information on the EXO DCP SOA 2.0

EXO Modbus Signal Output Adapter (599825)

The Modbus SOA is intended for use in a SCADA system and requires an EXO sonde and flying lead cable to function. This adapter converts an EXO signal into a Modbus protocol over RS-232 or RS-485.

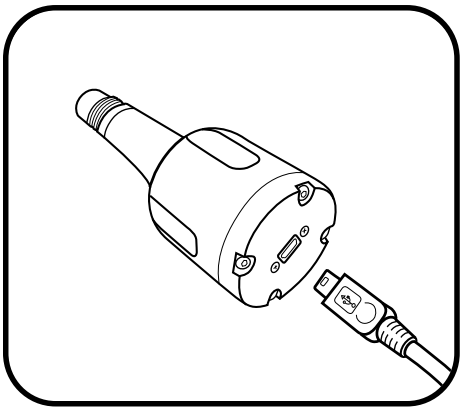
See Section 2.14 for more information on the EXO Modbus SOA.

2.10 Communication Adapters
USB

The USB signal output adapter (USB-SOA 599810) allows users to connect to an EXO sonde over a standard USB connection. Although the USB-SOA is rugged and water resistant, users should protect its connectors with the included cap when not in use.

NOTICE: The SOA should never be submerged.

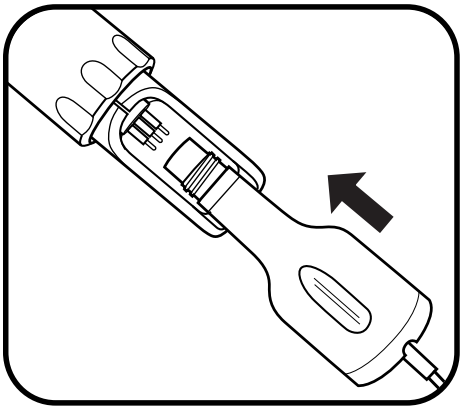
Prior to use, users must install KorEXO software and its drivers on the associated PC. The USB-SOA will not work without the drivers that accompany KorEXO. Drivers are included with the KorEXO Software download. Visit **YSI.com/KorEXO** for the latest drivers.



1 Connect USB cable to SOA and PC

Remove the protective cap from the USB end of the SOA, and ensure that the connector is clean and dry. Then insert the small end of the provided USB cable into the SOA connector and the large, standard side into one of the PC's USB ports. *The sonde should not be connected at this time.*

Attaching the adapter to the PC causes a new device to be recognized. Windows automatically installs the drivers and creates a new port. Each new adapter that is attached creates a new port.



2 Connect SOA to sonde

Remove the plug from the male 6-pin connector on the sonde. Apply a light layer of Krytox grease to the male pins on the sonde and the female connector on the USB-SOA. Then align the connector's six pins and jackets, and press them firmly together so that no gap remains.

Ports

KorEXO automatically scans ports for USB adapters. To view the USB adapter and its associated com port, go to the Control Panel on your computer, click Device Manager, then click Ports.

2.11 Communication Adapters

Data Collection Platform 2.0 (DCP)

Delivering quality data where and when you need it most.

Introduction:

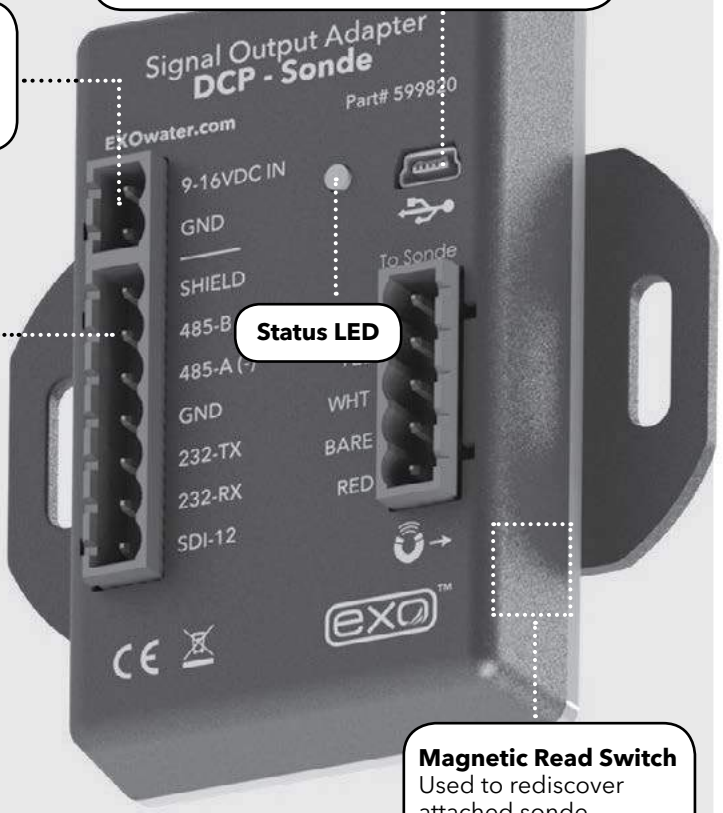
The 599820 is a communication adapter for the EXO multiparameter sonde platform. It converts the proprietary signal from the water quality sonde into either SDI-12 or RS-232 signals. The adapter simplifies integration into 3rd party DCP systems, and also features a USB port that supports passthrough communication directly to the connected sonde. This feature allows configuration, calibration, and data transfer without having to disconnect the field cabling.

Adapter Overview:

Mini USB Connector
Provide power to the adapter, and passthrough communication to the sonde.

Supply Power, 12VDC
Provided from external regulated power source (not included).

SDI-12 & RS-232 I/O Terminal
Use either SDI-12 or RS-232 terminals.



Status LED

Magnetic Read Switch
Used to rediscover attached sonde.

Safety:

Do not attempt electrical wiring beyond your skill level. Follow all applicable code and regulations subject to electrical wiring and operation of the system.

Specifications

Supply Voltage: 9 - 16 VDC or USB 5 VDC

Current Draw Adapter: ~20mA typical (@12VDC)

Current Draw Sonde: ~sleep 0.25mA reading and 100mA during operation

Max Net Current Draw for Systems: ~120mA (@12VDC)

Dimensions: L=3.5", W=3.5", H=1.5" (8.9cm x 8.9cm x 3.8cm)

Operating Temp: -40°C to +60°C

Storage Temp: -50°C to +80°C

Humidity: 0 to 99% non-condensing

What's Included:

The 599820 EXO Communication Adapter comes with:

- (1) DCP 2.0 Adapter
- (3) green wiring terminal blocks (Sonde 5-pin, Power 2-pin, DCP 7-pin)
- (1) Panel mounting bracket
- (1) Hook and loop fastener

If any item is missing, please contact **info@ysi.com** for replacements.

You'll also need:

- Flat blade screwdriver for terminal blocks
- Phillip's screwdriver for panel mount bracket
- EXO magnetic sensor tool (optional)
- EXO Flying Lead Field cable (599008-x)
- EXO sonde system, sensors, and associated hardware
- Latest KorEXO software (available from **YSI.com**)

Getting Started

Mounting:

The adapter should be protected from the elements, and it is recommended it be mounted inside of a sealed enclosure with desiccant to prevent condensation.

The adapter includes a panel mount in addition to self-adhesive hook and loop fastener. Either of these two methods can be used to securely mount the adapter. Use the provided Phillips screw to secure the panel mount:

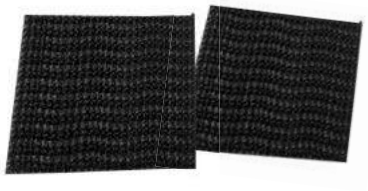
Panel Mount

1:

2:

Back Front

Self-Adhesive Hook and Loop Fastener



NOTE: *If using self adhesive hook and loop, clean and dry both surfaces before applying.*

NOTE: *This adapter is not required for use of SDI-12 with an EXO3 sonde. It is however, still required, if you need RS-232 communications.*

Status LED Indications	
Off	No power
On, no flashing	No Sonde connected
Flashing at 1 Hz	Sonde connected, everything normal
Flashing at 0.1 Hz	Low power sleep (Will flash on for 1 second when magnetic switch is activated.)

Wiring

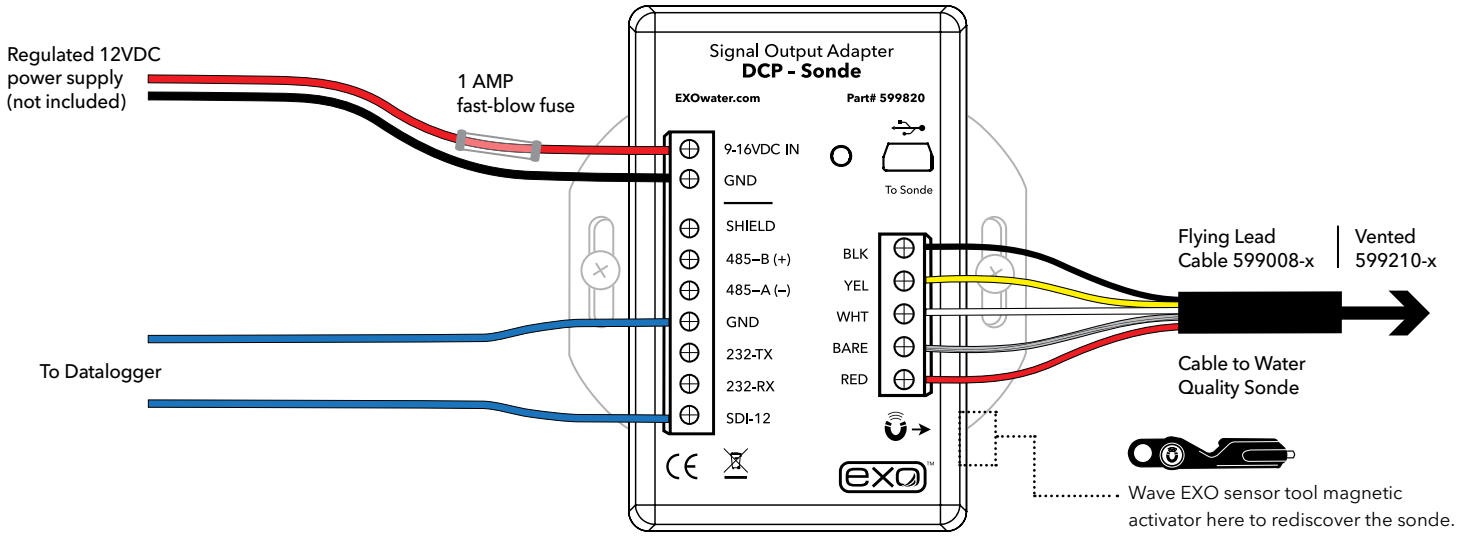
Have the following ready:

- EXO Sonde
- DCP 2.0 Adapter
- Flying Lead Cable
- Desiccant if using Vented Cable
- Flat blade screwdriver
- Power & Data Logger Wires

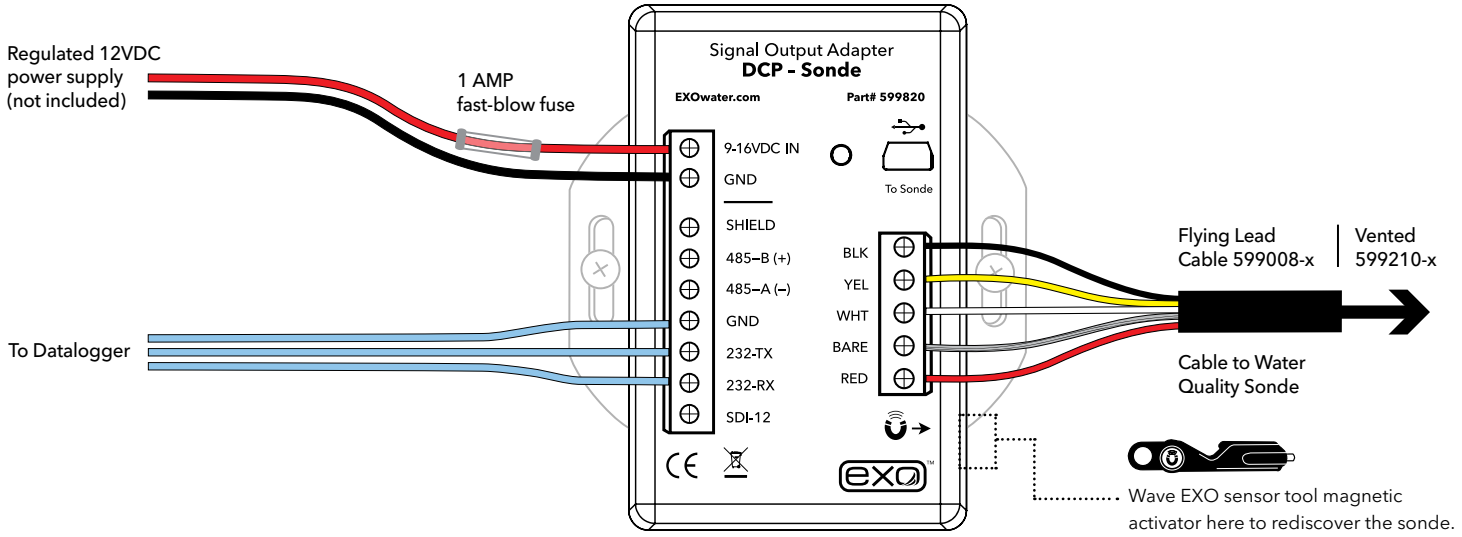
Webinar | A Simple Guide to Collecting Water Quality Data
Learn the basics of wiring your Sonde up to a DCP:
https://goo.gl/B4PPK7

Wiring Continued

Next wire the flying lead cable, power, and DCP ports as labeled in one of the following configurations:



OR



When connecting new sondes to the DCP adapter, it may be necessary to redetect the sonde. This can be done by power cycling the adapter or by using the magnetic read switch at the lower right hand side of the enclosure. Waving the magnet in the EXO sensor tool over the area referenced by the square above, will force a network redetect where all new sensors and configurations will be discovered.

NOTE: *The orange wire on the flying lead cable to the sonde will not be used. It can be taped back during installation.*

USB Passthrough Mode

The 599820 DCP Signal Output Adapter can function in a similar fashion as the 599810 USB communication adapter. After the Signal Output Adapter is wired as shown in the previous configuration, connecting to the USB port on the adapter will allow direct communications with the sonde using KorEXO software. **USB passthrough drivers** will automatically be installed along with KorEXO 2.0 software, they are also available separately from **YSI.com/KorEXO**. Install these drivers on your PC to communicate with a signal output adapter (SOA) through any version of Desktop KorEXO:

NOTE: *USB utilizes Communication Device Class (CDC) and installs as com port on PC: "YSI SOA/DCP Gen2". The USB connection may also be used to update firmware on the adapter using KorEXO software.*

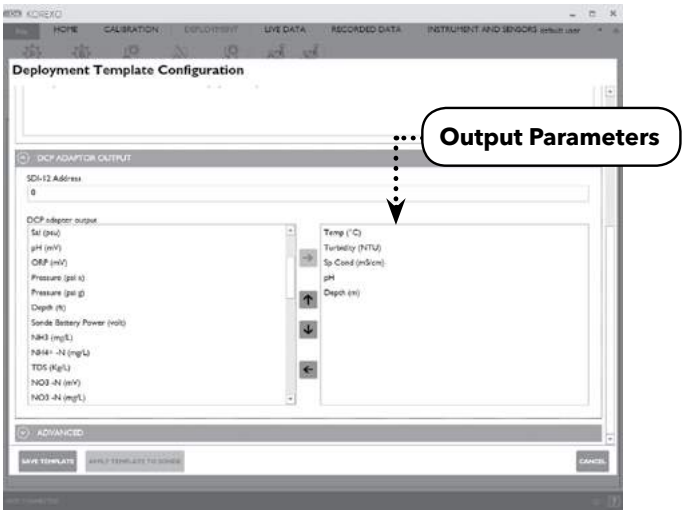
Output Configuration

In order to appropriately setup a sonde to communicate measurements to a datalogger, it is critical to align the settings from the sonde and the logger.

In the KorEXO software |**Deployment Settings**| choose the parameters and sort order, then push the template to the sonde.

The complete list of parameters is shown in the left column and the selected parameters to output via the DCP 2.0 adapter are shown on the right. This template can be saved locally on the PC, but it must also be pushed down to the sonde for the settings to take effect. So be sure to apply the template to the sonde.

NOTE: *There are two options when applying the template to the sonde, apply without logging or with logging. Either option may be used. When deploying with logging the sonde will create a redundant log file inside the sonde. Without logging the data will only be available to the RS-232 or SDI-12 outputs.*



KorEXO Version 2.0.x

For access to the beta software, or assistance changing the default settings, please contact Technical Support at **info@ysi.com**.

EXO DCP Signal Output Adapter Programming Basics

1. SDI-12 Interface

• General

- Compatible with v1.3 of SDI-12 specification
- Supports following standard commands:
  - '!' Address Query
  - 'A' Change Address
  - 'C' Concurrent Measurement
  - 'D' Data
  - 'I' Identification
  - 'M' Start Measurement
  - 'V' Start Verification

• Extended Commands

- SDI-12 'Z' command
- Supports the following RS-232 commands:
  - 'sn' Serial Number
  - 'para' Parameter List
  - 'twipeb' Start wipe
  - 'ver' S/W version
  - 'ssn' Sensor Serial Numbers

2. RS-232 Interface

• General

- Command Line
- '#' is user prompt
- Commands are not case sensitive
- Only spaces are recognized as delimiters
- A command is terminated by a <CR>
- Minimum time from power up to valid readings is 19 seconds

• Command List

See RS-232 commands in Section 2.12
See SDI-12 Port Settings in Section 2.13

An example of a NEMA enclosure where the DCP Signal Output Adapter is wired.

2.12 Communication Adapters
RS-232

The EXO DCP Signal Output Adapter (SOA) supports limited RS-232 commands. The SOA supports both SDI-12 and RS-232 communications. The order of the RS-232 parameter output is controlled by the SDI-12 tab on the deployment menu.

[ ] indicates argument is optional **<i>** indicates argument is an integer

data
Returns one line of data readings. Data parameters specified in para command. Data delimiter is specified in the setdelim command.

dowait [<i>]
Turns "wait for DO" on if <i>=1 and off if <i>=0. The response is "OK". If you do not supply <i>, then the response is the current value of dowait. When enabled the SOA/DCP will not return data until sonde has been on for "dowarmup" seconds.

dowarmup [<i>]
Sets DO sensor warmup time where <i>=warmup time in seconds. The response is "OK". If you do not supply <i>, then the response is the current value for dowarmup. When "dowait" is enabled the SOA/DCP will not return data until sonde has been on for "dowarmup" seconds.

fltreset
Resets all sonde sensor filters. The response is "OK".

hwipesleft
Returns a value other than 0 if a wiper event is in progress. The value returned is normally the amount of "half" wipes that are left to go. When wiping is completely finished, the value will go to 0.

para
Returns the parameter numbers of all parameters selected for output. Each number returned matches one for one with the values returned in the data command. The numbers are space delimited.

para [<i1> <i2> <i3> <i4> ...]
Sets the data parameter codes used with the data and run commands. The parameters are space delimited. If you do not supply any parameters then the response is the current list of parameters. Maximum number of parameters is 32.

pwruptorun [<i>]
Turns "power up to run" on if <i>=1 and off if <i>=0. The response is "OK". If you do not supply <i>, then the response is the current value of pwruptorun.

run
Causes the sonde to SOA/DCP to take sonde readings at a 1Hz rate. The output is similar to the Data command except that readings are taken continuously. No headers are output. To abort send '0', <esc>, or turn power off to the SOA/DCP and then reapply.

setcomm [<i1>] [<i2>]
Changes the SOA/DCP's comm port baud rate and data length. The baud rate will be immediately changed after this command, so you will need to reconfigure your terminal to match.

<i1> can be:

2 - 1200 baud

3 - 2400 baud

4 - 4800 baud

5 - 9600 baud (default)

6 - 19200 baud

7 - 38400 baud

8 - 57600 baud

9 - 115200 baud

<i2> can be:

0 - 7 bits

1 - 8 bits

Send these commands to the DCP via an RS-232 hyperterminal window configured with the following:

Bits per second	9600
Data bits	8
Parity	None
Stop bits	1
Flow control	None

setdelim [<i>]
Changes the SOA/DCP's delimiter used in the data command response. If you do not supply <i>, then the response is the current value for delimiter.

<i> can be: 0 = space, 1 = TAB, 2 = comma, 3 = none

setecho [<i>]
Enables (<i>=1) or disables (<i>=0) command echoes. When echoes are disabled, commands sent to the SOA/DCP will not be 'echoed' back and there will be no '# ' prompt. If you do not supply <i>, then the response is the current value for echo.

setmode [<i>]
Sets the RS232 mode. If <i>=0, mode is normal. If <i>=1 mode is NMEA. If you do not supply <i>, then the response is the current value for mode.

setradix [<i>]
Sets the radix point used for data output. If <i>=0 radix will be '.'. If <i>=1 radix will be ','. Note that in SDI-12 mode, the response to a 'D' command will always be with '.' regardless of this setting. The response is "OK". If you do not supply <i>, then the response is the current value for radix.

setsonde [<i>]
Selects a sonde for RS-232 communications when sondes are daisy-chained. <i> represents the order of the sonde in the chain where 1st sonde = 0, 2nd = 1, 3rd = 2. The response is "OK". If you do not supply <i>, then the response is the current value for the sonde.

sn
Returns the unique serial number programmed into every YSI sonde.

ssn
Returns the unique serial number for the sonde and all attached sensors.

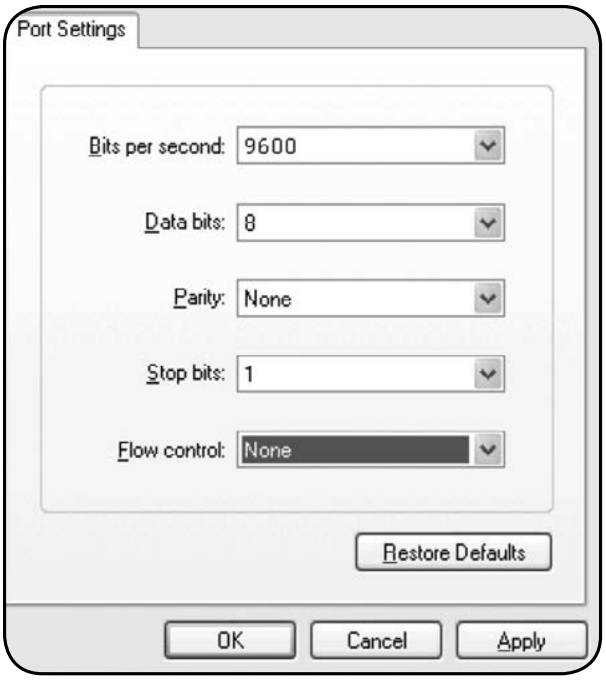
setperiod [<i>]
Sets the period for the data output in RUN mode. The period is set to <i> milliseconds. Minimum value is 250 (1/4 second), maximum value is 30000 (30 seconds). If you do not supply <i>, then the response is the current value for period. For periods less than 1000 and baud rates below 9600, the data output may be unreliable.

time [<hh:mm:ss>]
Allows user to set time in the sonde in the HH:MM:SS format. The response is "OK". If you do not supply <hh:mm:ss>, then the response is the current value of time.

twipeb
Starts a wiper event. The response is the approximate time in seconds it will take to perform the wipe.

ver
Returns the software version number of the sonde.

verdate
Returns the time and date at which the current version of software in the sonde was compiled.



RS-232 settings should resemble this image.

2.13 Communication Adapters

SDI-12

The sonde can be connected to an SDI-12 bus using a DCP Signal Output Adapter (SOA). The SOA provides the necessary SDI-12 electrical interface and communicates to the sonde via the topside RS-485 interface. The SOA will automatically recognize when a sonde is connected and retrieve the SDI-12 address and ID from the sonde. The SDI-12 data parameter list is set by the user in the Deploy menu. Go to Deploy | Open Template | Edit Template menu and click on the SDI-12 tab.

- Maximum of 23 codes in sonde parameter list.

Parameter	Code
Temperature, °C	1
Temperature, °F	2
Temperature, °K	3
Conductivity, mS/cm	4
Conductivity, µS/cm	5
Specific Conductance, mS/cm	6
Specific Conductance, µS/cm	7
TDS, g/L	10
Salinity, PPT	12
pH, mV	17
pH	18
ORP, mV	19
Pressure, psia	20
Pressure, psig	21
Depth, m	22
Depth, ft	23
Battery, V	28
Turbidity, NTU	37
NH3 (Ammonia), mg/L	47
NH4 (Ammonium), mg/L	48

Parameter	Code
Date, DDMMYY	51
Date, MMDDYY	52
Date, YYMMDD,	53
Time, HHMMSS	54
TDS, kg/L	95
NO3 (Nitrate), mV	101
NO3 (Nitrate), mg/L	106
NH4 (Ammonium), mV	108
TDS, mg/L	110
Chloride, mg/L	112
Chloride, mV	145
TSS, mg/L	190
TSS, g/L	191
Chlorophyll, ug/L	193
Chlorophyll, RFU	194
ODO, %Sat	211
ODO, mg/L	212
ODO, %Sat Local	214
BGA-PC, RFU	216
BGA-PE, RFU	218

Parameter	Code
Turbidity, FNU	223
Turbidity, Raw	224
BGA-PC, ug/L	225
BGA-PE, ug/L	226
fDOM, RFU	227
fDOM, QSU	228
Wiper Position, V	229
External Power, V	230
BGA-PC, Raw	231
BGA-PE, Raw	232
fDOM, Raw	233
Chlorophyll, Raw	234
Potassium, mV †	235
Potassium, mg/L †	236
nLF Conductivity, mS/cm	237
nLF Conductivity, µS/cm	238
Wiper Peak Current, mA	239
Vertical Position, m	240
Vertical Position, ft	241

† **NOTE:** *Potassium is considered future functionality, there is currently no EXO probe for Potassium (as of 2015).*

2.14 Communication Adapters
Modbus

Delivering quality data where and when you need it most.

Introduction:

The 599825 is a communication adapter for the EXO multiparameter sonde platform. It converts the proprietary signal from the water quality sonde into a Modbus protocol over either RS-232 or RS-485 signals. The adapter simplifies integration into 3rd party SCADA systems, and also features a USB port that supports passthrough communication directly to the connected sonde. This feature allows configuration, calibration, and data transfer without having to disconnect the field cabling.

Adapter Overview:

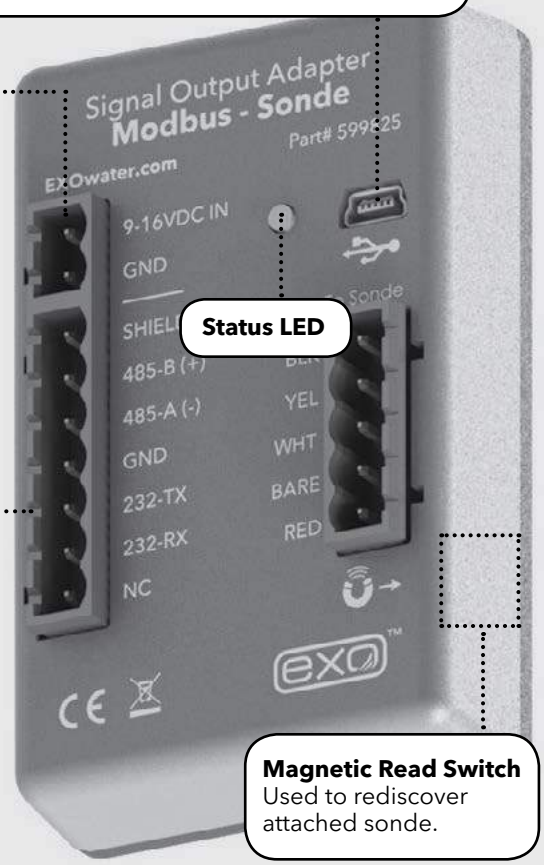
Mini USB Connector
Used to configure adapter settings, provide power to the adapter, and passthrough communication to the attached sonde.

Supply Power, 12VDC
Provided from external regulated power source (not included).

Modbus I/O Terminal
Use either 485 (default) or RS-232 terminals.

Status LED

Magnetic Read Switch
Used to rediscover attached sonde.



Safety:

Do not attempt electrical wiring beyond your skill level. Follow all applicable code and regulations subject to electrical wiring and operation of the system.

Specifications

Supply Voltage: 9 - 16 VDC or USB 5 VDC
Current Draw Adapter: ~20mA typical (@12VDC)
Current Draw Sonde: ~sleep 0.25mA reading and 100mA during operation
Max Net Current Draw for Systems: ~200mA (@12VDC)
Dimensions: L=3.5", W=3.5", H=1.5" (8.9cm x 8.9cm x 3.8cm)
Operating Temp: -40°C to +60°C
Storage Temp: -50°C to +80°C
Humidity: 0 to 99% non-condensing

What's Included:

The 599825 EXO Communication Adapter comes with:

- (1) Modbus Adapter
- (3) green wiring terminal blocks (Sonde 5-pin, Power 2-pin, Modbus 7-pin)
- (1) Panel mounting bracket
- (1) DIN rail mounting bracket
- (1) Hook and loop fastener

If any item is missing, please contact info@ysi.com for replacements.

You'll also need:

- Flat blade screwdriver for terminal blocks
- Phillip's screwdriver for panel mount bracket or din rail bracket
- EXO magnetic sensor tool (optional)
- EXO Flying Lead Field cable (599008-x) or Vented Flying Lead cable (599210-x)
- EXO sonde system, sensors, and associated hardware
- Latest KorEXO software (available from YSI.com)

Mounting:

The adapter should be protected from the elements, and it is recommended it be mounted inside of a sealed enclosure with desiccant to prevent condensation.

The adapter includes a panel mount or a DIN rail mount in addition to self-adhesive hook and loop fastener. Any of the three methods can be used to securely mount the adapter. Use the provided Phillips screw to secure the panel or din rail mount:

Panel Mount

1:

2:

Back Front

DIN Rail Mount

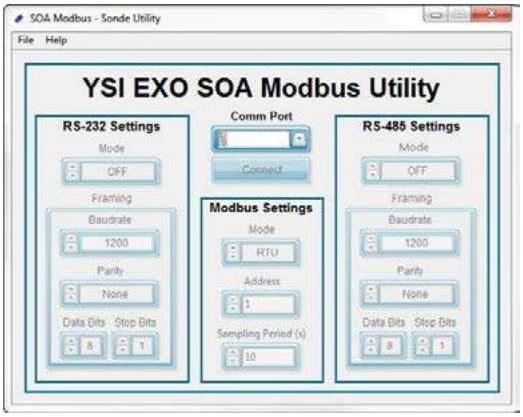
Self-Adhesive Hook and Loop Fastener

NOTE: *If using self adhesive hook and loop, clean and dry both surfaces before applying.*

Status LED Indications	
Off	No power
On	No Sonde connected
Flashing at 1 Hz	Sonde connected, everything normal
Flashing at 1/10 Hz	Low power sleep (Will flash on for 1 second when magnetic switch is activated.)

Configuration:

Downloading the SOA Modbus Utility
The EXO SOA Modbus Utility must be installed on your computer in order to change settings. The utility is available for download from the YSI **Software Downloads** page.



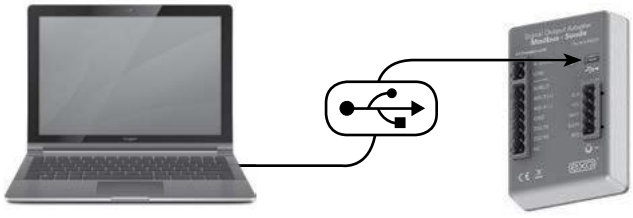
Connecting to the SOA Modbus Adapter
Method 1: Select the port by using the Comm Port selection box and then click Connect.

Method 2: Use the List Comm Ports user interface (UI) located in the Help menu to select a port. In the UI, double-click an application port and the application will automatically connect.

Configuring the SOA Modbus Adapter
Once you are connected, the application retrieves all of the current settings and displays them. To change a setting, modify the value of interest and the application will automatically update the SOA.

Default Settings	
Bus: RS-485	**Parity:** None
Mode: RTU	**Data Bits:** 8
Baud rate: 9600	**Stop Bit:** 1
Modbus Address: 1 (AKA slave address)	

USB passthrough drivers will automatically be installed along with KorEXO 2.0 software, they are also available separately from **YSI.com/KorEXO** website. Install these drivers on your PC to communicate with a signal output adapter (SOA) through any version of Desktop KorEXO:

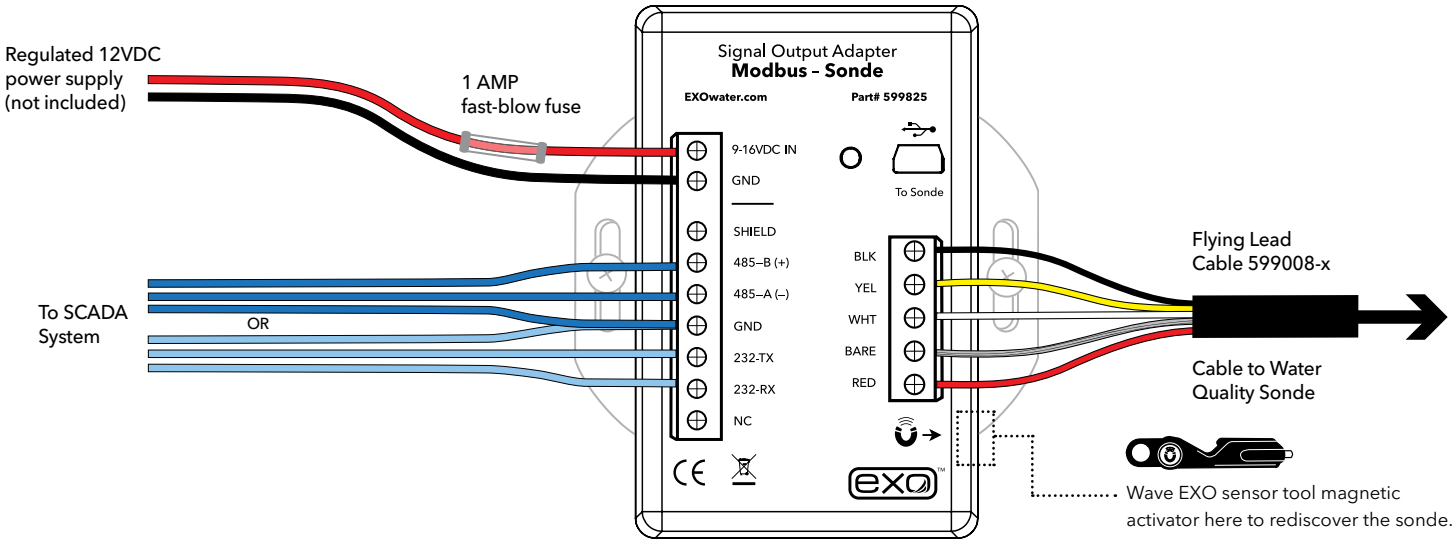


Wiring

Have the following ready:

- EXO Sonde
- Com Adapter
- Flying Lead Cable
- Flat blade screwdriver
- Power & SCADA Wires

Next wire the flying lead cable, power, and Modbus ports as labeled:



NOTE: *The orange wire on the flying lead cable to the sonde will not be used. It can be taped back during installation.*

NOTE: *3rd party RS-485 to TCP adapters may be used in conjunction with the EXO Modbus Adapter, however we are unable to provide specific support or configuration settings for these modules. The gridconnect "Net485" adapter has been successfully used in applications requiring TCP Modbus interface.*

When connecting new sondes to the Modbus adapter, it may be necessary to redetect the sonde. This can be done by power cycling the adapter or by using the magnetic read switch at the lower right hand side of the enclosure. Waving the magnet in the EXO sensor tool over the area referenced by the square above, will force a network redetect where all new sensors and configurations will be discovered.

USB Passthrough Mode

The 599825 Modbus Adapter can function in a similar fashion as the 599810 USB communication adapter. It will power the device and provide limited power to the sonde. After the Modbus adapter is wired as shown in the previous configuration, connecting to the USB port will allow direct communications with the sonde using KorEXO software.

NOTE: *USB utilizes Communication Device Class (CDC) and installs as com port on PC: "YSI SOA/DCP Gen2".*
The USB connection may also be used to update firmware on the adapter using KorEXO software.

General Modbus Information

- Register references are to the typical Holding Registers. Depending on your SCADA system these may be the 400,000 registers, the 40,000 registers, or simply the register values defined in this document. In this document the register value will generally be used. In all cases the register value will be +1 from the address value.

- The Output adapter makes use of the Modbus Holding register system to transfer data. It will respond to the Modbus commands "Read Holding Registers", "Write Single Register" and "Preset Multiple Registers". For all other commands the 599825 Modbus Adapter will return an illegal function exception. In general if you attempt to read or write from to a reserved or unused area, the 599825 Modbus adapter will return an illegal data access exception.

- The 599825 Modbus adapter is a slave device.

- The Modbus adapter maintains a current set of data in the holding registers. Use the "Read Holding Registers" command to obtain the most recent set of data from sonde connected to the 599825 Modbus adapter. Each parameter from the EXO water quality sonde is stored in a different register (or register pair). Also in different registers is status information from the 599825 Modbus adapter and the same command is used to read status. Values in still other registers control which parameters are enabled in the sonde. Programmers can enable and disable sonde parameters by writing to these registers using the "Preset Multiple Register" command.

- There are 3 main register areas to deal with the parameters:
  - Parameter type
  - Parameter status
  - IEEE floating point parameter data (Scaled integer parameter data, available but not recommended for use.)

Each of these areas is 32 registers long, except for the floating point data area which is 32 register pairs long. The first register (or register pair for the floating point data) in each area corresponds to the first parameter, the second corresponds to the second parameter, etc.

An example of a NEMA enclosure where PLC + Modbus adapter are wired.

General Modbus Information

40,000 Read Holding Address	40,000 Read Holding Register	Read/Write	Description
0	1	Read/Write Single Reg	**Sample Period:** The period in seconds at which the SOA will sample the sonde data and update holding registers (value between 0-3600)
1	2	Write Only Single Reg	**Force Sample:** Write any value here to force the SOA to update holding registers with sonde data allow 15 seconds for values to show up in data registers
2	3	Write Only Single Reg	**Force Wipe:** Write any value here to force the connected sonde to run its wiper
3-127	4-128	--	Unused – reserved for future special functions
128-159	129-160	Read/Write	**Parameter type:** The PLC must write to this area to tell the SOA what parameters it wants. Up to 32 parameters can be written here. After the last parameter the PLC must write a "0. The table on the "**Available Parameters Codes**" page lists the valid parameter type codes.
160-225	161-256	--	Reserved for future parameter type
256-287	257-288	Read Only	**Parameter status:** The PLC can read back the values in these registers to check the status of the parameters. The value in register 257 corresponds to the parameter type in register 129 and so on. The meaning of the returned value is: 0 – The parameter is available. 1 – The parameter type has not been set (i.e. type = 0) 2 – The parameter requested is not currently available.
288-383	289-384	--	Reserved for future parameter status
384-447	385-448	Read Only	**IEEE 754 Floating point parameter data:** This is the actual parameter data in floating point form. Two registers are used for each value to make up the 32 bits required for a 4 byte IEEE floating point number. The value in register pair 385:386 corresponds to the parameter type in register 129 and so on. It is highly recommended that this be used rather than the scaled integer format.
448-639	449-640	--	Reserved for future IEEE floating point parameter data
640-671	641-672	Read Only	**Scaled integer parameter data:** The PLC should only read data from the SOA using this method if it cannot handle floating point data. Most PLCs can manipulate floating point values, so you should try to avoid reading scaled integer values. The value in register 641 corresponds to the parameter type in register 129 and so on. The values are scaled according to a fixed table in the SOA. The scaled data is in an unsigned integer format. Each parameter type has a specific range and resolution. Refer to the scaled integer range table (page 8) for values for each parameter. For example, temperature °C has the range of –50 to 605.35, with a resolution of 0.01. Here are some integer values that could be returned along with their engineering equivalents: **0:** -50°C or less. **1:** -49.99°C **2:** -49.98°C **5000:** 0°C **7234:** 22.34°C **7500:** 25°C **65534:** 605.34°C **65535:** 605.35°C or higher
672-767	673-768	--	Reserved for future scaled integer parameter data
768+	769+	--	Unused

Common Acronyms: PCL Programmable Logic Controller
SCADA Supervisory Control and Data Acquisition

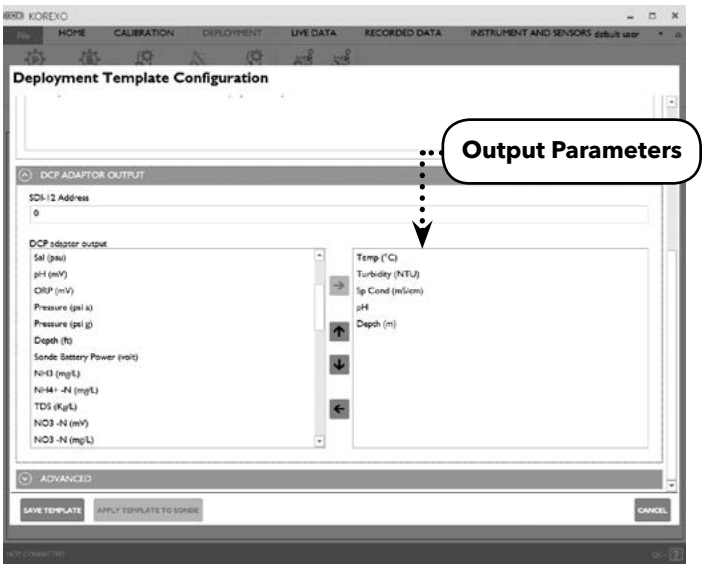
Registry Configuration

This section deals with mapping the water quality parameter types to the respective holding register 129-160. These are the measurement values generated by the water quality sonde. There are two methods to set the parameter map. The preferred method is to use the deployment templates available in any version of KorEXO. This standard functionality allows the parameters to be selected and saved. Alternatively the registers may be directly written by the SCADA system.

In the KorEXO software |**Deployment Settings**| choose the parameters and sort order, then push the template to the sonde.

The complete list of parameters is shown in the left column and the selected parameters to output via the Modbus adapter are shown on the right. This template can be saved locally on the PC, but it must also be pushed down to the sonde for the settings to take effect. So be sure to apply the template to the sonde.

NOTE: *There are two options when applying the template to the sonde, apply without logging or with logging. Either option may be used. When deploying with logging the sonde will create a redundant log file inside the sonde. Without logging, the data will only be available to the SCADA system.*



KorEXO Version 2.0.x

In the example below: Temp °C, Turbidity, SpCond, pH, and Depth M were chosen. This will automatically create a register map as follows:

Read Holding Address	Read Holding Register	Read/Write	Value	Description
128	129	Read/Write	1	The parameter code for Temp °C is displayed here
129	130	Read/Write	223	The parameter code for Turbidity (FNU or NTU) is displayed here
130	131	Read/Write	6	The parameter code for Sp Cond ms/cm is displayed here
131	132	Read/Write	18	The parameter code for pH is displayed here
132	133	Read/Write	22	The parameter code for Depth M is displayed here
133	134	Read/Write	0	Zero indicates the end of the register/parameter map

These register maps are stored in the sonde, and automatically program the 599825 Modbus adapter when power cycled or the magnetic read switch is activated. The alternative method is to write these parameter codes using the SCADA system in the format indicated above.

Available Parameter Codes

The alternative setup method is to write these parameter codes using the SCADA system in the format indicated.
The table below is the reference list of all available parameter codes for Read Holding Registers 129-160.

Parameter	Code
Temperature, °C	1
Temperature, °F	2
Temperature, °K	3
Conductivity, mS/cm	4
Conductivity, µS/cm	5
Specific Conductance, mS/cm	6
Specific Conductance, µS/cm	7
TDS, g/L	10
Salinity, PPT	12
pH, mV	17
pH	18
ORP, mV	19
Pressure, psia	20
Pressure, psig	21
Depth, m	22
Depth, ft	23
Battery, V	28
Turbidity, NTU	37
NH3 (Ammonia), mg/L	47
NH4 (Ammonium), mg/L	48

Parameter	Code
Date, DDMMYY	51
Date, MMDDYY	52
Date, YYMMDD,	53
Time, HHMMSS	54
TDS, kg/L	95
NO3 (Nitrate), mV	101
NO3 (Nitrate), mg/L	106
NH4 (Ammonium), mV	108
TDS, mg/L	110
Chloride, mg/L	112
Chloride, mV	145
TSS, mg/L	190
TSS, g/L	191
Chlorophyll, ug/L	193
Chlorophyll, RFU	194
ODO, %Sat	211
ODO, mg/L	212
ODO, %Sat Local	214
BGA-PC, RFU	216
BGA-PE, RFU	218

Parameter	Code
Turbidity, FNU	223
Turbidity, Raw	224
BGA-PC, ug/L	225
BGA-PE, ug/L	226
fDOM, RFU	227
fDOM, QSU	228
Wiper Position, V	229
External Power, V	230
BGA-PC, Raw	231
BGA-PE, Raw	232
fDOM, Raw	233
Chlorophyll, Raw	234
Potassium, mV †	235
Potassium, mg/L †	236
nLF Conductivity, mS/cm	237
nLF Conductivity, µS/cm	238
Wiper Peak Current, mA	239
Vertical Position, m	240
Vertical Position, ft	241

† **NOTE:** *Potassium is considered future functionality, there is currently no EXO probe for Potassium (as of 2015).*

The subsequent values for the parameter map are displayed in IEEE floating point parameter format (IEEE 754). The Parameter data is stored in read only address 385-448. Two address are used for each value to make up the 32 bits required for a 4 byte IEEE floating point number. The value in address pair 385:386 corresponds to the parameter type in register 129, etc.

In our example let's assume the following values: Temp 25.11°C, Turbidity 2.34 FNU, SpCond 3.02 ms/cm, pH 7.23, and Depth 1.45 M

Read Holding Address	Read Holding Register	Read/ Write	Value (IEEE 754)	Description
384	385	Read	0xE147	The least significant 16 bits of the 32-bit floating point value for 25.11
385	386	Read	0x41C8	The most significant 16 bits of the 32-bit floating point value for 25.11
386	387	Read	0x47AE	The least significant 16 bits of the 32-bit floating point value for 3.02
387	388	Read	0x4041	The most significant 16 bits of the 32-bit floating point value for 3.02
388	389	Read	0x5C29	The least significant 16 bits of the 32-bit floating point value for 7.23
389	390	Read	0x40E7	The most significant 16 bits of the 32-bit floating point value for 7.23

Advanced Configuration

The 599825 Modbus adapter will automatically sleep after 60 seconds of not being queried. To prevent the adapter from sleeping, query the adapter more frequently than 60 seconds. Alternatively program a sample interval into register 1. This is the interval the 599825 Modbus adapter will refresh its readings from the underwater sonde. It can be advantageous to sample at a 10 or 15 minute interval to extend the life of the sensors.

As an example a 10 minute (600 second) sample value in register 1 will query the sonde every 10 minutes to refresh the values in 385-448 IEE floating point registers. It is recommended you program a sample interval into the 599825 Modbus adapter half that of your scan interval. As an example if your SCADA will query the adapter every 20 minutes (1200 seconds) then it is recommended you write a 10 minute (600 seconds) sample value in address 1. This methodology will ensure the queried data is never more than 10 minutes old.

Activating the wiper: The EXO2/3 system is likely equipped with an central wiper to clean the sensors. There are two different mechanisms to activate the wiper.

The first is to write any number into register #3, this will trigger the EXO sonde to wipe the sensors in both directions. 60 seconds should be allocated for the wiping to complete, and the data presented to the Modbus holding registers during the wiping sequence will not be representative of the water quality because of the effects of the wiper passing over the sensors. It may be helpful to program a routine wipe interval into the SCADA system as well as an operator button to manually trigger the wipe sequence.

The second method is to program the sonde to autonomously sample at an interval that is greater than every two minutes. By default the sonde will wipe all the sensors before taking a reading. So programming a 1 hour deployment in the KorEXO software the sonde with automatically wipe the sensors. Note the real time data presented over Modbus during the wiping sequence will not be representative of the water quality because of the effects of the wiper passing over the sensors. This methodology will generate a redundant set of data internal to the sonde to compliment the data presented to the SCADA system.

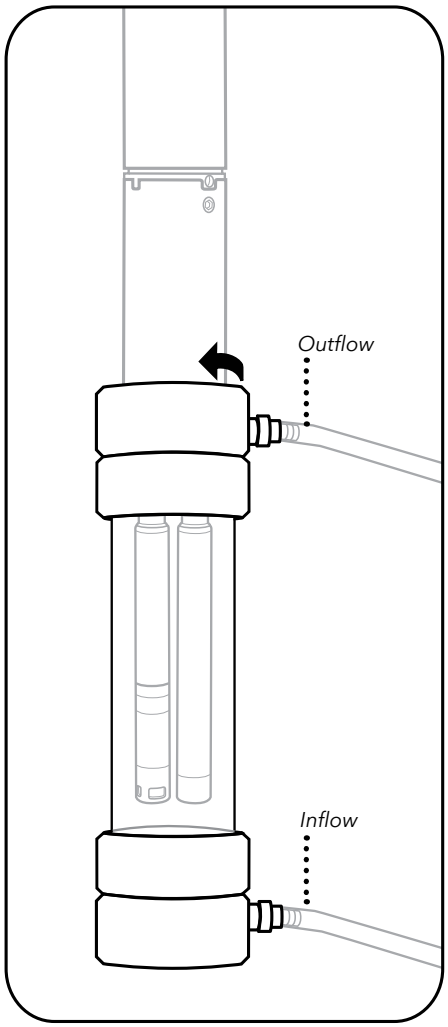
Scaled Integer Range Table

Parameter	Code	Scale Low	Scale High
Temperature, °C	1	-50	605.35
Temperature, °F	2	-50	605.35
Temperature, °K	3	0	655.35
Conductivity, mS/cm	4	0	655.35
Conductivity, uS/cm	5	0	65535
Specific Conductance, mS/cm	6	0	655.35
Specific Conductance, uS/cm	7	0	65535
TDS, g/L	10	0	65.535
Salinity, PPT	12	0	65.535
pH, mV	17	-1638.4	1638.35
pH	18	-27.768	39.767
ORP, mV	19	-1638.4	1638.35
Pressure, psia	20	-50	605.35
Pressure, psig	21	-50	605.35
Depth, m	22	-50	605.35
Depth, ft	23	-50	605.35
Battery, V	28	0	65.535
Turbidity, NTU	37	0	6553.5
NH3 (Ammonia), mg/L	47	0	655.35
NH4 (Ammonium), mg/L	48	0	655.35
Date, DDMMYY	51	N/A	N/A
Date, MMDDYY	52	N/A	N/A
Date, YYMMDD,	53	N/A	N/A
Time, HHMMSS	54	N/A	N/A
TDS, kg/L	95	0	65.535
NO3 (Nitrate), mV	101	-1638.4	1638.35
NO3 (Nitrate), mg/L	106	0	655.35
NH4 (Ammonium), mV	108	-1638.4	1638.35
TDS, mg/L	110	0	65535
Chloride, mg/L	112	0	655.35

Parameter	Code	Scale Low	Scale High
Chloride, mV	145	-1638.4	1638.35
TSS, mg/L	190	0	6553.5
TSS, g/L	191	0	6.5535
Chlorophyll, ug/L	193	0	655.35
Chlorophyll, RFU	194	0	655.35
ODO, %Sat	211	0	655.35
ODO, mg/L	212	0	65.535
ODO, %Sat Local	214	0	655.35
BGA-PC, RFU	216	0	655.35
BGA-PE, RFU	218	0	655.35
Turbidity, FNU	223	0	6553.5
Turbidity, Raw	224	0	655.35
BGA-PC, ug/L	225	0	655.35
BGA-PE, ug/L	226	0	655.35
fDOM, RFU	227	0	655.35
fDOM, QSU	228	0	655.35
Wiper Position, V	229	0	65.535
External Power, V	230	0	65.535
BGA-PC, Raw	231	0	655.35
BGA-PE, Raw	232	0	655.35
fDOM, Raw	233	0	655.35
Chlorophyll, Raw	234	0	655.35
Potassium, mV	235	-1638.4	1638.35
Potassium, mg/L	236	0	655.35
nLF Conductivity, mS/cm	237	0	655.35
nLF Conductivity, uS/cm	238	0	65535
Wiper Peak Current, mA	239	0	65.535
Vertical Position, m	240	-50	605.35
Vertical Position, ft	241	-50	605.35

2.15 Connect Sonde
Flow Cell

There are two versions of the EXO flow cell: EXO1 flow cell (599080) and EXO2 / EXO3 flow cell (599201). Flow rate through the flow cell is typically between 100 mL and 1 L per minute. Maximum flow rate depends on tubing type, size, and length. Maximum pressure for each flow cell is 25 psi. Flow cell volumes (without sensors installed) are approximately 410 mL for EXO1, and 925 mL for EXO2 and EXO3.



1 Inspect sonde and flow cell

Remove the sensor guard and/or calibration cup so that the sensors are exposed.

Make sure that the threads of the sonde and flow cell as well as all o-rings are clean and free of any particles such as sand, grit, or dirt.

2 Insert sonde into flow cell

Insert the sonde into the top of the flow cell. Be careful not to bump or scrape the sensors on the sides of the flow cell.

Screw the sonde into the flow cell by turning the sonde clockwise until it is hand-tightened into place; do not use a tool.

3 Connect tubing to flow cell

Install the Quick Connect tube fittings onto the flow cell by inserting them into the Quick Connect coupling body. They should snap into place.

Connect the tubing from your pump (not included) to the Quick Connect tube fittings, making sure that the tubing is pushed securely onto the fittings. The inflow should be at the bottom of the flow cell and the outflow should be at the top.

Keep flow cell vertical to purge it and ensure air release from Conductivity/ Temperature sensor.

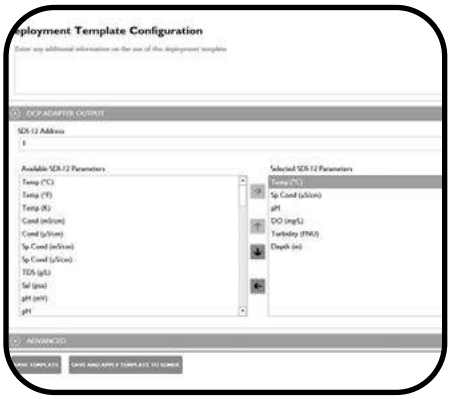
NOTICE: Do not turn on water to the system *until* the flow cell is securely connected.

2.16 Daisy Chaining
Sonde Expansion

It is possible to daisy chain up to three EXO2 sondes using the built-in topside auxiliary port.
Below is a quick start guide for setting up sondes for long-term deployment in this application.

NOTE: *Daisy chaining is only possible with EXO2 sondes.*

NOTE: *These instructions are for the DCP-SOA 1.0. With the new 2.0 model, you no longer have to be this meticulous about the order in which you connect the instruments. Simply hook all the components together and then use the magnetic activation on the side of the DCP-SOA 2.0 to allow it to reset and rebuild the map.*



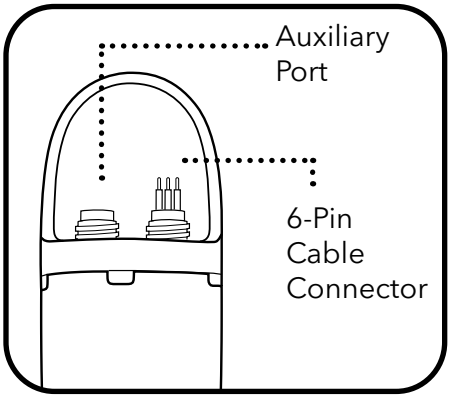
1 Set Deployment Times

Connect to each sonde individually via KorEXO. One by one, use the Deploy menu to Read Current Sonde Settings and make changes to the deployment templates. If using SDI-12 communications (recommended), set each sonde with a unique SDI-12 address.

2 Connect the Sondes

Remove power from the DCP adapter and remove all batteries from the instruments, then connect the 2-3 sondes in series using standard EXO field cables (connecting one sonde's communications connector with another sonde's topside auxiliary port).

NOTE: *Total cable length cannot exceed 300m, and the sondes themselves cannot exceed 250m depth.*



3 Connect Sondes to SOA-DCP

Using a flying lead cable, connect the topmost sonde to an EXO DCP Signal Output Adapter. Install batteries in the sonde furthest from the DCP adapter first. Then install batteries in the next sonde furthest from the adapter and then the sonde closest to the adapter if there are three sondes attached. Make sure the installed batteries are new and have around 6.0 volts supplied.

The final step is to apply power to the DCP adapter.

4 Test the System

Once the batteries have been installed and power has been supplied to the DCP adapter - use the SDI-12/RS232 commands in Section 2.12 and 2.13, communicate with each daisy chained sonde to ensure data is collected.

NOTE: *Deploy the daisy chained system with a support cable connected to the bail of each sonde. If any changes are made to the configuration of the setup, the DCP adapter will need to be power cycled so the changes will take effect.*

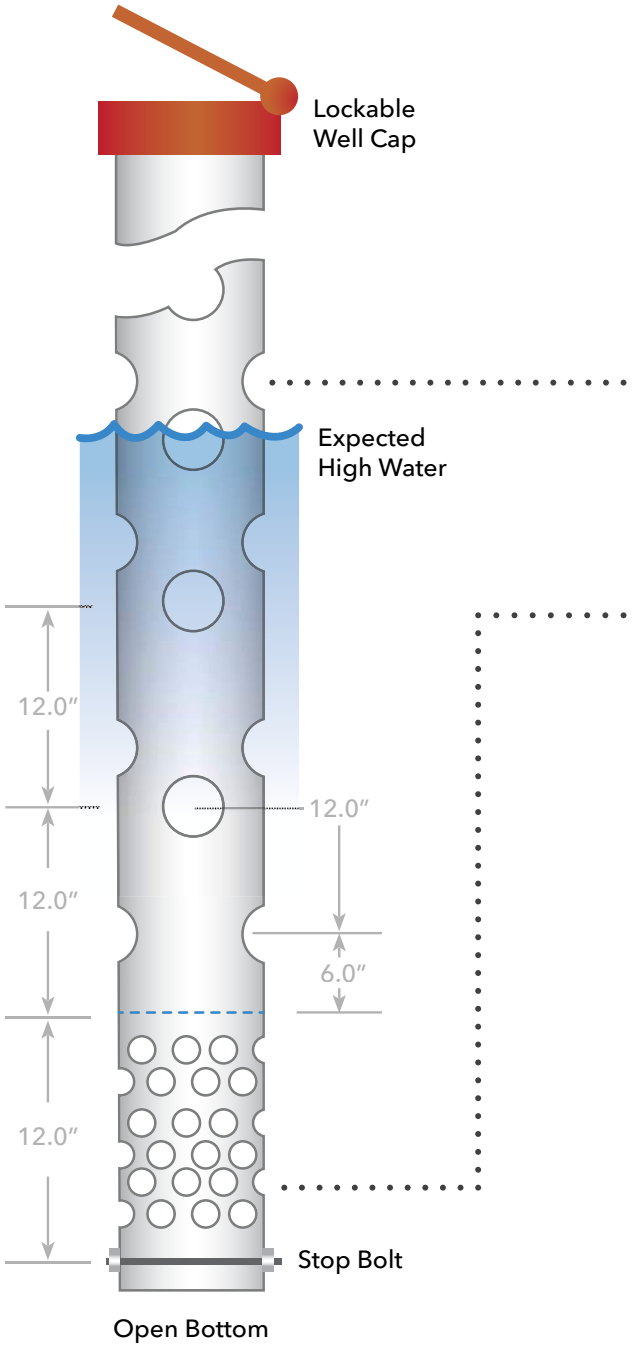
2.17 Sonde Clamping / Mooring

Long-Term Monitoring

In long-term monitoring applications, where the sonde will be left unattended for long periods of time, it is critical that you properly mount and protect your EXO sonde. This will ensure you receive quality data and that your instrument is not lost in a flood or other natural event. While there are many options available to you to secure your sonde for long-term monitoring, including mooring cages and protective housing, below you will find a general guide for the most common method - the deployment tube.

Vertical Deployment Tube

The most common configuration for a deployment tube, typically off a pier or other fixed location. Highly recommended for the highest quality data as it ensures a proper flow of water to the sensors, and avoids stagnation.



MATERIALS

- SCH 40 or SCH 80 - 4″ PVC Pipe
- 1/2″ SS Bolt, 6″ Long
- 1/2″ Flat Washers, Lock and Nut
- 4″ Lockable Well Cap, Plastic or Aluminum
- 5200 Marine Sealant (for bonding pipe to cap)

INSTRUCTIONS

<u>Vent or tube flushing hole pattern</u>:
2.5″ internal diameter.

Start one set 6″ from end or top of sensor holes. Drill two holes at 0° and 180°. Start second set of two holes at 12″ from sensor holes, drill at 90° and 270°.

<u>Sensor area hole pattern</u>:
Starting 1.0″ above the stop bolt, drill 1.0″ internal diameter holes around the entire sensor area. Should resembled Swiss-cheese. This allows for maximum flow of water to the sensors.

Mounted to Pier

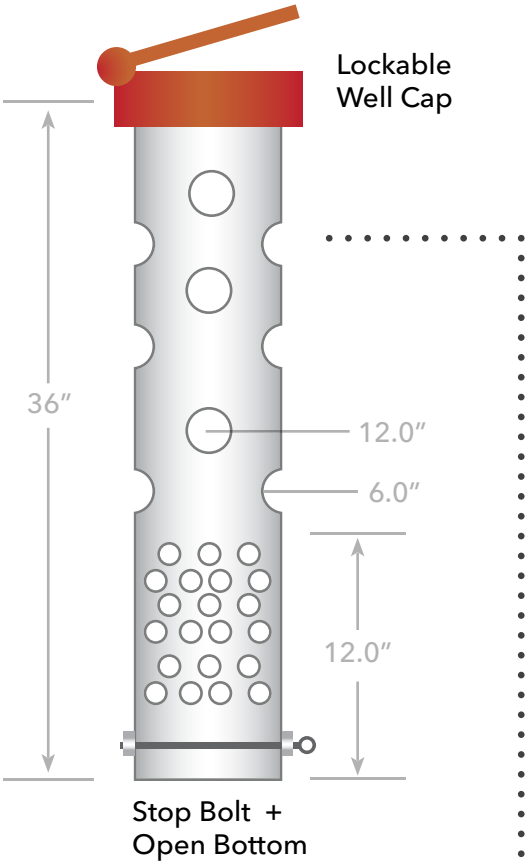
Copper Design

NOTES

- Clean and degrease pipe prior to modifications
- In marine and other fouling sites paint inside and out with anti-fouling paint
- Clean pipe at least twice a year

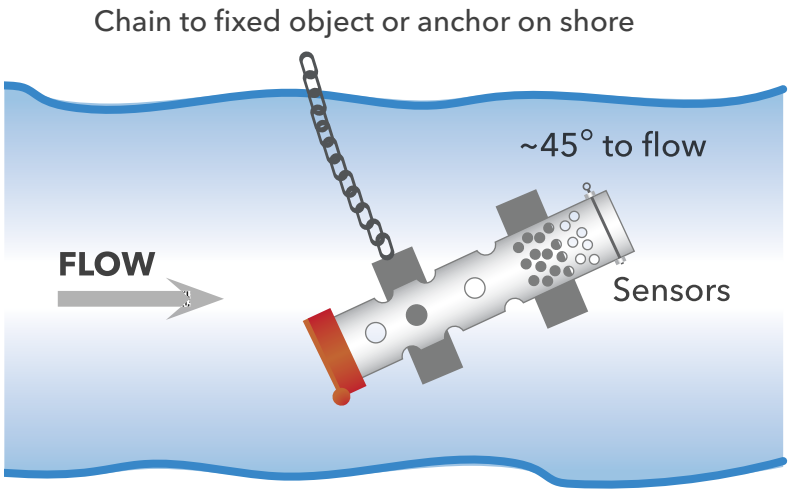
Horizontal Deployment Tube

In shallow water applications it is possible to deploy your EXO sonde horizontally. However, care must be taken that the sensors stay submerged and hydrated. This configuration has inherent risks such as sediment build up and is somewhat susceptible to flooding events even when properly fixed in place.



MATERIALS

- SCH 40 or SCH 80 - 4″ PVC Pipe, 36″ Long
- 1/2″ SS Bolt or Eye Bolt, 6″ Long
- 1/2″ Flat Washers, Lock and Nut
- 4″ Lockable Well Cap, Plastic or Aluminum
- 5200 Marine Sealant (for bonding pipe to cap)
- Two heavy weighted slabs to support pipe



Shows exposed sensors.
No debris deployments only.

INSTRUCTIONS

<u>Vent or tube flushing hole pattern</u>:
2.5″ internal diameter.

Drill one set of two, starting 6″ from sensor holes at 0° and 180°. Drill second set of two 12″ holes upwards at 90° and 270°.

<u>Sensor area hole pattern</u>:
1.0″ internal diameter, 1.5″ on centers 12″ area from 1″ above stop bolt.

NOTES

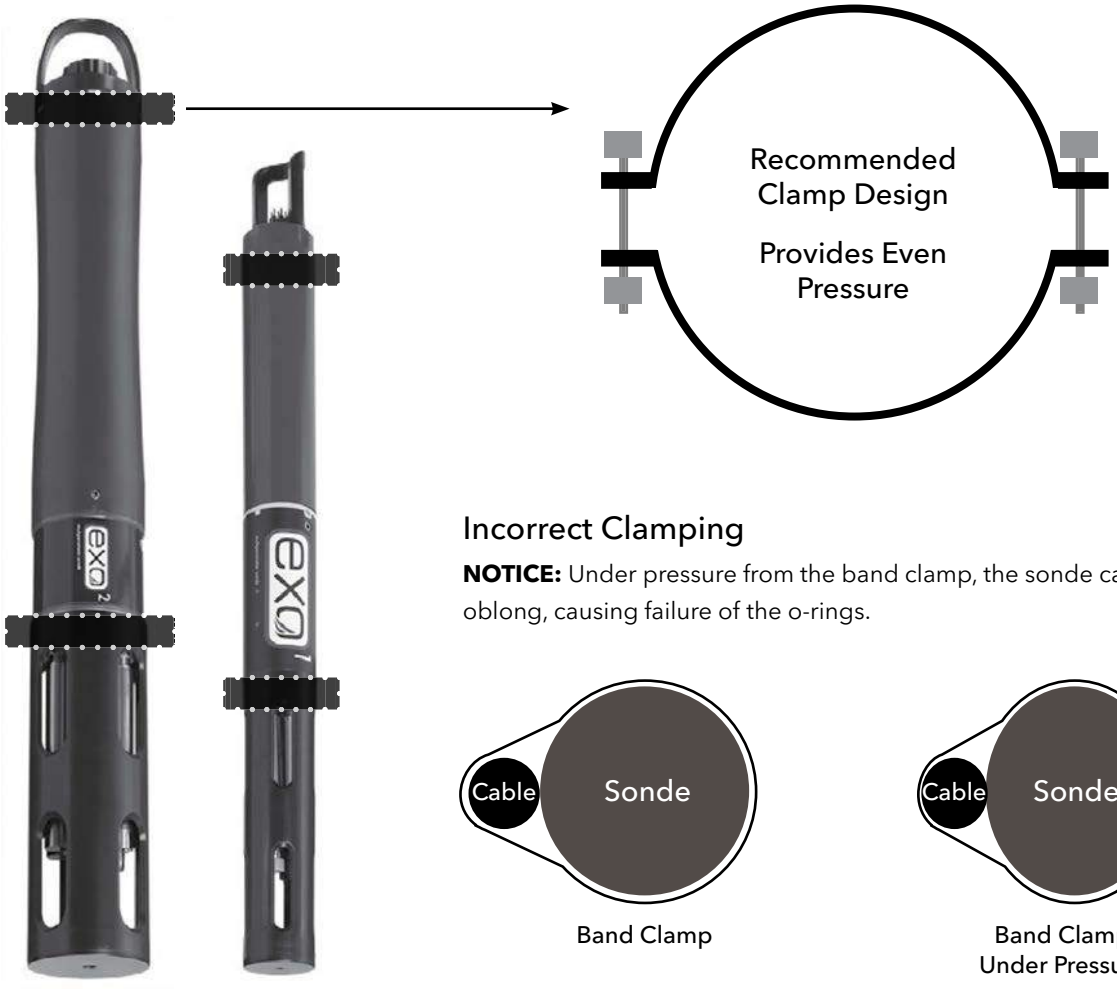
- PVC pipe must be firmly secured to its base or mount to prevent loss in high flows
- Mount and pipe should be treated with anti-fouling paint if in fouling environment
- Secure submerged parts to shore with chain or SS wire rope to a fixed object
- Never clamp sonde directly to mount

Sonde Clamping Guide

Great care should be taken when securing an EXO sonde to other objects. The preference is to deploy the sonde inside of a PVC pipe without clamps as described previously. However, if clamping is desired, the sonde should never be mounted directly to a mooring line, steel cable or piling as the pressure from a band clamp will deform the sonde and potentially cause leaks.

NOTICE: Damage and leaks from improper clamping is not covered under warranty.

Preferred Clamping Areas



Incorrect Clamping

NOTICE: Under pressure from the band clamp, the sonde can become oblong, causing failure of the o-rings.

Band Clamp

Band Clamp
Under Pressure

Mooring Cages

Some users prefer to house their Sonde in a protective mooring cage for their application.

Section 3
KorEXO Software

3.1 KorEXO Software
Introduction

KorEXO Software and drivers require permissions for successful installation. Administrative privileges may be necessary for a business or networked PC.

System Requirements

Supported 32 bit (x86) and 64 bit (x64) Microsoft Operating Systems:

- Microsoft Windows 7 Home Basic SP1
- Microsoft Windows 7 Home Premium SP1
- Microsoft Windows 7 Professional SP1
- Microsoft Windows 7 Enterprise SP1
- Microsoft Windows 7 Ultimate SP1
- Microsoft Windows 8 Home Basic
- Microsoft Windows 8 Home Premium
- Microsoft Windows 8 Professional
- Microsoft Windows 8 Enterprise
- Microsoft Windows 8.1 Basic
- Microsoft Windows 8.1 Professional
- Microsoft Windows 8.1 Enterprise
- Microsoft Windows 10 Home
- Microsoft Windows 10 Professional
- Microsoft Windows 10 Enterprise
- Microsoft Windows 10 Education

Ram Memory Requirement:

- Minimum of 2 GB of RAM installed

Hard Disk Free Space:

- Minimum of 500 MB of free hard drive space

Screen Resolution:

- 1024x768 or higher

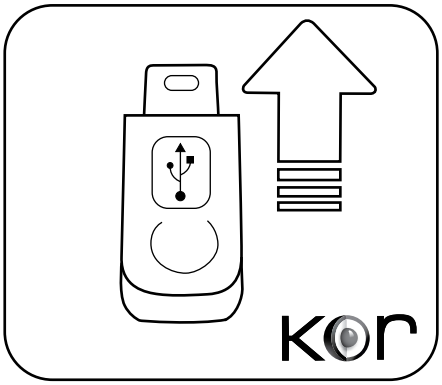
Internet access is required to support software and device updates. For any questions or concerns related to the installation or operation of KorEXO Software, please contact Technical Support at **info@ysi.com.**

3.2 KorEXO Software
Installation

KorEXO Software is supplied with all EXO Sondes on a USB flash drive. Installation will require administrative privileges.

NOTE: *It is important to install KorEXO Software prior to connecting EXO hardware, as the required drivers are installed along with the software.*

Follow these steps to complete the installation process:



1. Insert the supplied USB flash drive into a USB port on your computer.
2. Double-click Start.exe in the EXO DRIVE window to launch the Installer.
3. Click INSTALL DRIVERS and click INSTALL ALL to install all EXO hardware drivers. Follow the prompts to complete each driver installation.
   NOTE: *Administrative Privileges are needed to perform each driver installation.*
4. After drivers are installed, click BACK to return to the KorEXO Installer main menu.
5. Click INSTALL APPLICATION and check the box to agree to license terms and conditions, and then click INSTALL.
   NOTE: *Administrative Privileges are needed to perform the software installation.*
6. After successful install, close the Installer.
7. Open the KorEXO Software program for the first time. You may be asked if you want to allow a program from an unknown publisher to make changes on the computer. If so, select YES.
   NOTE: *Administrative Privileges may be needed to run KorEXO Software for the first time; Administrative Privileges will not be needed for subsequent launches of the software.*

Installation Troubleshooting:

Issue - Software Crash	**Solution**
This is the first time KorEXO has been installed on this PC and the software crashes the first time you open it.	Contact your IT Department or obtain read/write permissions to C:\ProgramData\YSI

3.3 KorEXO Software

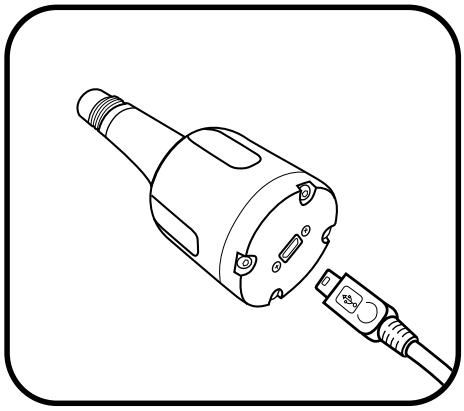
Instrument Connection Panel

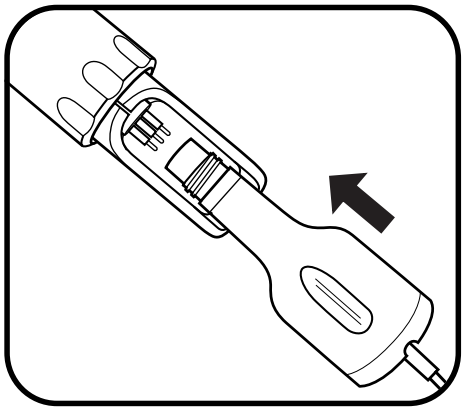
KorEXO Software connection to any EXO device is established through the Instrument Connection Panel. There are two types of connection:

- Wired via USB cable
- Wireless via *Bluetooth* (not available for EXO Handheld)

Wired Connection:

There are a few ways to establish a wired connection to an EXO Sonde. The most common method involves using a USB Signal Output Adapter (SOA) which plugs into the sonde directly. Alternatively, one can use the EXO Handheld or the EXO GO which connects to the sonde via a field cable and connects to the computer via a USB cable. The following instructions pertain to connection via the USB SOA:





1 Connect the USB Cable to the Signal Output Adapter (SOA) and the PC

Remove the protective cap from the USB end of the SOA, and ensure that the connector is clean and dry. Insert the Mini USB end of the cable into the SOA connector and the USB A end of the cable into one of the PC's USB ports. The sonde should not be connected at this time.

Attaching the adapter to the PC causes a new device to be recognized. Windows automatically installs the drivers and creates a new COM port. Each new adapter that is attached creates a new COM port. To confirm that the SOA is successfully recognized as a COM port, open the Device Manager on the PC and view it under Ports.

2 Connect the SOA to the EXO Sonde

Remove the plug from the male 6-pin connector on the sonde. Apply a light layer of Krytox grease to the male pins on the sonde and the female connector on the USB-SOA. Then align the connector's six pins and jackets, and press them firmly together so that no gap remains.

3 Open KorEXO Software

The PC connection via the SOA will supply power to the EXO Sonde; batteries are not required. Upon launching the software, the EXO Sonde should appear in the Instrument Connection Panel. Simply click the CONNECT button to establish communication with the sonde. An option to Automatically Connect to Instrument is available in the General Settings.

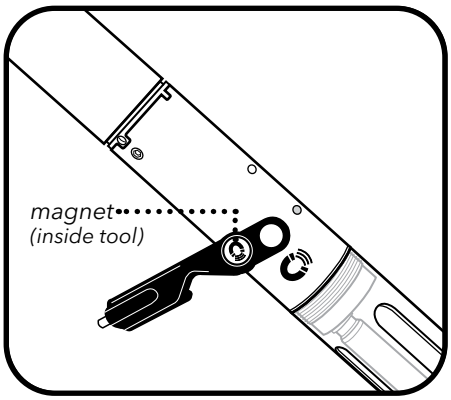
SOA Troubleshooting:

Issue - Cannot Find EXO Device	**Solution**
After you install the driver, the device shows up as "USB Serial Device" or with an exclamation point in Device Manager.	Run the installer as an administrator by right clicking on "Start.exe" and choosing "Run as Administrator."

Wireless Connection:

Every EXO Sonde includes a built-in *Bluetooth* chip which allows for wireless communication with a computer that has BT capabilities. This is extremely convenient for calibration and sampling at the surface level. However, the *Bluetooth* communication is severed when the sonde is submerged under water. The EXO GO adapter provides a *Bluetooth* connection to an EXO Sonde that may be submerged. The following instructions pertain to connection via the EXO Sonde's internal *Bluetooth*.

NOTE: *To wirelessly connect to an EXO Sonde, your computer must either have internal* Bluetooth *or a USB Bluetooth dongle.*



1 Activate the Sonde's *Bluetooth*

Tap a magnet on the designated icon on the EXO Sonde to awaken and activate *Bluetooth*. A magnet is built into the probe installation/removal tool with a matching icon. If no magnet is available, you may cycle power to the sonde by removing the batteries and reinstalling them to awaken and activate *Bluetooth*.

A blue LED will illuminate continuously for up to 5 minutes to indicate that *Bluetooth* is active and the sonde is discoverable. Once a link has been established with KorEXO Software, the blue LED blinks at 2 Hz to indicate the sonde is communicating.

An alternative to using the EXO Sonde's built-in *Bluetooth* is using the EXO GO communication adapter. Simply connect the EXO GO to the sonde using a field cable, power on the EXO GO which activates its own *Bluetooth*, and proceed to scan for it using KorEXO Software.

2 Scan for *Bluetooth* Device

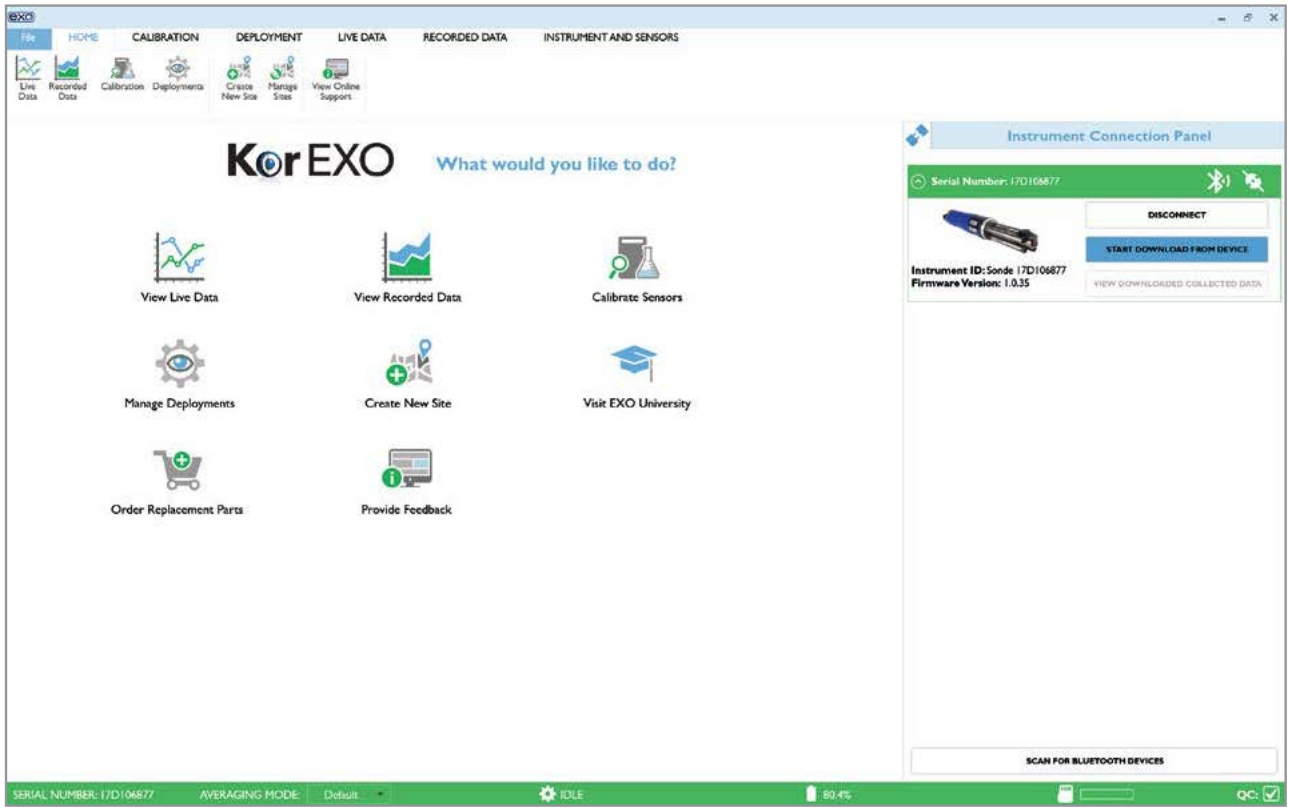
Using KorEXO Software, click the SCAN FOR BLUETOOTH DEVICES button in the Instrument Connection Panel. This might need to be repeated several times before the software finds the sonde. Once the EXO Sonde appears, simply click the CONNECT button to establish communication. An option to Automatically Connect to Instrument is available in the General Settings.

Upon connection, the KorEXO Software will automatically check the SmartQC score of the sonde. Also, depending on software settings, data may automatically start downloading; otherwise, data may be manually downloaded by clicking START DOWNLOAD FROM DEVICE.

3.4 KorEXO Software

Home Screen

The KorEXO Home screen provides quick access to the most common functions of the software and links to helpful pages on YSI.com.



Instrument Connection Panel – Displays any EXO hardware that is connected or available for connection.

View Live Data – Navigates to the Dashboard with live readings from the sonde. These measurements may be saved locally to the software database. An EXO must be connected to see data.

View Recorded Data – Navigates to the Recorded Data screen where users can access the database to find measurement data files that have been captured from the Live Data screen or downloaded from the EXO Sonde or EXO Handheld.

Calibrate Sensors – Navigates to the Calibration screen with a list of available sensors to calibrate. An EXO must be connected to perform a calibration. Users can also view and export calibration records from this screen.

Manage Deployments – Navigates to the Deployment screen which displays deployment settings for the connected EXO Sonde. Users can edit the sonde's deployment settings and deploy the sonde. An EXO must be connected to view its settings and start a deployment. Users may also view and create deployment templates and sites from this screen.

Create New Site – Allows users to create a new site which can be saved locally to the software.

Visit EXO University – Navigates to the EXO University channel on YSI.com. An internet connection is required to access this site.

Order Replacement Parts – Navigates to the YSI.com webstore. An internet connection is required to access this site.

Provide Feedback – Navigates to an online form to provide software feedback. An internet connection is required to access this site.

Menus

The top of the software screen is home to several menu options:

- **FILE**
- **HOME**
- **CALIBRATION**
- **DEPLOYMENT**
- **LIVE DATA**
- **RECORDED DATA**
- **INSTRUMENT AND SENSORS**

Ribbon

A ribbon resides below the menu bar which contains options unique to the menu that is selected. For example, the ribbon on the calibration screen includes options to find, export, and print calibration records. Users may choose to hide the ribbon from view or keep it open as they navigate the software.

Status Bar

The status bar displays important information about the connected EXO Sonde.

- Instrument Serial Number
- Averaging Mode – Select from drop-down list
  - Default = Normal Averaging
  - Accelerated = Faster Averaging
  - Rapid = Fastest Averaging
- Deployment Status – Idle (not logging) or Deployed (logging or scheduled to log)
- Battery Percentage
- Free Memory
- QC Score (see Section 4.4 for more information on SmartQC) – Clicking the QC Score will take you to the INSTRUMENT AND SENSORS screen.

3.5 KorEXO Software
File Menu

The File Menu allows users to view software information and adjust software-specific settings.

- Import
- Settings
- About
- Exit

Import

Users can import various files transferred from version 1.0.X of KorEXO Software or from other instances of KorEXO version 2.X installed on different computers. These files may be transferred remotely through email or manually using a USB flash drive. Take note of which folder the file is transferred to on the computer.

IMPORT CALIBRATION – Allows users to import calibration files from another instance of KorEXO Software. Compatible files will have the ".cal or .xml" extension.

IMPORT DEPLOYMENT – Allows users to import deployment templates from another instance of KorEXO Software. Compatible files will have the ".dep or .xml" extension.

IMPORT EXO BINARY FILE – Allows users to import data files from another instance of KorEXO Software. Compatible files will have the ".bin" extension.

IMPORT SITE – Allows users to import sites created from an older version (1.0.X) of KorEXO Software. Compatible files will have the ".sit" extension.

Settings

Users can adjust general settings related to the software as well as parameter specific settings. It is important to note that these settings are saved locally and only pertain to the software itself. These settings are not pushed to any EXO devices nor are they carried over to instances of KorEXO Software installed on other computers.

General Settings

AUTOMATION SETTINGS

- Automatically Update Software and Firmware – Toggle On/Off
  The software will indicate if there is an update available in the File menu. An internet connection is required to check for software and firmware updates.
- Automatically Connect to Instrument – Toggle On/Off
  The EXO device will automatically connect as soon as it is discovered by the Instrument Connection Panel.
- Automatically Download Data from Instrument to PC – Toggle On/Off
  Upon connection to the EXO device, it will automatically download any new data that has been collected since it was last connected to the software.
- Automatically Update Instrument Time to PC Time – Toggle On/Off
  The software will update the EXO clock to sync with the PC time.

FILE EXPORT

- CSV Delimiting Character – Select from drop-down list
  The delimiting character represents a boundary and acts to separate data in a CSV file. The default option is a comma ',' but some users may prefer a period '.' or Tab as the delimiter.
- CSV Export Type – Select from drop-down list
  There are two options for the CSV export of a measurement file:
  - With Header – Includes a section for mean values and standard deviation for every column of measurement data. Additionally, detailed parameter names are included as well as a dedicated row for sensor serial numbers.
  - Without Header – A simplified view where the top row of the spreadsheet features column labels with the respective data in the rows that follow. Parameter names are shortened and occupy the same cell as their respective sensor serial number.

STARTUP OPTIONS

- Require User Login – Toggle On/Off
  This requires the user to select a User Name when the software is launched. The selected User Name will be the default ID tagged to any data captured in the Live Data screen and any calibration that is performed. The User Name can be switched at any time without having to exit or restart the software.

LANGUAGE SETTINGS

- Select Language – Select from drop-down list
  Available languages include:
  - Chinese (Simplified)
  - Chinese (Traditional)
  - English (United States)
  - English (United Kingdom)
  - French
  - German
  - Italian
  - Japanese
  - Korean
  - Norse
  - Portuguese
  - Spanish (Spain)
  - Spanish (Americas)
  - Vietnamese
- Override Regional Settings – Select radio button
  There are two options for regional settings:
  Use Selected Language Regional Settings – Sets the regional settings based on the language selected in KorEXO Software.
  Use Local OS Regional Settings – Matches the regional settings to the computer's local operating system.

Parameter Settings

Parameter-specific display preferences are found in the Settings menu. This is where users can enable or disable parameters and select the units of measure for display in Live Data view and Recorded Data view. Note that these settings are saved locally to KorEXO Software and do not change sensor hardware settings.

Available Parameter Settings Include

Display Settings	Parameter	Unit
Algae	Phycocyanin	RFU
		µg/L
		cells/mL (requires user input)
	Phycoerythrin	RFU
		µg/L
		cells/mL (requires user input)
Barometer	Barometer	mmHg
		mbars
		inHg
		psi
		kPa
		Atm
Conductivity	Conductivity	µS/cm
		mS/cm
	Specific Conductivity	µS/cm
		mS/cm
	Resistivity	ohms-cm
		kohms-cm
		mohms-cm
	TDS (Total Dissolved Solids)	mg/L
		g/L
		kg/L
	Salinity	psu
		ppt
	NLF Conductivity	µS/cm
		mS/cm
	Water Density	σ
		σ t
Chlorophyll	Chlorophyll	RFU
		µg/L
		cells/mL (requires user input)
Depth	Depth	m
		ft
	Vertical Position	m
		ft
	Absolute Pressure	psi a
		bar a
	Gage Pressure	psi g
		bar g

(continued)

Display Settings	Parameter	Unit
DO	Dissolved Oxygen	% Sat
		mg/L
		% Local
		% LocalB
fDOM	fDOM	QSU
		ppb
		RFU
GPS	GPS	Decimal Degrees
	Altitude	m
		ft
ISE	NH4+ -N (Ammonium)	mg/L
		mV
	NH3 (Ammonia)	mg/L
	NO3 -N (Nitrate)	mg/L
		mV
	CL- (Chloride)	mg/L
		mV
ORP	ORP	mV
PAR	PAR Channel 1	µmol·s-1·m-2 (requires user input)
	PAR Channel 2	µmol·s-1·m-2 (requires user input)
pH	pH	pH
		mV
Sonde	Cable Power	volt
	Battery Voltage	volt
Temperature	Temperature	°C
		°F
		K
Turbidity	Turbidity	FNU
		NTU
	TSS (Total Suspended Solids)	mg/L (requires user input)
		g/L (requires user input)
Wiper	Wiper Position	volt

About

Users can view software version information as well as phone, email, and online support information. A status notification will be displayed that indicates whether or not there is an update available.

Exit

This will close the software.

3.6 KorEXO Software
Calibration Screen

The calibration screen is where users calibrate EXO sensors, view calibration records, and set calibration reminders. This section will explain the calibration options and settings. Information related to calibration methods for a specific parameter calibration can be found in Section 4.

Calibrate

This displays a list of parameters that available to calibrate. The parameters are organized under each respective sensor. Every parameter has two options:

1. CALIBRATE – Select this to perform a user calibration.

2. FACTORY RESET CALIBRATION – Select this to restore the factory default calibration. Note this deletes the user calibrations from the sensor and reverts to the original factory settings. A user calibration must be performed after the factory reset.

Find Calibration Records

This opens the calibration records database where users can filter and find previous calibration records. A calibration record is generated and stored every time a parameter is calibrated. Multiple calibration records may be selected to view simultaneously.

Selected records are listed under the Calibration Records Panel. These records are sorted by calibration date and organized by sensor on the left side of the screen. Select a specific record to view its calibration details displayed on the right side of the screen. See Section 4.3 for more information on Calibration Records.

Export to CSV

Select this to save in a file format which can be opened in a spreadsheet (such as Excel).

Export to XML

Select this to save in file format which can be imported by another instance of KorEXO Software.

Print Records

Select this to print a calibration report for any record shown in the Calibration Records Panel.

Manage Sensor Reminders

NOTE: This feature is only availalbe on the Premium license.

Reminders may be enabled or disabled for select parameters based on a predefined calibration interval. This interval may be adjusted by the user. Additionally, reminders may be set for the replacement of sensor modules and ODO caps.

These settings may affect the QC Score displayed by the software. For example, if the number of days since the last calibration is greater than the interval set, the software QC Score (SoftQC) will be red.

3.7 KorEXO Software
Deployment Screen

The deployment screen is where users setup the sonde for unattended logging. The sonde log status and deployment information is displayed in the main window. Additionally, a ribbon menu includes options to create, edit, start, and stop a deployment. An EXO must be connected to view its settings and start a deployment.

Start & Stop Deployment

Click Start Deployment to begin logging at the present or a future time. Three options will be presented for Start Time:

1. NEXT INTERVAL – Logging will begin at the next time interval as specified by the deployment template.

2. NOW – Logging will begin immediately.

3. CUSTOM – Logging will begin at a user-specified date and time.

Deployment Template

A deployment template includes all the settings necessary for the sonde to accomplish unattended logging. There are three options for creating or editing a template:

Create Template

Creates a new template from scratch.

Create Template from Sonde

Pulls the deployment settings from a connected EXO Sonde which can then be edited, saved, and reapplied to the sonde.

Open Template

Opens an existing template which can be edited, saved, and applied to a connected sonde.

Each template includes the BASIC, DCP ADAPTER OUTPUT, and ADVANCED settings.

BASIC DEPLOYMENT SETTINGS:

Deployment Template Name – this is the name the template will be saved as
Logging Interval Time – this is how frequently the sonde will log data
File Name Prefix – this is the file name under which the logged data will be saved
Site Name – name of the location to be tagged with the logged data
User Name – name of the user to be tagged with the logged data
Deployment Template Description – any additional information users would like to reference for this template

DCP ADAPTER OUTPUT:

NOTE: *This section is only applicable if the sonde will be communicating to an external device via either SDI-12 or Modbus protocol.*

SDI-12 Address – address of the EXO Sonde
Available SDI-12 Parameters – all parameters available to select and organize

See Section 2.13 for more information about SDI-12 communication.

ADVANCED:
There are several advanced settings which are optional for the deployment.

Logging Mode:
Normal – The sonde will log readings based on the normal interval time specified in the BASIC settings.
Sample and Hold – This is designed to ensure that the data the sonde logs internally matches the data sent to a DCP.
Burst – The sonde will log a data point once a second for the given duration.

Burst Mode Duration – Specify the duration for Burst mode.

Additional Averaging Duration – The averaging setting will apply as the sonde logs a data point. For example, if 10 seconds is selected, then 10 '1-second' readings will be averaged to a single data point.

Samples per Wipe – Specify how many samples will be logged between the wipe interval.

System-wide Averaging Mode – Choose from three averaging modes:
1. DEFAULT – Select for continuous monitoring at a fixed site
2. ACCELERATED – Select for step profiling
3. RAPID – Select for advanced applications where the sonde is moving

See Section 4.1 for more information on Averaging Modes.

Adaptive Logging:
Adaptive logging may be enabled to change the log interval time based on up to two user specified parameters and thresholds. When the parameter reads above or below a specific threshold, the sonde begins to log at the Adaptive Logging Interval. When the parameter reading crosses back over the threshold, the sonde will return to its normal logging interval.

SAVE TEMPLATE – Saves the template locally to the software.

SAVE AND APPLY TEMPLATE TO SONDE - Saves the template locally to the software and applies the settings to the sonde.

Sites

Sites can be created to allow users to organize their data by custom Site Names. The site name will be tagged to any data logged while that site is active. A site can be active in a deployment (specified in the deployment template) and in the Live Data screen for sampling.

Create a New Site

Users can input a custom site name (required) and a site description (optional). The site creation date is auto-populated. Additional options include adding a site photo and adding up to ten custom fields. The site photo must be a 24-bit BMP file no larger than 240 pixels wide by 260 pixels tall.

Manage Sites:

Access a local site database to view, modify, or delete existing sites. This also allows users to import existing sites from an EXO Handheld.

3.8 KorEXO Software
Live & Recorded Data

Live Data

The Live Data screen display readings from a connected EXO Sonde. There are three options for viewing data on this screen:

DASHBOARD – The default, grid view of enabled parameter values which are refreshed at the specified time interval.

GRAPH – A time-based or depth-based graph view; each graph can display up to two parameters specified by the user.

TABLE – A column based view where new rows of data are added to a list at the specified time interval.

Save Single Point

Logs one data set at the time the button is pressed.

Start Saving Data

Logs continuously at the specified time interval.

Stop Saving Data

Stops the continuous logging.

Current Site

The active site that is tagged to the logged data.

Interval

The time interval in which data is refreshed and logged.

Clear All Graphs

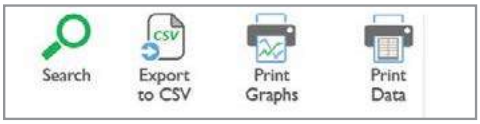
Clears data from any open graphs.

Start Wiping

Activates the wiper on an EXO Sonde.

Recorded Data

The Recorded Data screen displays data files that have been logged in the software and/or downloaded from the EXO Sonde's internal memory. Users must first select the file(s) in the Search menu before data are displayed. Data can be viewed in Table or Graph view. Additionally, data can be exported or printed.



Search

Access and filter the software database to find logged data files; multiple files can be viewed simultaneously.

Export to CSV

Saves in a file format which can be opened in a spreadsheet (such as Excel).

Print Graphs

Prints a graph of the selected data.

Print Data

Prints a table of the selected data.

3.9 KorEXO Software
Instruments and Sensors

The INSTRUMENTS AND SENSORS screen allows users to view the status and edit settings for any connected EXO devices. EXO devices are listed with the host device at the top and the sensors below. Logged data files can be manually downloaded from the sonde or handheld. The QC Score of each EXO device is available to view. Simply click on the specific device to view details related to its QC Score (See Section 4.4 for more information on SmartQC).

Update Instrument Firmware

Instrument firmware can be manually updated by clicking the Update icon in the ribbon.

> **NOTE**: *The latest firmware must be downloaded first. Check the File menu to see if there is an update available. An internet connection is required to check for updates.*

Legacy Handheld

It is possible to communicate with the legacy EXO Handheld to manage calibration, site, deployment, and measurement records.

Section 4
Sensors and Calibration

4.1 Sensors

Overview

The EXO product line includes sensors that detect a variety of physical, chemical, and biological properties of water. EXO sensors are designed to collect highly accurate data under ever-changing conditions.

Data Filtering

All EXO sensors share some common embedded software, including the filtering of real-time data. Sensors acquire environmental data at a constant rate, and use this stream of data as the input to the filtering algorithm that produces results seen by the user. EXO sondes collect data from the EXO sensors and are able to output data at rates up to 4 Hz.

Basic Rolling Filter

The filter is fundamentally a rolling or window average of past acquired inputs to the filter, such that as a new data value is added to the summation, the oldest data value is removed, and the total summation is divided by the total number of data values. It is a simple average, just rolling or moving in time. Starting with the February 2014 software release, different rolling time windows for the filter are now supported.

Averaging Modes

The Averaging Mode for EXO sensors can be modified by the user in the Deployment and Live Data settings in KorEXO Software and the EXO Handheld. Three Averaging options are available:

Default – This is the mode for all sensors set at the factory and provides optimum data filtering for most applications. It provides the highest accuracy, automatic averaging during unattended monitoring or fixed mooring. This mode has up to 40 seconds of filtering on the sensors.

Accelerated* – This mode should be used for spot sampling and slow (or paused) depth profiles. The sensors are averaging 5-10 seconds of data in a rolling window, unless there are any outliers.

Rapid* – This mode should be used where the sonde is moving quickly through the water, such as with rapid profiling and unique applications like AUV's, gliders, or towed applications. The data will be noisy and will never settle on a single steady number. This mode has 2-3 second filtering on the sensors.

*TIP: Enable the Vertical Position parameter in the Depth unit options to view the real-time position of the sonde in the water column. This is helpful in profiling applications to ensure the sonde is lowered to the desired depth without waiting for the Depth data to stabilize.

> **NOTE**: *Making any changes to the Averaging Mode will stop a deployment. As a sonde takes measurements, it compares new readings to those taken in the previous 2-30 seconds (depending on the selected option). If the new reading is not significantly different than past measurements, then it merely factors into the rolling average with older data points to create a smooth curve. If the new reading is significantly different than past measurements, then it restarts the rolling average of data points.*

To quickly check a sonde's Averaging Mode setting in KorEXO Software, check the bottom status bar and the word Default, Accelerated, or Rapid will be displayed adjacent to the sonde's serial number. To access Averaging Mode with the handheld, press the Deploy button, select Sonde Settings, and then Averaging.

Adaptive Filtering

The drawback to a basic rolling filter is that response time to an impulse event is delayed, and the more entries in the average summation, the longer the delay for the result to converge on the true value. To correct this, the filter algorithm monitors the new data arriving and compares it to the current averaged result, looking for indication of an impulse event. When new data deviate from the average by more than a predetermined tolerance, the number of data entries within the rolling average is reduced to a minimum count and the remaining values are flushed with the new data. The result is a more accurate capture of the impulse event data, entirely eliminating the inherent delay caused by the rolling average.

Outlier Rejection

Every time a newly acquired data value is added, the rolling average entries are scanned for outlier data. Although such data has already been determined to fall within the tolerances defined above, the remaining worst offenders are removed from the rolling average calculation. This outlier rejection allows for smoother continuous data results.

Calibration Stability

During calibration, the filtering is active as described, plus an additional feature works to provide stability feedback to the user. When the user attempts to calibrate a sensor, the sudden changes in environment are perceived as impulses or plunge events and the filtering reacts accordingly. The results immediately show the value of the solution, and after a few moments, the filter incrementally engages fully and supplies the smoothest data. However, as the sensor and the calibration solution work towards equilibrium, the measurement may slowly drift. The sensor will monitor the results from the filter and determine if the measurement is stable. It watches the results and calculates a slope from each and every result to the next. Once the slope settles and is consistently flat for approximately 30 seconds, the sensor is considered stable. KorEXO is then notified and the user will see a message that the calibration reading is stable.

Sensor Response Times

Response times for EXO sensors are based on laboratory testing. This testing, though stringent, cannot mimic the actual response times in the field due to the wide variety of use cases. To characterize an EXO sensor's response time, a step change in the sensor's primary output parameter is applied, and the time to reach 63% of the final stimulus value is recorded. Repeated characterization of multiple sensors provides the T63 specification.

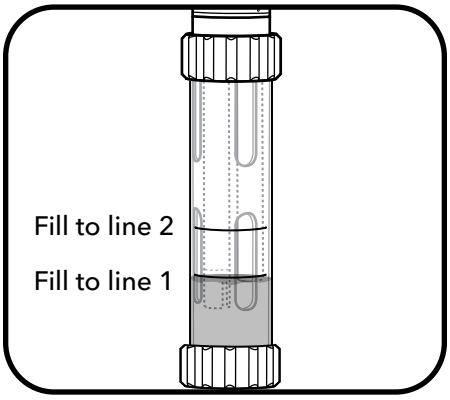
Sensor Accuracy Specifications

To maintain accuracy specifications for EXO sensors, we recommend that users calibrate sensors in the lab in standards with temperatures as close to the ambient temperature of the field water as possible.

4.2 Calibration
Basic Overview

EXO sensors (except temperature) require periodic calibration to assure high performance. Calibration procedures follow the same basic steps with slight variations for particular parameters. Calibration procedures described in this section will mainly focus on using KorEXO Software. Users should refer to the EXO Handheld Mini-Manual for calibration procedures utilizing the handheld.

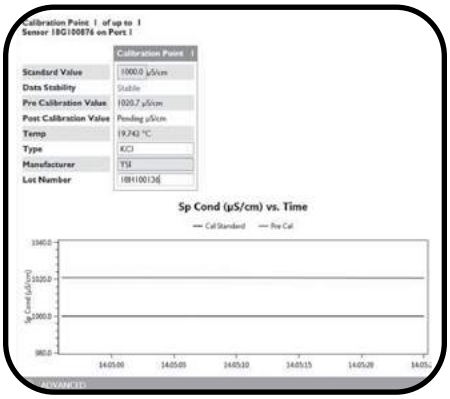
NOTE: *All EXO sensors should be user-calibrated before initial use.*



Calibration set-up

For accurate results, thoroughly rinse the EXO calibration cup with water, and then rinse with a small amount of the calibration standard for the sensor you are going to calibrate. Two to three rinses are recommended. Discard the rinse standard, then refill the calibration cup with fresh calibration standard. Fill the cup to approximately the first line with a full sensor payload or the second line with small sensor payload. Recommended volumes will vary, just make certain that the sensor is submerged. Be careful to avoid cross-contamination with other standards.

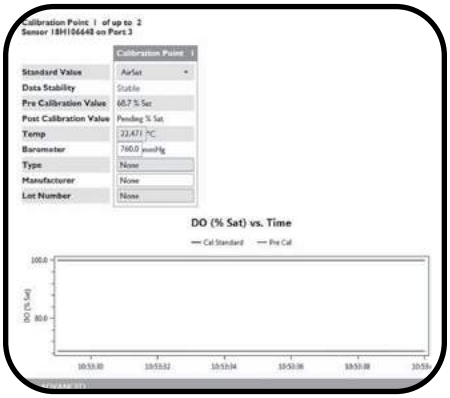
Begin with clean, dry probes installed on the EXO sonde. Install the clean calibration guard over the probe(s), and then immerse the probe(s) in the standard and tighten the calibration cup onto the EXO sonde. We recommend using one sonde guard for calibration procedures only, and another sonde guard for field deployments. This ensures a greater degree of cleanliness and accuracy for the calibration procedure.



Basic calibration in KorEXO software

Go to the Calibrate menu in KorEXO Software. This menu's appearance will vary depending on the sensors installed in the sonde. Select the sensor you are going to calibrate from the list. Next select the parameter for the sensor you are going to calibrate. Some sensors have only one parameter option, while other sensors have multiple options.

Selecting the parameter will initiate the probe's calibration in the standard; initially the data reported will be unstable and then will move to stable readings. Enter the Standard Value if necessary. The Standard Value should match that of the standard you are using. You may also enter optional information for type of standard, manufacturer of standard, and lot number by accessing the Advanced menu.

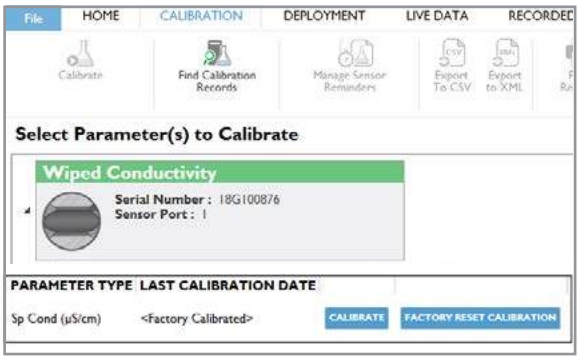


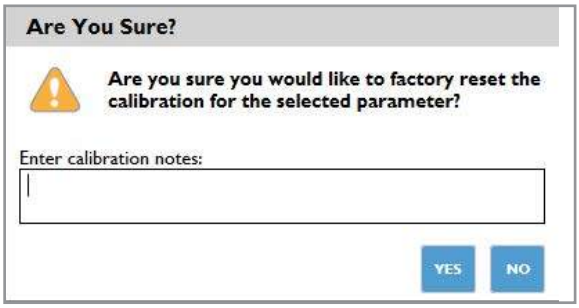
Users should confirm that the value is within their acceptable margin of error. Once readings are stable, click Apply to accept this calibration point. Repeat the process for each calibration point. **Click Complete when all points have been calibrated.**

A calibration summary appears with a QC score. View, export, and/or print the calibration worksheet. If a calibration error appears, repeat the calibration procedure.

Factory Reset Calibration

A Factory Reset Calibration can be performed to return the sensor gain and offset to factory specifications. Performing a Factory Reset Calibration will allow the user to start a calibration with default sensor metadata values. A new calibration of the sensor will then help with additional troubleshooting, if needed.





Performing a Factory Reset Calibration in KorEXO:

Step 1

Click on the Calibration tab or button.

Step 2

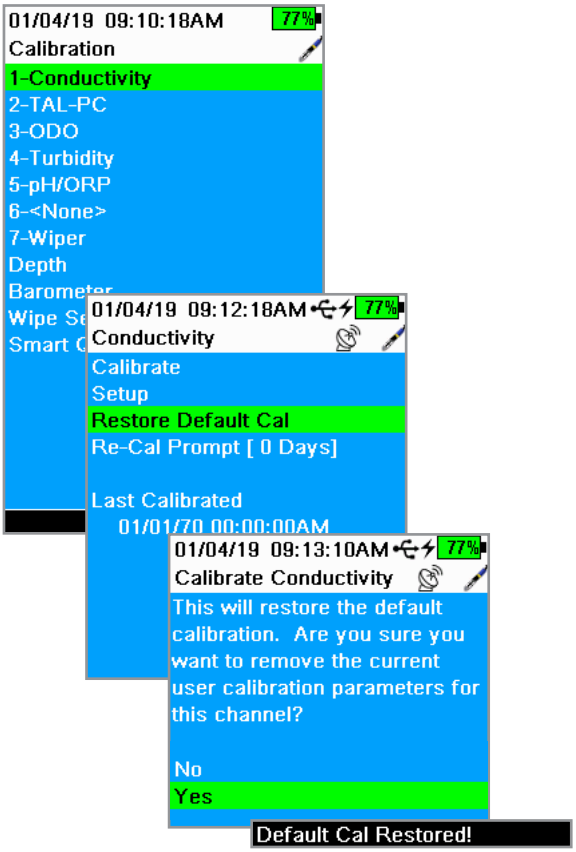
Click the turn-out arrow next to the parameter desired.

Step 3

Click the Factory Reset Calibration button.

Step 4

Type any desired notes into the pop-up window and then click the Yes button to confirm the action.



Performing a Factory Reset Calibration in the Handheld:

Step 1

Click the Calibration button.

Step 2

Select the desired parameter.

Step 3

Select Restore Default Cal.

Step 4

Select Yes. A message will be shown on the bottom of the screen to confirm that the action was successful.

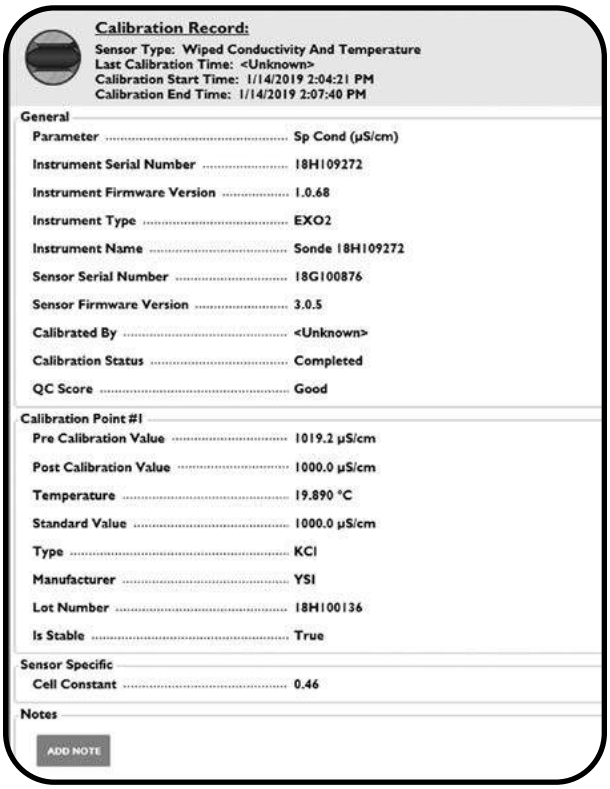
4.3 Calibration
Calibration Report

The Calibration Report is a record of the calibration for an EXO sensor. The report contains quality assurance information including date and time of calibration, date of previous calibration, sensor firmware version, type of calibration performed, standard used, and QC score.

Calibration Reports are saved in the KorEXO Software database on the computer or the EXO Handheld that was used during calibration (not on the sonde or the sensors). All reports can be accessed and viewed through the Calibration Records menu in KorEXO Software.

Sample Reports:

1-point calibration of specific conductance on EXO conductivity/temperature probe



Calibration Record:
Sensor Type: Wiped Conductivity And Temperature
Last Calibration Time: <Unknown>
Calibration Start Time: 1/14/2019 2:04:21 PM
Calibration End Time: 1/14/2019 2:07:40 PM

General

Parameter	Sp Cond (µS/cm)
Instrument Serial Number	18H109272
Instrument Firmware Version	1.0.68
Instrument Type	EXO2
Instrument Name	Sonde 18H109272
Sensor Serial Number	18G100876
Sensor Firmware Version	3.0.5
Calibrated By	<Unknown>
Calibration Status	Completed
QC Score	Good

Calibration Point #1

Pre Calibration Value	1019.2 µS/cm
Post Calibration Value	1000.0 µS/cm
Temperature	19.890 °C
Standard Value	1000.0 µS/cm
Type	KCl
Manufacturer	YSI
Lot Number	18H100136
Is Stable	True

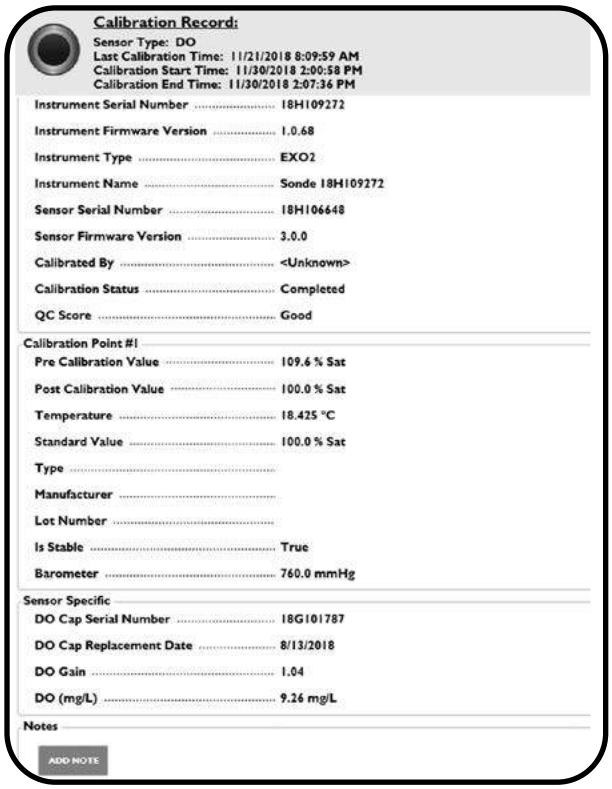
Sensor Specific

Cell Constant	0.46

Notes

ADD NOTE

1-point calibration of percent saturation on EXO optical dissolved oxygen probe



Calibration Record:
Sensor Type: DO
Last Calibration Time: 11/21/2018 8:09:59 AM
Calibration Start Time: 11/30/2018 2:00:58 PM
Calibration End Time: 11/30/2018 2:07:36 PM

Instrument Serial Number	18H109272
Instrument Firmware Version	1.0.68
Instrument Type	EXO2
Instrument Name	Sonde 18H109272
Sensor Serial Number	18H106648
Sensor Firmware Version	3.0.0
Calibrated By	<Unknown>
Calibration Status	Completed
QC Score	Good

Calibration Point #1

Pre Calibration Value	109.6 % Sat
Post Calibration Value	100.0 % Sat
Temperature	18.425 °C
Standard Value	100.0 % Sat
Type	
Manufacturer	
Lot Number	
Is Stable	True
Barometer	760.0 mmHg

Sensor Specific

DO Cap Serial Number	18G101787
DO Cap Replacement Date	8/13/2018
DO Gain	1.04
DO (mg/L)	9.26 mg/L

Notes

ADD NOTE

Additional Post-Calibration Info

ODO Gain: The ODO gain is a diagnostic value recorded on the Calibration Report and used for advanced diagnostic purposes. The nominal value is 1, and accurate calibrations of the DO sensor will only slightly deviate from this number.

Cell Constant: The cell constant is the current value of the conductivity and is a function of the factory original cell constant and the most recent user calibration. The cell constant will drift over time based on the sensor's electrodes, and the cell constant can be used to track drift.

Slope: The slope for the pH sensor is the mV per decade (pH unit) where 59 is the typical value. Slope allows the user to track drift away from 59 to determine the life/aging of the sensor module.

Change mV: The change millivolts is the mV change between either 4 and 7 or 7 and 10 calibration values for the pH sensor. It is the mV deviation away from the middle calibration point number.

4.4 SmartQC
Overview

SmartQC is a mechanism to normalize different sensors and to assess the current state of individual sensor performance relative to factory-defined performance parameters. Every EXO sensor has an embedded microprocessor which, along with calibration metadata, enables EXO to warn users of calibration errors or when a sensor is unable to be calibrated due to age, fouling, or damage, for example. For any sensor a QC score is presented as red, yellow, or green:

- A **green** SmartQC score means the sensor is calibrated properly and all parameters used to assess its performance state are within factory-defined limits.
- A **yellow** SmartQC score means that the sensor will still perform within factory-defined limits, but that during calibration enough of an adjustment was required to suggest that the sensor is drifting from those limits or may soon require some adjustments, such as a new DO cap. A yellow QC score might also result from variations in calibration standards and operators. One's comfort with a yellow score is case-dependent: for long-term deployments a yellow score is not optimal. For deployments of a couple of weeks or for spot-sampling, a yellow score may be perfectly acceptable, depending upon the sensor in question. This is addressed for individual sensors throughout the EXO Manual.
- A **red** SmartQC score means that the sensor is not performing within factory-specified limits. Also, in some cases a red QC score might mean that a component of the sensor is due to be replaced (such as a DO cap), or the user has defined some other limit, such as the term expired since the most recent calibration. These examples are captured under the term *SoftQC* because they are set by the user in Kor software, and such settings will override a green SmartQC score when using the software.

The way in which EXO assesses the calibration metadata is dependent upon the sensor type, and examples of information used include signal to noise ratio, signal gain, raw millivolts, and cell constants. "Gain" is one of the most common principles applied in the SmartQC system, and one might think of gain as m in the linear relationship y = *m*x +b where x is the real-time parameter result computed from a particular factory setting and y is the same parameter but modified and computed from a setting as defined by the user's calibration.

For example suppose that during a calibration the %ODO saturation is calculated from the factory settings to be 92%. This would be *x*. This same setting may be calculated to be 97% during the user's calibration, and this would be *y*. The gain, or *m*, would be calculated to be 1.054, and in this specific example that would be reported in the calibration worksheet as the *ODO Gain*.

In an ideal world where gains are calculated, *m* would be 1 and b would be zero, meaning that there has been no change at all in the sensor's performance since it left the factory. For most sensors this simple relationship can be applied, and gain and offsets are the primary drivers of the QC score (the ranges for them are proprietary, however). Other sensors have more complex sets of coefficients that are used, and factory-to-user calibration outputs are defined by more complex polynomial relationships.

Though proprietary limits and algorithms are used in calculation of the QC scores, much of the metadata that are used (such as millivolts, slopes, or gain factors) are visible to the user in the calibration worksheets. Sometimes these metadata are of more value to the user than the actual QC score, and users can assess whether and how they should use these metadata to build their own SOPs and acceptance criteria. This is readily achieved since each calibration worksheet shows not only the QC score for that calibration event but also the metadata and an audit trail for sensor calibration and performance throughout a sensor's lifetime.

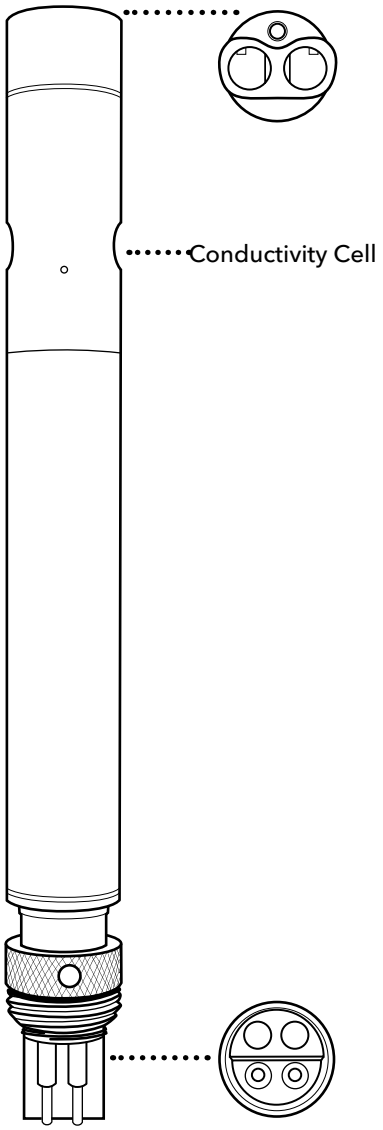
In this manual each individual sensor is described, and the descriptions of calibration for each sensor include recommendations regarding the interpretation and steps to take based upon green, yellow, or red QC scores.

4.5 Conductivity / Temperature

Sensor Overview

The EXO combination conductivity and temperature sensor should be installed in nearly all sonde applications. Not only will this sensor provide the most accurate and fastest response temperature data, but it will also provide the best data for the use in temperature compensation for the other EXO probes. The conductivity data is used to calculate salinity, non-linear function (nLF) conductivity, specific conductance, and total dissolved solids, and compensate for changes in density of water (as a function of temperature and salinity) in depth calculations if a depth sensor is installed.

(continued)



599870-01

Specifications

Conductivity

Default Units	microSiemens/centimeter
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Range	0 to 200 mS/cm
Accuracy	0-100 mS/cm: ±0.5% of reading or 0.001 mS/cm, whichever is greater; 100-200 mS/cm: ±1% of reading
Response	T63<2 sec
Resolution	0.0001 to 0.01 mS/cm range-dependent
Sensor Type	4-electrode nickel cell

Temperature

Default Units	°Celsius
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Accuracy	-5 to 35°C: ±0.01°C 35 to 50°C: ±0.05°C
Response	T63<1 sec
Resolution	0.001°C
Sensor Type	Thermistor

Temperature Thermistor

The temperature sensor uses a highly stable and aged thermistor with extremely low-drift characteristics. The thermistor's resistance changes with temperature. The measured resistance is then converted to temperature using an algorithm. The temperature sensor receives a multi-point NIST traceable wet calibration and the accuracy specification of 0.01˚C is valid for expected life of the probe. No calibration or maintenance of the temperature sensor is required, but accuracy checks can be conducted against a NIST-traceable temperature probe supplied by the user.

Conductivity Electrodes

The conductivity sensor uses four internal, pure-nickel electrodes to measure solution conductance. Two of the electrodes are current driven, and two are used to measure the voltage drop. The measured voltage drop is then converted into a conductance value in milliSiemens (millimhos). To convert this value to a conductivity value in milliSiemens per cm (mS/cm), the conductance is multiplied by the cell constant that has units of reciprocal cm (cm^{-1}). The cell constant for the conductivity cell is approximately 5.1/cm ±10%. For most applications, the cell constant is automatically determined (or confirmed) with each deployment of the system when the calibration procedure is followed.

Temperature Compensation

EXO sensors have internal thermistors for quality assurance purposes. Turbidity uses the internal thermistor for temperature compensation, while all other EXO sensors reference the C/T probe for temperature compensation. To display and log temperature, a C/T probe must be installed in an EXO sonde. Thermistor readings are logged in the sonde's raw data–viewable in KorEXO software–but are not included in data exported to Excel.

Conductivity = This is a measurement of water conductance from the drive and sense electrodes on the conductivity electrode. The output is in mS/cm or µS/cm. Note that the conductivity of solutions of ionic species is highly dependent on temperature, and the conductivity output is NOT compensated for temperature.

Specific Conductivity = When Specific Conductance is selected, the sonde uses the temperature and raw conductivity values associated with each determination to generate a specific conductance value compensated to 25°C by default. Both the Temperature Coefficient and reference temperature can be adjusted in the advanced sensor menu under calibration.

nLF Conductivity = The non-linear function (nLF) is defined by the ISO 7888 standard and is applicable for the temperature compensation of electrolytic conductivity of natural waters. This convention is typically used in German markets.

Salinity = Salinity is determined automatically from the sonde conductivity and temperature readings according to algorithms found in Standard Methods for the Examination of Water and Wastewater (ed. 1989). The use of the Practical Salinity Scale results in values that are unitless, since the measurements are carried out in reference to the conductivity of standard seawater at 15 °C.

4.6 Conductivity / Temperature Calibration

Clean the conductivity cell with the supplied soft brush before calibrating *(see Section 5.7)*.
Also, review the basic calibration description in Section 4.2.

This procedure calibrates conductivity, non-linear function (nLF) conductivity, specific conductance, salinity, and total dissolved solids.

A variety of standards are available based on the salinity of your environment. Select the appropriate calibration standard for your deployment environment; we recommend using standards greater than 1 mS/cm (1000 µS/cm) for greatest stability.

Pour conductivity standard into a clean and dry or pre-rinsed EXO calibration cup. YSI recommends filling the calibration cup up to the second marked line to ensure the standard is above the vent holes on the conductivity sensor. Immerse the probe end of the sonde into the solution, gently rotate and/or move the sonde up and down to remove any bubbles from the conductivity cell.

Allow at least one minute for temperature equilibration before proceeding.

In the Calibrate menu, select the Conductivity sensor and then select the parameter you wish to calibrate. These parameters may include conductivity, nLF conductivity, specific conductance, or salinity. Calibrating any one option automatically calibrates the other parameters. After selecting the option of choice (specific conductance is normally recommended), enter the value of the standard used during calibration. Be certain that the units are correct (microsiemens, not millisiemens).

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point.

> **NOTE:** If the data do not stabilize after 40 seconds, gently rotate the sonde or remove/reinstall the cal cup to make sure there are no air bubbles in the conductivity cell.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu.

Rinse the sonde and sensor(s) in tap or purified water and dry.

SmartQC for Conductivity/Temperature Sensors

The SmartQC Score for conductance is based on a gain factor, which is then computed into a cell constant that appears on the calibration worksheet. The gain may drift over time due to aging electrodes or calibration procedures performed on the sensor, and this will ultimately affect the cell constant. An ideal cell constant for the non-wiped conductivity sensor is 5.1/cm ± 10%, and the effects of changes in gain will be evident in changes in that value.

The CT sensor can be evaluated in air when it is new, and as the sensor ages this may be a useful tool for assessing its drift from factory performance. To perform an air check:

1. Clean the sensor thoroughly.
2. Perform a Factory Reset Calibration.
3. Rinse the sensor with DI water and dry it thoroughly.
4. Observe sensor readings in air. They should be very close to zero. While this is a subjective assessment, if the user has an idea of what air readings were when the sensor was new, monitoring this on occasion can provide clues as to whether the sensor is aging out of use.

Guidance on interpretation of the SmartQC score for this sensor is as follows:

Green: Gain is within acceptable limits. Calibration was performed successfully and resulted in a gain within factory specified limits.

Yellow: The gain has drifted a minor amount from factory specified limits. The sensor is still reporting correctly but adjustments may need to be made. If a user calibration results in a yellow QC Score:

1. First, thoroughly clean the sensor and ensure that all debris is removed from the surfaces of the sensor. Refer to Section 5.7 for additional information on how to properly clean the sensor in order to avoid damaging the sensor.
2. Next, perform a Factory Reset Calibration to reset the gain and cell constant to their factory default values. This is described in Section 4.2.
3. Finally, complete another calibration on the sensor using fresh standard.
4. Perform a check of readings in air.

If the QC Score remains yellow, the sensor is still able to be used, but the user should monitor this sensor during calibrations, including looking at the cell constant on the calibration worksheets.

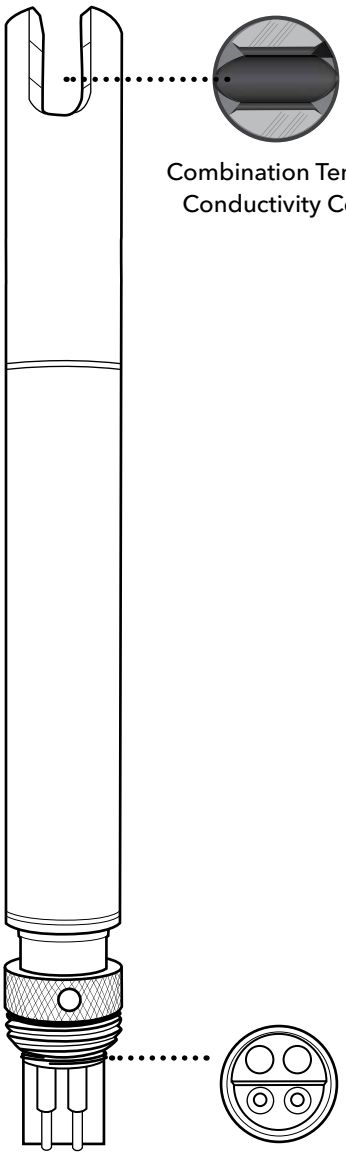
Red: The gain has drifted significantly from the factory specified limits. If the QC Score is red, the sensor may not report correct values. If a user calibration results in a red QC Score:

1. Verify that the standard value used during calibration was entered correctly. If the value was not entered correctly, the resulting QC Score would show a red value due to the gain changing significantly.
2. Thoroughly clean the sensor and ensure that all debris is removed from the surfaces of the sensor. Refer to Section 5.7 for additional information on how to properly clean the sensor in order to avoid damaging the sensor.
3. Perform a Factory Reset Calibration.
4. Complete a calibration using fresh standard.

If the QC Score returns to red after these steps, please contact YSI Technical Support for further assistance.

4.7 Wiped Conductivity / Temperature
Sensor Overview

Biofilms, barnacles, and algal growth are common culprits of poor data quality, clogging up conductivity cells and coating sensor optics. While EXO2's Central Wiper can mechanically remove biofouling from other sensors to maintain data integrity over long deployment periods, in particularly high fouling environments the EXO Wiped C/T sensor provides superior conductivity data by avoiding stagnant readings and reducing the impact of micro-environments.



599827

EXO Wiped C/T Considerations

Sensor performance and specifications are well suited for continuous monitoring applications, where the EXO sonde is installed at a fixed location. For sampling and vertical profiling applications the legacy (599870) Conductivity Temperature probe which has a much faster temperature response should be used.

The Wiped C/T will have a different cell constant than the legacy Conductivity probes. A nominal cell constant of 0.469 +/-0.05 is typical on wiped conductivity.

The EXO central wiper (599090) must have the wiper shaft seal serviced in the past year to use with your new wiped C/T probe. The wiper will work harder grooming the new sensor, therefore if your wiper hasn't had the shaft seal properly maintained there is a chance it could stall mid deployment.

Specifications

Conductivity

Range	0-100,000 µS/cm
Accuracy	±1% of reading or 2 µS/cm w.i.g.

Temperature

Range	-5 to 50°C
Accuracy	±0.2°C
Response Time	T95<30sec

Specific Conductance

Range	0-100,000 µS/cm
Accuracy	±1% of reading or 2 µS/cm w.i.g.

w.i.g. = whichever is greater

Watch Online
EXO2 Wiped (C/T) Video Quick Start Guide:
https://goo.gl/w67OQU

4.8 Wiped Conductivity / Temperature
Calibration and Deployment

Calibration

A wet calibration of your new conductivity sensor should be completed before initial use. It is recommended that you complete a single point calibration in a standard similar to the conductivity readings that you expect to measure. It is recommended not to use standards below 1,000 µs/cm for fresh water applications as they can become easily contaminated. The temperature sensor cannot be user calibrated. Best practice is to periodically test the performance of the temperature sensor against a NIST traceable thermometer at several reference points.

NOTE: *All EXO sensors should be user calibrated before initial use.*

Deployment Setup

The Wiped C/T sensor is optimized for continuous monitoring where a variety of environmental fouling conditions would affect the performance of the sensor without wiping. Numerous solutions can be employed to mitigate the effects of bio-fouling. These can include the use of copper tape, anti-fouling guards, anti-fouling paints, as well as local techniques developed for site specific challenges. However, none of these options can be directly applied to the conductivity cell of the wiped C/T sensor. Using the central wiper to groom the conductivity cell before readings prevents biofouling-induced drift of the conductivity cell.

The sensor includes a new central wiper brush (599673). A brush's wear and replacement intervals vary greatly based on specific application challenges, but 2-12 months use has been observed. Below are three examples of brush wear that will occur with use. It is recommended the wiper brush be replaced before it reaches level 3 for optimal cleaning. We recommend using a new wiper brush with the initial deployment.

Level 1- New brush, minimal "splay"

Level 2- Moderate splaying, have spare ready

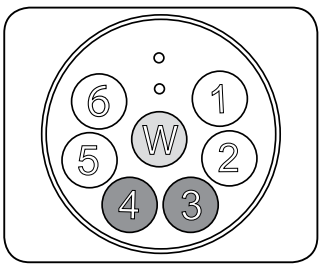
Level 3- Excessive splay, replace to prevent stalling of wiper

NOTICE: It is not recommended using wiped C/T in conjunction with EXO Ammonium, Nitrate, or Chloride electrodes as they are protected with a guard which accelerates the brush splay.

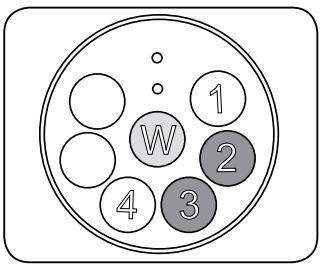
Sensor Installation

A new sensor includes a kit (599831) containing probe alignment o-rings and disposable zip ties. These items are to be used to optimally align the wiped conductivity probe cell with the brush. Refer to the instruction sheet included in the kit for directions and recommendations for applying the spacers. EXO sensors can be installed in any port, however for optimal cleaning avoid installing the Wiped C/T sensor as the first or last sensor in a group. If two conductivity sensors are installed in a single sonde, the temperature from the sensor with the lower port will be used for temperature compensation of other parameters.

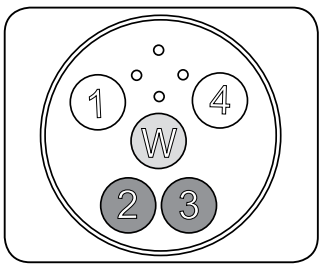
Having the sensor installed towards the middle of an array is optimal. Below are some examples:



EXO2 Optimal Wiped C/T positions: 3 or 4



EXO2 Optimal Wiped C/T positions: 2 or 3



EXO3 Optimal Wiped C/T positions: 2 or 3

NOTICE: When installing a wiped conductivity/temperature sensor in an EXO3 sonde, use ports 2 and 3.

SmartQC for Wiped Conductivity/Temperature Sensors

The SmartQC Score for conductance is based on a gain factor, which is then computed into a cell constant that appears on the calibration worksheet. The gain may drift over time due to aging electrodes or calibration procedures performed on the sensor, and this will ultimately affect the cell constant. An ideal cell constant for the wiped conductivity sensor is 0.469/cm ± 0.05, and the effects of changes in gain will be evident in changes in that value.

Guidance on interpretation of the SmartQC score for this sensor are as follows:

Green: Gain is within acceptable limits. Calibration was performed successfully and resulted in a gain within factory specified limits.

Yellow: The gain has drifted a minor amount from factory specified limits. The sensor is still reporting correctly but adjustments may need to be made. If a user calibration results in a yellow QC Score:

1. First, thoroughly clean the sensor and ensure that all debris is removed from the surfaces of the sensor. Refer to the Sensor Maintenance Section 5.7 of the manual for additional information on how to properly clean the instrument in order to avoid damaging the sensor.
2. Next, perform a Factory Reset Calibration to reset the gain and cell constant to their factory default values.
3. Finally, complete another calibration on the sensor using fresh standard.

If the QC Score remains yellow, the sensor is still able to be used, but the user should monitor this sensor during calibrations, including looking at the cell constant on the calibration worksheets.

Red: The gain has drifted significantly from the factory specified limits. If the QC Score is red, the sensor may not report correct values. If a user calibration results in a red QC Score:

1. Verify that the standard value used during calibration was entered correctly. If the value was not entered correctly, the resulting QC Score would show a red value due to the gain changing significantly.
2. Thoroughly clean the sensor and ensure that all debris is removed from the surfaces of the sensor. Refer to Section 5.7 for additional information on how to properly clean the sensor in order to avoid damaging the sensor.
3. Perform a Factory Reset Calibration.
4. Complete a calibration using fresh standard.

If the QC Score returns to red after these steps, please contact YSI Technical Support for further assistance.

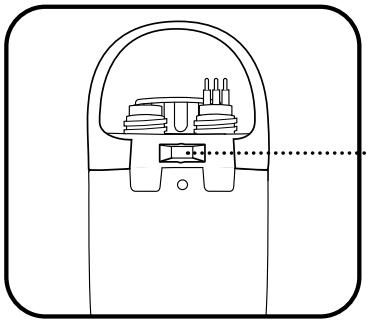
4.9 Depth and Level

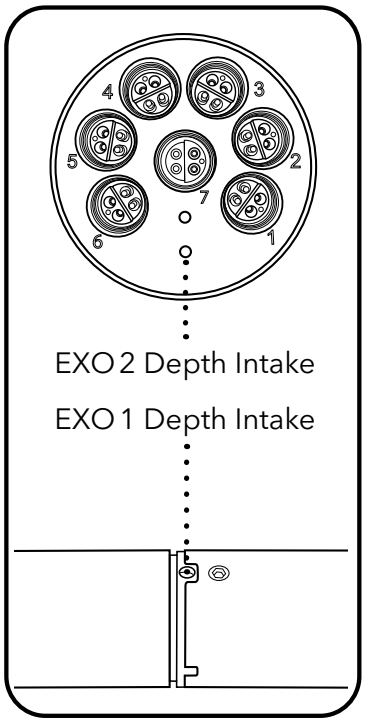
Sensor Overview

EXO measures depth of water with a non-vented strain gauge. (See Section 6 if your sonde is equipped with vented level.) A differential strain gauge transducer measures pressure with one side of the transducer exposed to the water and the other side exposed to a vacuum. We calculate depth from the pressure exerted by the water column minus atmospheric pressure. Factors influencing depth measurement include barometric pressure, water density, and temperature. Calibration in the atmosphere "zeros" the sensor with respect to the local barometric pressure. A change in barometric pressure will result in a zero shift unless the transducer is recalibrated to the new pressure.

EXO sondes have intake openings to allow water to act on the strain gauge. The EXO1 intake is located in the yellow section between the battery compartment and label of the sonde. The EXO2 intake openings are two small holes on the face of the sonde bulkhead.

Location of Depth Sensor





Depth Sensor Location relative to other water quality sensors (see EXO sonde label)

Depth Sensor Location
27.2 cm (EXO1), 13.9 cm (EXO2)
to WQ Sensors

Depth sensors on the EXO2 sondes are not on center. When deploying the sonde *vertically,* take care to ensure the sonde is redeployed in same position. Often a marker pin inside a PVC pipe is used. In *horizontal* deployments, take care to ensure the redeployments are always in the same orientation. This is especially important for the EXO2 sonde because the depth sensor is off-axis.

To assist with consistent horizontal orientation, the EXO2 sonde has an indentation at the top of the sonde for a marker or positioning pin.

The sonde should be installed with at least 1 cm of water above the intake ports. If a conductivity sensor is installed, the depth will be compensated automatically for changes in the density of water as temperature and salinity change.

Depth Configuration

EXO sondes must be ordered with a specific depth sensor option:

59950x-00 = no depth
59950x-01 = 0-10 m depth
59950x-02 = 0-100 m depth
59950x-03 = 0-250 m depth
59950x-04 = 0-10 m vented level

The depth configuration must be chosen at time of ordering. Once a sonde is shipped with a depth configuration it cannot be changed by the user.

Specifications

Units	PSI, Depth (m, ft, bar)
Temperature	
Operating	-5 to +50°C
Storage	-20 to +80°C
Range	*Shallow:* 0 to 33 ft (10 m) *Medium:* 0 to 328 ft (100 m) *Deep:* 0 to 820 ft (250 m) *Vented:* 0 to 33 ft (10 m)
Accuracy	*Shallow:* ±0.04% FS (±0.013 ft or ±0.004 m) *Medium:* ±0.04% FS (±0.13 ft or ±0.04 m) *Deep:* ±0.04% FS (±0.33 ft or ±0.10 m) *Vented:* ±0.03% FS (±0.010 ft or ±0.003 m)
Response	T63<2 sec
Resolution	0.001 ft (0.001 m)
Sensor Type	Stainless steel strain gauge

4.10 Depth and Level Calibration

NOTE: *This calibration option is available only if your sonde is equipped with an integral depth sensor or a vented level sensor.*

For the calibration, make certain that the depth sensor or vented level sensor is in air and not immersed in any solution. Also, review the basic calibration description in Section 4.2.

In the Calibrate menu, select Depth and then select Calibrate.

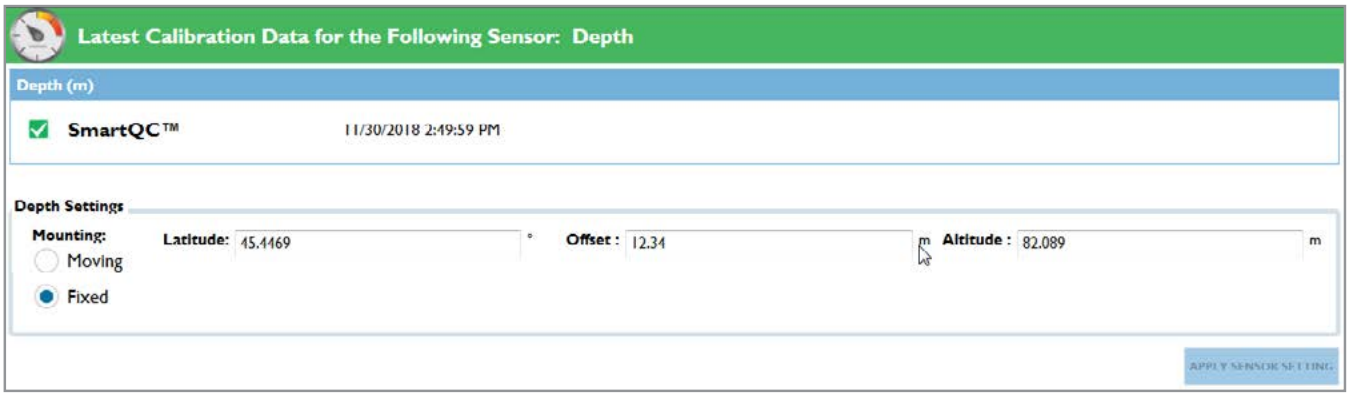
0 is the only acceptable calibration value. An offset may be entered under the Depth sensor settings..

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point. This process zeros the sensor with regard to current barometric pressure.

Click Exit to return to the sensor calibration menu.

For best performance of depth measurements, users should ensure that the orientation of the sonde remains constant while taking readings. This is especially important for vented level measurements. Keep the sonde still and in one position while calibrating.

Advanced



Mounting: Use the Advanced menu to select if a sonde will be mounted in a moving/profiling deployment instead of a fixed location.

Depth Offset: Enter a value in meters (m) to offset the depth at the point of measurement.

Altitude/Latitude: Enter the coordinates for the local altitude (in feet, relative to sea level) and latitude (in degrees) where the sonde is sampling. Latitude values are used in the calculation of depth or level to account for global variations in the gravitational field.

SmartQC for Depth, Non-vented

The SmartQC Score for non-vented depth is based on an expected offset that would be computed by the sensor during calibration.

Green: The offset computed during the calibration is within factory specified limits.

Yellow: The offset computed during the calibration is slightly outside of factory specified limits.

1. If the sensor is being deployed at high altitudes, the computed offset during calibration may be outside of the factory specified limits. The data collected by the depth sensor at higher elevations is not incorrect; simply the offset is outside of normal lower-elevation ranges. At higher elevations, all sensors may experience the yellow QC Score and a green QC score may never be attainable.
2. Ensure that the sensor is free of debris. If there is debris clogging the inlet, use water to clear the inlet. Use care to avoid damaging the thin pressure membrane. Refer to Section 5.5 for additional information on how to properly clean the instrument in order to avoid damaging the sensor.
3. Make sure that the sensor was completely dry before performing the calibration. If needed, use a can of compressed air to dry off the sensor to perform a better calibration. Do NOT stick any tools or utensils inside the pressure sensor vent hole. The sensor membrane is extremely thin and easily punctured.
4. Perform a Factory Reset Calibration to restore the offset to factory calibrated values and then perform another calibration.

If the QC Score is still yellow after performing another calibration, the sensor is still able to be used. The user should continue to monitor the sensor for additional drift away from the factory defaults.

Red: The offset computed during the calibration is significantly outside of factory specified limits.

1. Ensure that the sensor inlet is free of debris. If there is debris clogging the inlet, use water to clear the inlet. Use care to avoid damaging the thin pressure membrane. Refer to Section 5.5 for additional information on how to properly clean the instrument in order to avoid damaging the sensor.
2. Verify that the membrane is not punctured.
3. Perform a Factory Reset Calibration to restore the offset to factory calibrated values and then perform another calibration.

If the QC Score returns to red after the above procedures were performed, please contact YSI Technical Support for further assistance.

SmartQC for Depth, Vented

The SmartQC Score for level is based on an expected offset that would be computed by the sensor during calibration.

Green: The offset computed during the calibration is within factory specified limits.

Yellow: The offset computed during the calibration is slightly outside of factory specified limits.

1. If the sensor is being deployed at high altitudes, the computed offset during calibration may be outside of the factory specified limits. The data collected by the depth sensor at higher elevations is not incorrect; simply the offset is outside of normal lower-elevation ranges. At higher elevations, all sensors may experience the yellow QC Score and a green QC score may never be attainable.
2. Ensure that the sensor is free of debris. If there is debris clogging the inlet, use water to clear the inlet. Use care to avoid damaging the thin pressure membrane. Refer to Section 6.5 for additional information on how to properly clean and care for the instrument.
3. Make sure that the sensor was completely dry before performing the calibration. If needed, use a can of compressed air to dry off the sensor to perform a better calibration. Do NOT stick any tools or utensils inside the pressure sensor vent hole. The sensor membrane is extremely thin and easily punctured.
4. Verify that the vent tube exposed to atmospheric conditions is properly connected to a desiccant canister or connected to a dummy plug to prevent moisture from entering the vent tube. If moisture accumulates in the vent tube, calibrations will not be accurate. Information on how to connect a desiccant container to a vented level sonde can be found in Section 6.3.
5. Perform a Factory Reset Calibration to restore the offset to factory calibrated values and then perform another calibration.

If the QC Score remains yellow after performing another calibration, the sensor is still able to be used. The user should continue to monitor the sensor for additional drift away from the factory defaults.

Red: The offset computed during the calibration is significantly outside of factory specified limits.

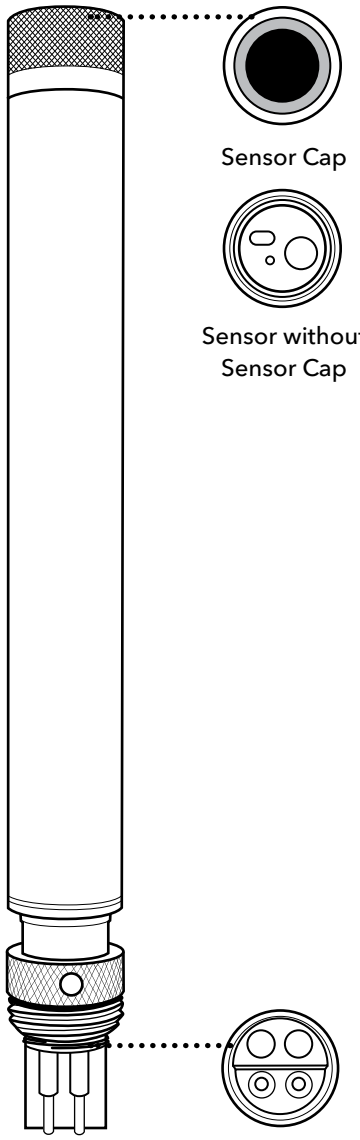
1. Ensure that the sensor inlet is free of debris. If there is debris clogging the inlet, use water to clear the inlet. Use care to avoid damaging the thin pressure membrane. Refer to Section 6.5, for additional information on how to properly clean and care for the instrument.
2. Determine if there is a likelihood that moisture has entered the vent tube. If the desiccant canister is full of water, the vent tube may have significant moisture inside.
3. Verify that the membrane is not punctured.
4. Perform a Factory Reset Calibration to restore the offset to factory calibrated values and then perform another calibration.

If the QC Score returns to red after the above procedures were performed, please contact YSI Technical Support for further assistance.

4.11 Dissolved Oxygen

Sensor Overview

The principle of operation of the EXO optical dissolved oxygen sensor is based on the well-documented concept that dissolved oxygen quenches both the intensity and the lifetime of the luminescence associated with a carefully chosen chemical dye. The EXO DO sensor operates by shining a blue light of the proper wavelength on this luminescent dye which is immobilized in a matrix and formed into a disk. The blue light causes the immobilized dye to luminesce and the lifetime of this dye luminescence is measured via a photodiode in the probe. To increase the accuracy and stability of the technique, the dye is also irradiated with red light during part of the measurement cycle to act as a reference in the determination of the luminescence lifetime.



599100-01;
599110 sensor cap

When there is no oxygen present, the lifetime of the signal is maximal; as oxygen is introduced to the membrane surface of the sensor, the lifetime becomes shorter. Thus, the lifetime of the luminescence is inversely proportional to the amount of oxygen present and the relationship between the oxygen pressure outside the sensor and the lifetime can be quantified by the Stern-Volmer equation: **((Tzero/T) – 1) versus O_2 pressure**

For most lifetime-based optical DO sensors, this Stern-Volmer relationship is not strictly linear (particularly at higher oxygen pressures) and the data must be processed using analysis by polynomial non-linear regression. Fortunately, the non-linearity does not change significantly with time so that, as long as each sensor is characterized with regard to its response to changing oxygen pressure, the curvature in the relationship does not affect the ability of the sensor to accurately measure oxygen for an extended period of time.

(continued)

Specifications

Units	% Saturation, mg/L
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Range	0 to 500% air sat. 0 to 50 mg/L
Accuracy	0-200%: ±1% reading or 1% air sat., whichever is greater; 200-500%: ±5% reading 0-20 mg/L: ±1% of reading or 0.1 mg/L; 20-50 mg/L: ±5% reading
Response	T63<5 sec
Resolution	0.1% air sat. 0.01 mg/L
Sensor Type	Optical, luminescence lifetime

Variables that Affect DO Measurements

Variables that could affect dissolved oxygen measurements include temperature, salinity, and barometric pressure. Temperature and salinity are compensated for during instrument calibration and field use with the use of additional sensors and/or instrument software settings. Barometric pressure relates to the pressure of oxygen in the calibration environment, and barometric pressure changes due to a change in altitude or local weather. Generally the effect of barometric pressure is overcome by proper sensor calibration to a standard pressure. However, if the user measures dissolved oxygen in something besides percent saturation, then the EXO DO sensor can store a local barometric reading put into the KorEXO software (DO % local) or the EXO handheld can take a live barometric reading with its internal barometer (ODO % EU).

ODO % Sat = Raw DO reading corrected with temperature and local barometric pressure at the time of calibration: (local mmHg / 760 mmHg) x 100 = %Sat

ODO % Local = Raw DO reading corrected with temperature and % Sat output fixed to 100% regardless of barometric pressure entry. (The entered local barometric pressure is used by KorEXO software for mg/L calculations.)

ODO % EU = ODO % Sat reading corrected with live barometric reading (available only on EXO Handheld). Fixes the % Sat output to 100%, and conforms to British and EU standards.

4.12 Dissolved Oxygen
Calibration

First review the basic calibration description in Section 4.2.

ODO % sat and ODO % local – 1-point

Place the sonde with sensor into either water-saturated air or air-saturated water:
(a) Water-saturated air: Ensure there are no water droplets on the DO sensor or the thermistor. Place into a calibration cup containing about 1/8 inch of water that is vented by loosening the threads. (Do not seal the cup to the sonde.) Wait 10-15 minutes before proceeding to allow the temperature and oxygen pressure to equilibrate. Keep out of direct sunlight.
(b) Air-saturated water: Place into a container of water which has been continuously sparged with an aquarium pump and air stone for one hour. Wait approximately 5 minutes before proceeding to allow the temperature and oxygen pressure to equilibrate.

In the Calibrate menu, select ODO, then select ODO % sat or ODO % local. Calibrating in ODO % sat automatically calibrates ODO mg/L and ODO % local and vice versa.

Enter the current barometric pressure in mm of Hg (Inches of Hg x 25.4 = mm Hg).

NOTE: *Laboratory barometer readings are usually "true" (uncorrected) values of air pressure and can be used "as is" for oxygen calibration. Weather service readings are usually not "true", i.e., they are corrected to sea level, and therefore cannot be used until they are "uncorrected".* An approximate formula for this "uncorrection" (where the BP readings MUST be in mm Hg) is:
True BP = [Corrected BP] – [2.5 * (Local Altitude in ft above sea level/100)]

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu.

mg/L – 1-point

Place the sonde with sensor in a container which contains a known concentration of dissolved oxygen in mg/L and that is within ±10% of air saturation as determined by one of the following methods:

- Winkler titration
- Aerating the solution and assuming that it is saturated
- Measurement with another instrument

NOTE: *Carrying out DO mg/L calibrations at values outside the range of ±10 % of air saturation is likely to compromise the accuracy specification of the EXO sensor. For highest accuracy, calibrate in % saturation.*

In the Calibrate menu, select ODO, then select ODO mg/L. Calibrating in ODO mg/L automatically calibrates ODO % sat and vice versa.

Enter the known mg/L concentration for the standard value. Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point. Click Complete.

Rinse the sonde and sensor(s) in tap or purified water and dry.

ODO % sat, ODO % local or mg/L – 2-point (or zero point)

Normally it is not necessary to perform a 2-point calibration for the DO sensor, and the procedure is not recommended unless (a) you are certain that the sensor does not meet your accuracy requirements at low DO levels and (b) you are operating under conditions where you are certain to be able to generate a medium which is truly oxygen-free.

For ODO % sat or ODO % local, calibrate your sonde at zero oxygen and in water-saturated air or air-saturated water. For ODO mg/L, calibrate your sonde at zero oxygen and a known concentration of oxygen within ±10% of air-saturation. The key to performing a 2-point calibration is to make certain that your zero-oxygen medium is truly oxygen-free:

- If you use nitrogen gas for the zero-point calibration, make certain that the vessel you use has a small exit port to prevent back diffusion of air and that you have completely purged the vessel before confirming the calibration.
- If you use sodium sulfite solution for the zero-point calibration, prepare the solution at a concentration of approximately 2 g/L at least two hours prior to use and keep it sealed in a bottle which does not allow diffusion of oxygen through the sides of the container. Transfer the sodium sulfite solution rapidly from its container to the calibration cup, fill the cup as full as possible with solution to minimize head space, and seal the cup to the sonde to prevent diffusion of air into the vessel.

Place the sonde with DO and temperature sensors in the zero-oxygen medium.

In the Calibrate menu, select ODO, then select either ODO % sat, ODO % local or ODO mg/L.

Select Zero from the Standard Value drop-down window.

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point.

- If you used sodium sulfite solution as your zero calibration medium, you must thoroughly remove all traces of the reagent from the probes and wiper prior to proceeding to the second point. We recommend that the second calibration point be in air-saturated water if you use sodium sulfite solution.

Next place the sensors in the medium containing a known oxygen pressure or concentration and wait at least 10 minutes for temperature equilibration. Click Add Another Cal Point. Then enter either the barometer reading in mm Hg (for ODO %) or the actual concentration of oxygen as determined from a Winkler titration (for ODO mg/L), for instance. Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu.

NOTE: *Carrying out DO mg/L calibrations at values outside the range of ±10 % of air saturation is likely to compromise the accuracy specification of the EXO sensor. For highest accuracy, calibrate in % saturation.*

Rinse the sonde and sensor(s) in tap or purified water and dry.

SmartQC for Optical Dissolved Oxygen Sensors

Dissolved Oxygen (DO) calculations are derived from polynomial equations based on the K1-K7 coefficients that are provided with each new Dissolved Oxygen sensor cap. Each sensor has been thoroughly tested during the production process to generate these unique calibration coefficients. Calibration of the probe essentially changes these coefficients. The DO SmartQC score is based on a gain factor, which relates to the magnitude of coefficient change. The gain may drift as the sensor gets older and the optics begin to fade and may also be affected by the degradation of or damage to the unique material that is on the face of the sensor. If a zero-DO calibration is performed, SmartQC also calculates a zero-DO coefficient change.

Green: Gain is within acceptable limits. Calibration was performed successfully and resulted in a gain within factory specified limit.

Yellow: The gain or zero-DO calibration coefficient has drifted a minor amount from the factory specified limits. The sensor is still reporting correctly but adjustments may need to be made. If a user calibration results in a yellow QC Score:

1. Thoroughly clean the sensor and ensure that all debris is removed from the surfaces of the sensor. Refer to the Section 5.9 of the manual for additional information on how to properly clean the instrument in order to avoid damaging the sensor.
2. Ensure that proper calibration procedures were followed. Typical errors include not allowing enough time for the calibration chamber to come to equilibrium with the atmosphere or the chamber was not of adequate humidity. Time to equilibrate to an air-saturated water chamber may also not have been adequate. It is recommended to allow between 10-15 minutes for equilibration.
3. Check the lens cap for scratches. If there are scratches, the resulting gain after calibration may change because the amount of membrane remaining on the lens cap has changed.
4. If a new lens cap was installed,
   a. ensure that the new calibration coefficients were entered into the sensor using either the handheld or KorEXO software. The software will calibrate the sensor and also compute the QC Score based on the old lens cap coefficients if the values are not changed after installation of the new lens cap.
   b. perform a Factory Reset Calibration before performing a calibration to revert the gain and zero-DO coefficient back to factory defaults and
5. If a zero-DO calibration resulted in a yellow QC Score, it is recommended to create a new zero-DO solution. Depending upon the method used (sparging with nitrogen or sodium sulfite), either ensure that the proper amount of sodium sulfite is fully mixed into the water, or ensure that the gas purge chamber has an adequate amount of time to purge all oxygen from the water.
6. Sometimes low-quality nitrogen tanks are contaminated with trace amounts of oxygen—check the certificate with your nitrogen source to assure its purity.

If the QC Score returns to yellow, the sensor is still able to be used but the user should monitor this sensor during calibrations for any further drift.

Red: The gain or zero-DO calibration coefficient has drifted significantly from the factory specified limits. If the QC Score is red, the sensor may not report correct values. If a user calibration results in a red QC Score:

1. Throroughly clean the sensor and ensure that all debris is removed from the surfaces of the sensor. Occasionally, thin films from sediment may affix to the lens cap surface and will affect readings and calibrations. Refer to the Section 5.9 of the manual for additional information on how to properly clean in order to avoid damaging the sensor cap.
2. Ensure that proper calibration procedures were followed. Gross errors can cause the gain to change significantly from factory default values. Errors in calibration include sealing the calibration cup to the sonde completely, allowing the calibration setup to equilibrate in the sun, or not properly saturating the air environment with water.
3. Inspect the lens caps for coating loss on the sensor window. If the sensor cap has excessive coating loss to the point that calibration is being affected, replace the sensor lens cap. Re-enter the calibration coefficients, execute a Factory Reset Calibration and perform a calibration on the newly installed sensor lens cap.
4. Verify that proper calibration coefficients were entered if the sensor lens cap was replaced.
5. If a zero-DO calibration was performed, perform a Factory Reset Calibration and redo the 2-point calibration procedure. Allow for ample time for the sensor to equilibrate to both zero and 100% saturation values.

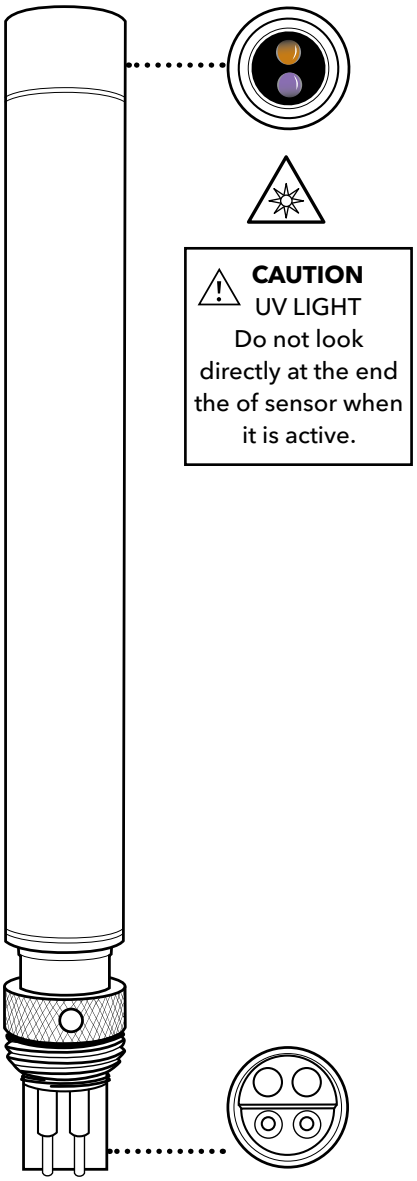
If the QC Score returns to red after the above steps were attempted, please contact YSI Technical Support for further assistance.

4.13 fDOM
Sensor Overview

The EXO fDOM (Fluorescent Dissolved Organic Matter) sensor detects the fluorescent component of DOM (Dissolved Organic Matter) when exposed to near-ultraviolet (UV) light.

Colored Dissolved Organic Matter

Users might wish to quantify *colored* dissolved organic matter (CDOM) in order to determine the amount of light which is absorbed by stained water and thus is not available for photosynthesis. In most cases, fDOM can be used as a surrogate for CDOM.



599104-01

Quinine Sulfate

A surrogate for fDOM is quinine sulfate, which, in acid solution, fluoresces similarly to dissolved organic matter. The units of fDOM are quinine sulfate units (QSUs) where 1 QSU = 1 ppb quinine sulfate and thus quinine sulfate is really an indirect surrogate for the desired CDOM parameter.

The EXO fDOM sensor shows virtually perfect linearity (R^2=1.0000) on serial dilution of a colorless solution of quinine sulfate. However, on serial dilution of stained water field samples, the sensor shows some underlinearity. The point of underlinearity in field samples varies and is affected by the UV absorbance of the DOM in the water. Testing shows that underlinearity can occur at fDOM concentrations as low as 50 QSU. This factor means that a field sample with an fDOM reading of 140 QSU will contain significantly more than double the fDOM of a sample that reads 70 QSU. This effect—good linearity in colorless quinine sulfate solution, but underlinearity in stained field samples—is also exhibited by other commercially available fDOM sensors and thus the performance of the EXO sensor is likely to be equivalent or better than the competition while providing the advantages of easy integration into a multiparameter package and automatic mechanical cleaning when used in monitoring studies with an EXO2 sonde.

Specifications

Units	Quinine Sulfate Units (QSU), ppb
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Range	0 to 300 ppb QSU
Response	T63<2 sec
Resolution	0.01 ppb QSU
Sensor Type	Optical, fluorescence
Linearity	R^2>0.999 for serial dilution of 300 ppb Quinine Sulfate solution
Detection Limit	0.07 ppb QSU
Optics: Excitation	365±5 nm
Emission	480±40 nm

4.14 fDOM Calibration Standards

Quinine Sulfate Solution for fDOM Sensor

⚠ **WARNING:** Before using a quinine sulfate reagent (solid or solution) or sulfuric acid reagent, read the safety instructions provided by the supplier. Take extra precautions when making dilutions of concentrated sulfuric acid, as this reagent is particularly dangerous. Remember that only trained personnel should handle chemicals.

Preparation

Use the following procedure to prepare a 300 µg/L solution of quinine sulfate (300 QSU) that can be used to calibrate the EXO fDOM sensor for field use:

1. Purchase solid quinine sulfate dihydrate (CAS# 6119-70-6) with a high purity (>99%).
2. Purchase 0.1 N (0.05 M) sulfuric acid (CAS# 7664-93-3), to avoid the hazards of diluting concentrated sulfuric acid to make this reagent.
3. Weigh 0.100 g of solid quinine sulfate dihydrate and quantitatively transfer the solid to a 100-mL volumetric flask. Dissolve the solid in about 50 mL of 0.05 M (0.1 N) sulfuric acid (H_2SO_4), dilute the solution to the mark of the volumetric flask with additional 0.05 M sulfuric acid, and mix well by repeated inversion. This solution is 1000 ppm in quinine sulfate (0.1%).
4. Transfer 0.3 mL of the 1000 ppm solution to a 1000 mL volumetric and then fill the flask to the top graduation with 0.05 M sulfuric acid. Mix well to obtain a solution of 300 µg/L (300 QSU or 100 RFU).
5. Store the concentrated standard solution in a darkened glass bottle in a refrigerator to retard decomposition. The dilute standard prepared in the previous step should be used within 5 days of preparation and should be discarded immediately after exposure to EXO's metal components.

Degradation of quinine fluorescence by copper and chloride

NOTICE: Exposure of the quinine sulfate solution to any copper-based component of the EXO sonde and sensors (primarily the wiper assembly) will begin to degrade the solution significantly within minutes. Quinine fluorescence is also degraded by the presence of chloride or halide ions, found in estuarine or seawater, conductivity standards, and Zobell solution. Thus, clean your sensors thoroughly and perform your calibration as quickly as possible on immersion of the sensors into the quinine sulfate solution. Discard the used standard. When quinine sulfate standards are required in the future, perform another dilution of the concentrated solution.

Effect of temperature on fluorescence

The intensity of the fluorescence of many dyes shows an inverse relationship with temperature. This effect must be accounted for when calibrating the EXO fDOM sensor with quinine sulfate solution. Enter the QSU or RFU value from the table below that corresponds to the temperature of the standard.

Temp (˚C)	RFU	QSU	Temp (˚C)	RFU	QSU
30	96.4	289.2	18	101.8	305.4
28	97.3	291.9	16	102.7	308.1
26	98.2	294.6	14	103.6	310.8
24	99.1	297.3	12	104.6	313.8
22	100	300	10	105.5	316.5
20	100.9	302.7	8	106.4	319.2

4.15 fDOM Calibration

Review the basic calibration description in Section 4.2.
Before calibrating, be certain that the sensing window is clean (cleaning instructions, Section 5.6).

This procedure calibrates fDOM RFU or fDOM QSU/ppb. If the user has both units selected, then this procedure must be performed twice, once for each unit, to completely calibrate the parameter.

For 2-point calibrations, the first standard must be clear water (0 µg/L). The second standard should be a 300 µg/L quinine sulfate solution. For detailed instructions for mixing this solution, see Section 4.14.

> **NOTICE:** Do not leave sensors in quinine sulfate solution for a long time. A chemical reaction occurs with the copper on the sonde (wiper assembly, sonde bulkhead, copper tape) that degrades the solution and causes it to drift. Also, start with very clean sensors, as the presence of chloride and halide ions (from estuarine or seawater, conductivity standards, and Zobell solution) can compromise QS fluorescence.

QSU – 1- or 2-point

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water.

In the Calibrate menu, select fDOM, then select QSU/ppb. Select either a 1- or 2-point calibration. Enter 0 for first standard value and 300 µg/L for second standard value.

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point.

Remove the central wiper from the EXO2 sonde before proceeding to the next step.

Next place the sensors in the correct amount of 300 µg/L quinine sulfate standard in the calibration cup. Click Add Another Cal Point in the software. Observe the Pre Calibration Value readings and the Data Stability. While stabilizing, verify that no air bubbles reside on the sensing face of the sensor. If there are bubbles, gently shake or move the sensor to dislodge. When data are Stable, click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

RFU – 1- or 2-point

Pour the correct amount of clear deionized or distilled water into the calibration cup. Immerse the probe end of the sonde in the water.

In the Calibrate menu, select fDOM, then select RFU. Select either a 1- or 2-point calibration. Enter 0 for first standard value and 100 RFU for second standard value.

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, and when they are Stable, click Apply to accept this calibration point.

Remove the central wiper from the EXO2 sonde before proceeding to the next step.

Next place the sensors in the 300 µg/L quinine sulfate standard in the calibration cup. Click Add Another Cal Point in the software. Observe the Pre Calibration Value readings and the Data Stability. While stabilizing, verify that no air bubbles reside on the sensing face of the sensor. If there are bubbles, gently shake or move the sensor to dislodge. When data are Stable (or data shows no significant change for approximately 40 seconds), click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu. Rinse the sonde in tap or purified water and dry the sonde. Discard the used standard.

SmartQC for fDOM Sensors (RFU or QSU)

The SmartQC Score for fDOM is based on a gain factor and an offset factor. Both of these values may change as the sensor and the optics age.

Green: Gain and offset are within acceptable limits. Calibration was performed successfully and results are within factory specified limits.

Yellow: The sensor gain or offset is slightly outside of calibration limits.

1. Perform a Factory Reset Calibration and complete a recalibration.
    a. If performing a 1-point calibration, use fresh, clear water.
    b. If performing a 2-point calibration, use fresh, clear water and freshly made quinine sulfate solution.
2. Ensure that the standard value was entered correctly. Calibration of fDOM is temperature-dependent; make sure the appropriate value from the table in Section 4.14 was entered during calibration for either RFU or QSU.
3. Ensure that the sensor is free of contamination. Refer to Section 5.6 for additional information on how to properly clean the sensor in order to avoid damage.

If the QC Score returns to yellow, the sensor is still able to be used, but the user should monitor this sensor during calibrations for any further drift.

Red: The sensor gain or offset are significantly outside of factory specified limits. Follow the same three steps described above for a Yellow QC Score.

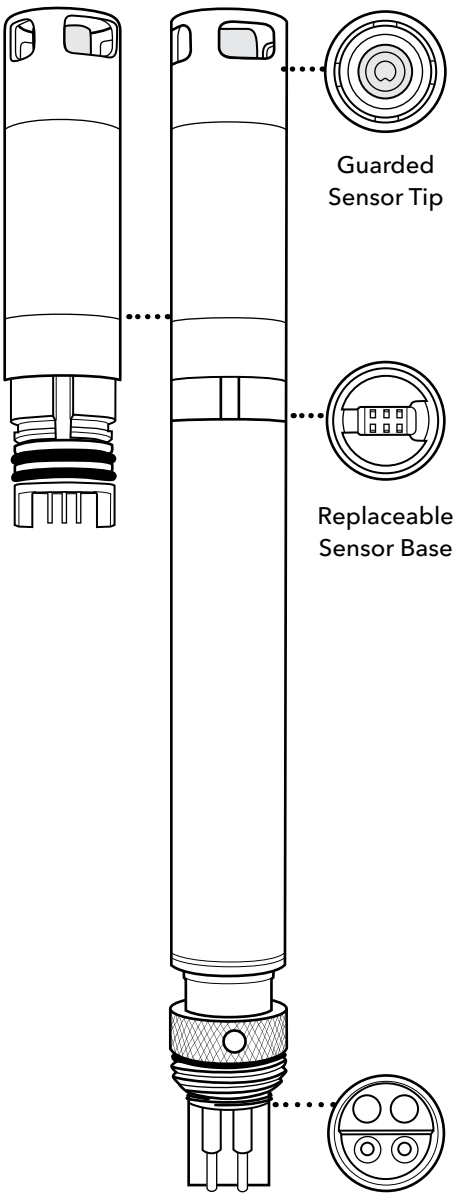
If the QC Score remains red, please contact YSI Technical Support for further assistance.

4.16 ISEs: Ammonium, Nitrate, & Chloride
Sensors Overview

NOTE: *Ammonium, nitrate, and chloride ion-selective electrodes (ISEs) should be used in freshwater applications only at depths of less than 55 feet (17 meters) and less than 25 psi.*

The ammonium and nitrate sensors use a silver/silver chloride wire electrode in a custom filling solution. The internal solution is separated from the sample medium by a polymer membrane, which selectively interacts with ammonium or nitrate ions. When the sensor is immersed in water, a potential is established across the membrane that depends on the relative amounts of ions in the sample and the internal solution. This potential is read relative to the Ag/AgCl reference electrode.

(continued)



599709, 599710, 599711;
599743-01, 599744-01, 599745-01 modules

Specifications

Ammonium - NH_4

Units	mg/L-N, millivolts
Temperature *Operating* *Storage*	 0 to 30˚C 0 to 30°C
Depth	0 to <55 ft (0 to <17 m)
Range	0 to 200 mg/L-N
Accuracy	±10% of reading or ±2 mg/L-N, whichever is greater
Response	T63<30 sec
Resolution	0.01 mg/L
Sensor Type	Ion-selective electrode
Conductivity	<1500 µS/cm

Nitrate - NO_3

Units	mg/L-N, millivolts
Temperature *Operating* *Storage*	 0 to 30˚C 0 to 30°C
Depth	0 to <55 ft (0 to <17 m)
Range	0 to 200 mg/L-N
Accuracy	±10% of reading or ±2 mg/L-N, whichever is greater
Response	T63<30 sec
Resolution	0.01 mg/L
Sensor Type	Ion-selective electrode
Conductivity	<1500 µS/cm

(Specs. continued)

Specifications *(continued)*

Chloride - Cl

Units	mg/L-Cl, millivolts
Temperature *Operating* *Storage*	 0 to 30˚C 0 to 30°C
Depth	0 to <55 ft (0 to <17 m)
Range	0 to 18000 mg/L-Cl
Accuracy	±15% of reading or ±5 mg/L-Cl, whichever is greater
Response	T63<30 sec
Resolution	0.01 mg/L
Sensor Type	Ion-selective electrode
Salinity	30 psu

NOTE: *Qualification testing for chloride was performed in a stirred calibration solution. Due to the solid state nature of the chloride ISE, the sensor exhibits moderate flow dependence. Mitigation can be achieved by stirring during calibration.*

The chloride sensor uses a solid-state membrane attached to a conductive wire. This sensor operates in a similar fashion to the ammonium and nitrate sensors.

For all ISEs, the linear relationship between the logarithm of the ammonium, nitrate or chloride activity and the observed voltage, as predicted by the Nernst equation, is the basis for the determination.

Ammonium is calculated from the pH, salinity, and temperature readings. If a pH sensor is not in use, the instrument will assume the sample is neutral (pH 7) for the calculation. If a conductivity sensor (salinity) is not in use, the instrument will use the salinity correction value entered in the ammonium sensor calibration screen for the calculation.

Replaceable Sensor Module

The EXO ammonium, chloride, and nitrate sensors have a unique design that incorporates a user-replaceable sensor tip (module) and a reusable sensor base that houses the processing electronics, memory, and wet-mate connector. This allows users to reduce the costs associated with these sensors by only replacing the relatively inexpensive module periodically and not the more costly base.

The connection of the module to the sensor base is designed for one connection only and the procedure must be conducted in an indoor and dry environment. Once installed the module cannot be removed until you are prepared to replace it with a new module.
See Section 5.14 for detailed instructions.

The typical life expectancy of an ISE sensor is three to six months, depending on use.

Precautions

- ISEs are intended for sampling purposes and **must** be calibrated frequently due to sensor drift.
- ISEs can be used in long-term deployments for qualitative trends. Use with an EXO wiper will deform the brush over time and may require more frequent brush replacement. The brush deformation may intensify with the fouling present in the monitored environment.
- ISE sensors only come in guarded configurations. Customers should not remove the plastic guard that protects the ISE membrane.
- For long-term deployments, sensor data should be compared to that of grab samples throughout the monitoring period to note drift.

For a full list of precautions see the end of Section 4.17.

4.17 ISEs: Ammonium, Nitrate, & Chloride
Calibration

This procedure calibrates the EXO ammonium, chloride, or nitrate sensor. The sensors can be calibrated to one, two or three points. The 3-point calibration method assures maximum accuracy when the temperature of the media to be monitored cannot be anticipated; we strongly recommend a 3-point calibration for best performance of ISE sensors. Review the basic calibration description in Section 4.2.

The temperature response of ion-selective electrodes is not as predictable as that of pH sensors. Therefore, be sure to carry out a 3-point calibration the first time you use the sensor. This will provide a default setting for the effect of temperature on your sensor. After this initial calibration, you can use the less time-consuming 2-point and 1-point routines to update the 3-point calibration. However, we strongly recommend a new 3-point calibration after each deployment of 30 days or longer.

Due to the nature of ion-selective electrodes, it is recommended that they be used for sampling purposes for the greatest accuracy. Using an ISE in long-term deployments is possible, but it's important to note that drift occurs over an extended period of time. Collecting grab samples from the site is encouraged to correct for drift. Additionally, sample readings should be taken after sensors have fully stabilized. Calibrating in a continuously stirred solution from 1 to 5 minutes has shown to improve sensor performance. For best performance sensors should be calibrated as close to the expected field conditions as possible.

For more ISE precautions, drift, and accuracy notes please see ISE Precautions at the end of this section.

Calibration Options (Ammonium Example)

1-point

Perform the 1-point option only if you are adjusting a previous calibration. If a 2-point or 3-point calibration has been performed previously, you can adjust the calibration by carrying out a 1-point calibration.

2-point

Perform the 2-point option to calibrate the ammonium sensor using only two calibration standard solutions. In this procedure, the ammonium sensor is calibrated using a 1 mg/L NH_4^+ -N and 100 mg/L NH_4^+ -N calibration standard solutions. A 2-point calibration procedure (as opposed to a 3-point procedure) can save time if the temperature range of the media being monitored is known and stable.

3-point

Perform the 3-point option to calibrate the ammonium sensor using three calibration standard solutions, two at ambient temperature and one at a temperature substantially different from ambient. The 3-point calibration method should be used to assure maximum accuracy when the temperature of the media to be monitored cannot be anticipated. 3-point calibration temperatures should span the range of interest, for example 20°C and 2°C for "cold" and 20°C and 30°C for "hot". The procedure for this calibration is the same as for a 2-point calibration, but the software will prompt you to place the sensor in the additional calibration standard solution to complete the 3-point procedure. Be certain that the calibration standard solution and sensor are thermally equilibrated prior to proceeding with the calibration. The recommended order of calibration standards is (1) 1 mg/L NH_4^+ -N standard at ambient temperature, (2) 100 mg/L NH_4^+ -N standard at ambient temperature, and (3) 1 mg/L NH_4^+ -N standard at a different temperature (usually lower) than ambient, ±10°C minimum.

- To save time during calibration, chill/heat a sufficient amount of 1 mg/L NH_4^+ -N calibration standard solution prior to the start of calibration.

Ammonium Pre-calibration

Soaking

EXO Ammonium Sensors are shipped in a container that holds a sponge soaked in 100 mg/L ammonium standard solution. Before initial use the sensor membrane needs to be soaked in 100 mg/L ammonium standard solution (YSI part #003843). Most users find it useful to soak the sensors overnight; shorter soaking times may be used if the sensor output is monitored and is fully stabilized.

In addition to initially soaking the sensor, users may also see improved performance if the ammonium sensor is soaked in 100 mg/L solution after field deployments. This process helps remove any interfering ions from the sensor membrane.

After the activation process the sensor should be rinsed thoroughly and the following calibration precautions should be observed.

The ammonium sensor should be calibrated using solutions of known total ammonium-nitrogen content or YSI Standards.

part #003841	1 mg/L
part #003842	10 mg/L
part #003843	100 mg/L

If a two point calibration protocol is used, the temperature of the standards should be as close as possible to that of the environmental medium to be monitored. The recommended calibration procedure is one involving three solutions. Two of the solutions should be at ambient temperature while the third should be at least 10˚C different from ambient temperature. This protocol minimizes the effects of taking readings at temperatures that are significantly different from ambient laboratory temperatures.

Calibration Tip

Exposure to the high ionic content of pH buffers can cause a significant, but temporary, drift in the Ammonium, Nitrate, and Chloride sensors. Therefore, when calibrating the pH/ORP probe, YSI recommends that you use one of the following methods to minimize errors in the subsequent readings:

1. Calibrate pH first, immersing all of the probes in the pH buffers. After calibrating pH, place the probes in 100 mg/L nitrate or ammonium standard or 1000 mg/L chloride standard and monitor the reading. Usually, the reading starts low and may take as long as 30 minutes to reach a stable value. When it does, proceed with calibration of the ISE sensor.

2. When calibrating pH, remove ISE modules from the sonde bulkhead and plug the ports. After pH calibration is complete, replace the ISE sensors and proceed with their calibration with no stabilization delay.

Despite the potential problems with interference when using ISEs, it is important to remember that almost all interfering species produce an artificially high ammonium reading. Thus, if the sonde indicates the presence of only small quantities of ammonium, it is unlikely that the reading is erroneously low because of interference. Unusually high ammonium readings (which could be due to interfering ions) should be confirmed by laboratory analysis after collection of water samples.

Ammonium 3-point

NOTICE: Do not expose electrodes to high-conductivity solutions. Exposure will reduce data quality and response of the sensors. During calibration of other sensors, remove the ISEs to avoid exposing them to conductivity standards, Zobell solution, pH buffer, or any solution with significant conductivity.

In the Calibrate menu, select Ammonium, then select Calibrate.

Pour a sufficient amount of 1 mg/L NH_4^+ -N calibration standard solution at ambient temperature in a clean and dry or pre-rinsed calibration cup. Carefully immerse the sensor end of the sonde into the solution, making sure the sensor's tip is in solution by at least 1 cm. Allow at least 1 minute for temperature equilibration before proceeding.

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point.

Rinse the sensors in deionized water between changes of the calibration solutions. Pour a sufficient amount of 100 mg/L of NH_4^+ -N calibration standard solution at ambient temperature into a clean, dry or pre-rinsed calibration cup and carefully immerse the sensor end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Click Add Another Cal Point in the software. Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point.

Rinse the sensors in deionized water between changes of the calibration solutions. Immerse the sensor end of the sonde in the pre-chilled 1 mg/L NH_4^+ -N calibration standard solution ensuring that the temperature is at least 10°C different than ambient. Allow at least 1 minute for temperature equilibration before proceeding.

Click Add Another Cal Point in the software. Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu

Rinse the sonde in tap or purified water.

Nitrate 3-point

The calibration procedure for nitrate is identical to the procedure for ammonium, except that the calibration standard solution values are in mg/L NO_3^- -N instead of NH4+ -N.

Chloride 3-point

The calibration procedure for chloride is identical to the procedure for ammonium and nitrate, except that the calibration standard solution values are in mg/L Cl^- instead of NH_4^+ -N or NO_3^- -N. YSI recommends that the user employ standards for chloride that are 10 times greater than for ammonium and nitrate and that span the expected deployment conditions. Typical calibration ranges are 10mg/L Cl^- and 1000mg/L Cl^- or 1000mg/L Cl^- and 18000mg/L Cl^-.

Chloride Standard for Chloride Sensor

⚠ **WARNING:** Read and follow all the safety instructions and MSDS documentation supplied with the chemical before proceeding. Remember that only trained personnel should handle hazardous chemicals.

Preparation

Use the following procedure to prepare 10 and 1000 mg/L chloride reagents for the EXO Chloride sensor. (Nitrate and Ammonium standards can be purchased from YSI or other laboratory supply companies.)

10 mg/L Standard

1. Accurately measure 10 mL of the above 1000 mg/L standard solution into a 1000 mL volumetric flask.
2. Add 0.5 grams of anhydrous magnesium sulfate to the flask.
3. Add 500 mL of water, swirl to dissolve the solid reagents, and then dilute to the volumetric mark with water. Mix well by repeated inversion and then transfer the 10 mg/L standard to a storage bottle.
4. Rinse the flask extensively with water prior to its use in the preparation of the 1000 mg/L standard.

1000 mg/L Standard

1. Purchase solid sodium chloride from a supplier.
2. Accurately weigh 1.655 grams of anhydrous sodium chloride and transfer into a 1000 mL volumetric flask.
3. Add 0.5 grams of anhydrous magnesium sulfate to the flask.
4. Add 500 mL of water to the flask, swirl to dissolve all of the reagents. Dilute to the volumetric mark with water. Mix well by repeated inversion and then transfer the 1000 mg/L standard to a storage bottle.

   Alternatively, simply add 0.5 grams of magnesium sulfate to a liter of a 1000 mg/L chloride standard from a certified supplier.

Sensor Drift

The ion-selective electrodes have the greatest tendency to exhibit calibration drift over time. This drift should not be a major issue for sampling studies where the instrument can be frequently calibrated. However, if the sensor is used in longer-term deployments, drift is almost certain to occur. The extent of the drift will vary depending on the age of the probe, the flow rate at the site, and the quality of the water. For all monitoring studies using ion-selective electrodes, the user should acquire a few grab samples during the deployment for analysis in the laboratory or with another sensor that has been recently calibrated.

Sensor Accuracy Specifications

The typical accuracy specification for the sensors (+/-10% of reading or 2 mg/L which ever is greater for ammonium and nitrate and ±15% of reading or 5 mg/L which ever is greater for chloride) refer to sampling applications where only minimal time has elapsed between calibration and field use.

To maintain accuracy specifications for EXO sensor, we recommend that users calibrate sensors in the lab in standards with temperatures as close to the ambient temperature of the field water as possible.

All ion-selective electrodes are subject to the interaction of species with the sensor membrane, which are similar in nature to the analyte. These interfering species thus include other halide ions (fluoride, bromide, and iodide) as well as other anions.

Despite the potential problems with interference when using ISEs, it is important to remember that almost all interfering species produce an artificially high reading. Thus, if the sensor indicates the presence of only small quantities, it is unlikely that the reading is erroneously low because of interference. Unusually high readings (which could be due to interfering ions) should be confirmed by laboratory analysis after collection of water samples.

ISE Precautions

Ion-selective electrodes may not stabilize as rapidly as pH sensors. Be sure to allow plenty of time for the readings to come to their final values during all calibration routines.

Ion-selective electrodes generally drift more than pH sensors. To check for this drift, read the sensor's value in a calibration standard solution at the end of each deployment.

Ammonium and nitrate standards are good growth media for a variety of microorganisms. This growth can significantly reduce the nitrogen content of your standards, an effect that is particularly important for the 1 mg/L solution. It is best to use new standards for each calibration, but if you decide to save your solutions for reuse, we recommend refrigerated storage to minimize the growth of these organisms.

Remember that the ammonium, nitrate, and chloride sensors will take longer to stabilize after exposure to high conductivity solutions such as a pH buffer. To accelerate the recovery process, soak the sensor in 100 mg/L ammonium or nitrate standard solution or 1000 mg/L Cl- standard solution for a few minutes after exposure. In addition, be particularly careful that readings are stable during subsequent calibrations.

Of all the sensors available on the sonde, ion selective electrodes have the greatest tendency to exhibit calibration drift over time. This drift should not be a major problem for sampling studies where the instrument can be frequently calibrated. However, if an ammonium sensor is used in a longer-term deployment study with the sonde, the user should be aware that drift is almost certain to occur. The extent of the drift will vary depending on the age of the probe, the flow rate at the site, and the quality of the water. For all monitoring studies using ion selective electrodes, the user should acquire a few "grab samples" during the course of the deployment for analysis in the laboratory by chemical means or with another ammonium sensor which has been recently calibrated. Remember that the typical accuracy specification for the sensor (+/- 10 % of the reading or 2 mg/L, whichever is larger) refers to sampling applications where only minimal time has elapsed between calibration and field use.

Many users find it useful to swap ISEs after 30 days of deployment with freshly calibrated sensors. On the EXO platform the calibration is retained inside the sensor, so they can be calibrated in the lab and installed in the field.

SmartQC for ISE Sensors

ISE sensor algorithms are derived from three independent coefficients (called J, S, and A) as well as mV, temperature and salinity. J, S, and A are the calibrated coefficients and S specifically is concentration of the analyte being detected by the sensor. S is the coefficient whose gain factor is the basis of SmartQC for these sensors.

Green: Gain and offset are within acceptable limits. Calibration was performed successfully and results are within factory specified limits.

Yellow: The S gain is slightly outside of calibration limits.

1. Perform a Factory Reset Calibration and re-do the calibration.
2. If the sensor had not been properly stored it may be necessary to rehydrate the reference junction, as described in Section 5.13.
3. Pre-calibration soaking is advisable for ISEs, especially if a non-green SmartQC score occurs. Pre-soak in the appropriate calibration solution and attempt again to recalibrate.
4. During calibration, ensure that the standard solutions were thermally equilibrated, meaning that the temperature was stable and not changing during calibration. Sometimes putting the solutions in a water bath can help ensure this.
5. Ensure that the standard value was entered correctly.
6. It is imperative that the sensors, calibration cup, and sonde guard are all very clean when calibrating.
7. Since these modules have a relatively short lifespan, a prior user may have entered an expiration date into the software for when the sensor should be replaced. Check to see if that date is near.
8. Ensure that the sensor is free of debris. Refer to Section 5.13 for additional information on how to properly clean the sensor in order to avoid damage.

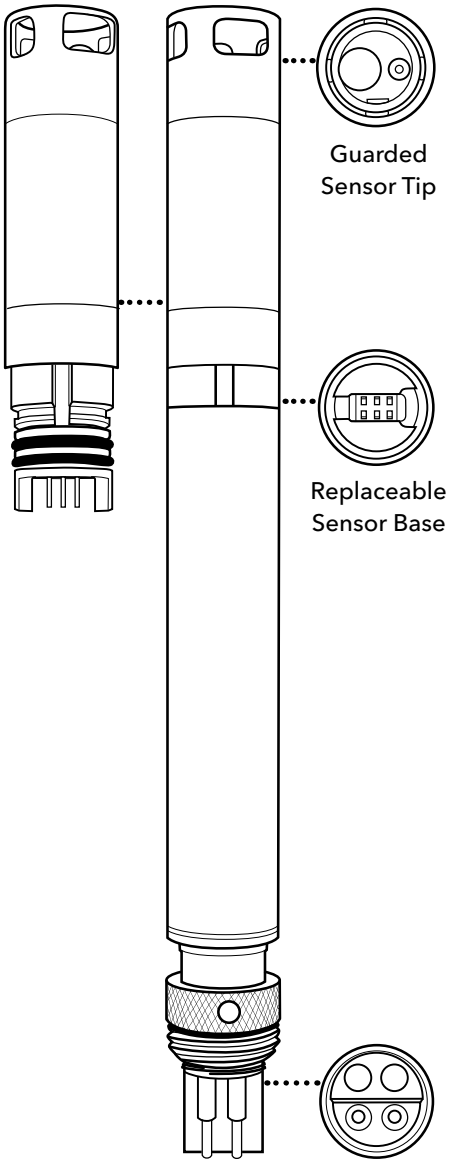
If the QC Score remains yellow, the sensor is still able to be used, but ISE's are the one case where a yellow-scored sensor should not be used for a continuous deployment, because the period of time before it would become red is probably short. It can be used for spot sampling, and should be recalibrated before each day's use.

Red: The S gain is significantly outside of factory specified limits. Follow the same steps described above for a Yellow QC Score. If the QC Score remains red, it is likely time to replace the sensor module. If replacement of the module does not return the sensor to a Green QC score, please contact YSI Technical Support for further assistance.

4.18 pH and ORP
Sensor Overview

Users can choose between a pH sensor or a combination pH/ORP sensor to measure these parameters. pH describes the acid and base characteristics of water. A pH of 7.0 is neutral; values below 7 are acidic; values above 7 are alkaline. ORP designates the oxidizing-reducing potential of a water sample and is useful for water which contains a high concentration of redox-active species, such as the salts of many metals and strong oxidizing (chlorine) and reducing (sulfite ion) agents. However, ORP is a non-specific measurement—the measured potential is reflective of a combination of the effects of all the dissolved species in the medium. Users should be careful not to overinterpret ORP data unless specific information about the site is known.

(continued)



599701, 599702, 599705, 599706;
599795-01, 599795-02, 599797-01,
599797-02 modules

Specifications

pH

Units	pH units
Temperature *Operating* *Storage*	 -5 to +50°C 0 to 60°C
Range	0 to 14 units
Accuracy	±0.1 pH units within ±10°C of calibration temperature; ±0.2 pH units for entire temp range
Response	T63<3 sec
Resolution	0.01 units
Sensor Type	Glass combination electrode

ORP

Units	millivolts
Temperature *Operating* *Storage*	 -5 to +50°C 0 to 60°C
Range	-999 to +999 mV
Accuracy	±20 mV in Redox standard solution
Response	T63<5 sec
Resolution	0.1 mV
Sensor Type	Platinum button

Replaceable Sensor Module

The EXO pH and pH/ORP sensors have a unique design that incorporates a user-replaceable sensor tip (module) and a reusable sensor base that houses the processing electronics, memory, and wet-mate connector. This allows users to reduce the costs associated with pH and pH/ORP sensors by only replacing the relatively inexpensive module periodically and not the more costly base.

The connection of the module to the sensor base is designed for one connection only and the procedure must be conducted in an indoor and dry environment. Once installed the module cannot be removed until you are prepared to replace it with a new module. See Section 5.14 for detailed instructions.

Users must order either a pH or pH/ORP sensor. Once ordered the sensor is *only* compatible with like-model sensor modules. For example, if a pH sensor is purchased initially, then the user must order a replaceable pH sensor module in the future; it cannot be replaced with a pH/ORP module.

Electrodes

EXO measures pH with two electrodes combined in the same probe: one for hydrogen ions and one as a reference. The sensor is a glass bulb filled with a solution of stable pH (usually 7) and the inside of the glass surface experiences constant binding of H^+ ions. The outside of the bulb is exposed to the sample, where the concentration of hydrogen ions varies. The resulting differential creates a potential read by the meter versus the stable potential of the reference.

The ORP of the media is measured by the difference in potential between an electrode which is relatively chemically inert and a reference electrode. The ORP sensor consists of a platinum button found on the tip of the probe. The potential associated with this metal is read versus the Ag/AgCl reference electrode of the combination sensor that utilizes gelled electrolyte. ORP values are presented in millivolts and are not compensated for temperature.

Signal Quality

Signal conditioning electronics within the pH sensor module improve response, increase stability, and reduce proximal interference during calibration. Amplification (buffering) in the sensor head is used to eliminate any issue of humidity in the front-end circuitry and reduce noise.

4.19 pH Calibration

1-point

Select the 1-point option to calibrate the pH probe using one calibration standard.

> **NOTE:** *While a 1-point pH calibration is possible, YSI recommends using a 2 or 3-point calibration for greater accuracy.*

2-point

Select the 2-point option to calibrate the pH probe using two calibration standards. In this procedure, the pH sensor is calibrated with a pH 7 buffer and a pH 10 or pH 4 buffer depending upon your environmental water. A 2-point calibration can save time (versus a 3-point calibration) if the pH of the media to be monitored is known to be either basic or acidic.

3-point

Select the 3-point option to calibrate the pH probe using three calibration standards. In this procedure, the pH sensor is calibrated with a pH 7 buffer and both the pH 10 and the pH 4. The 3-point calibration method assures maximum accuracy when the pH of the media to be monitored cannot be anticipated.

Review the basic calibration description in Section 4.2.

Pour the correct amount of pH buffer in a clean and dry or pre-rinsed calibration cup. Carefully immerse the probe end of the sonde into the solution, making sure the sensor's glass bulb is in solution by at least 1 cm. Allow at least 1 minute for temperature equilibration before proceeding.

In the Calibrate menu, select pH or pH/ORP, then select Calibrate.

> **NOTE:** *Observe the temperature reading above the standard value*. The actual pH value of all buffers varies with temperature. Enter the correct value from the bottle label for your calibration temperature for maximum accuracy. For example, the pH of one manufacturer's pH 7 Buffer is 7.00 at 25˚C, but 7.02 at 20˚C.
> If no temperature sensor is installed, user can manually update temperature by entering a value.

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point. Click Add Another Cal Point in the software.

Rinse the sensor in deionized water. Pour the correct amount of the next pH buffer standard into a clean, dry or pre-rinsed calibration cup, and carefully immerse the probe end of the sonde into the solution. Allow at least 1 minute for temperature equilibration before proceeding.

Repeat the calibration procedure and click Apply when the data are stable. Rinse the sensor and pour the next pH buffer, if necessary. Repeat calibration procedure for the third point and click Apply when data are stable.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu, and then the back arrows to return to main Calibrate menu.

Rinse the sonde and sensors in tap or purified water and dry.

SmartQC for pH Sensors

The SmartQC Score for pH is based on both a gain and an offset. The offset calculation is based on the millivolts recorded during sensor calibration.

Green: Gain and offset are within acceptable limits. Calibration was performed successfully and results are within factory specified limits.

Yellow: Either the gain or the offset is slightly outside of factory specified limits.

1. Ensure that all debris is removed from the surfaces of the sensor. Refer to Section 5.12 for information on proper sensor cleaning in order to avoid damaging the sensor.
2. Verify that there are no cracks or visual damage to the glass bulb.
3. A yellow score can result from a contaminated standard; ensure that all buffers are clear (not cloudy) and free of debris, and that the calibration cup was clean.
4. A Factory Reset Calibration should be performed.
5. The electrolyte solution inside the sensor may be partially depleted which causes the millivolt values to drift over the range of calibration. This is not a user-addressable problem, but to prevent it make sure that sensor modules are stored in the same bottle of solution that was shipped with the new modules. Avoid storage of sensor modules in distilled or deionized water.
6. If the sensor is new, make sure that there are no air bubbles in the pH bulb. Sensors actually do have air in the reference solution, but if the sensor is in the upright position, as it should be during calibration, an air bubble should not be in the bulb. If air bubbles are found, shake the sensor gently to encourage electrolyte solution to flow into the bulb and the air to rise to the top (where it will not be visible).
7. Check the delta slope and mV per decade to ensure that the sensor is fine (see "Additional Information" below).

If the QC Score returns to yellow, the sensor (or module) is still able to be used but one should be cautious if a long-term deployment is planned. With a yellow QC score it is more acceptable to use the sensor for discrete sampling because the mV value can be easily monitored under those conditions. In either case, the user should monitor this sensor during calibrations and periodic calibration checks for any further drift. Finally, the sensor could be reconditioned using HCl and a bleach solution (Section 5.12), but persistent yellow QC Scores are a sign that the time to replace the sensor module may be approaching.

Red: The gain or offset is significantly outside of factory specified limits. Follow the same 6 steps described above for a Yellow QC score. If the score remains red then replace the sensor module with a new module, perform a Factory Reset Calibration, and calibrate the new module with fresh buffers.

If the QC Score remains red after the Factory Reset Calibration and recalibration, or after replacement of the module and performing a calibration, please contact YSI Technical Support for further assistance. Further if upon replacement with a new module the QC score is yellow, contact YSI Technical Support.

Additional QC Information for pH

The calibration worksheet provides information that can be useful for assessing performance of the pH modules with age. Two useful parameters shown there are the "delta slope" and the "mV per decade." In general the practice is to not use a pH module where the delta slope is ≥165 mV, and the mV per decade deviates by more than 5 units from an ideal of 59.16. However, these ranges assume a calibration was performed at or near to 25°C. For users who wish to better understand the underlying principles for these guidelines, and perhaps to establish their own acceptance criteria, read on.

The Nernst equation is a well-established relationship that governs pH:

$E = E_o + 2.3RT/\eta F * pH$
Where

E = millivolts output
E_o = a constant associated with the reference electrode
T = temperature of measurement in Kelvin
R = the universal gas constant
ηF = the Faraday constant

In simplified y = mx + b form, the relationship is (mV output) = (slope) x (pH) + (intercept). Using this form note that the term 2.3RT/ηF is the slope, and it is sometimes called the Nernst potential.

The absolute value of the Nernst potential, at 298 K (25°C), is 59.16 mV/pH unit. At standard temperature, then, when one would change the pH from 7 to 8, the mV change is expected to be -59.16. Extrapolating further, from pH 7 to pH 10, the mV change would be

3 * -59.16 = -177.3 mV/pH unit.

Similarly, from pH 7 to pH 4 the change would be +177.3 mV/pH unit.

Returning to the Nernst equation, note that these slopes are temperature-dependent. During calibration the mV values for two standard buffer solutions are experimentally established and used by the sonde's software to calculate the slope and intercept of the plot of mV vs. pH. Once this calibration has been performed, the mV output of the probe in any sample can be converted by the sonde into a pH value, *as long as the calibration and the reading are carried out at the same temperature*.

In reality the temperature is almost never the same in environmental monitoring as it is during calibration. Thus a mechanism must be in place to compensate for temperature, effectively converting the slope and intercept of the plot of pH vs. mV established at the temperature of calibration into a slope and intercept at the temperature of measurement.

This mechanism is already provided by the Nernst equation. The slope of the plot of pH vs. mV is *directly proportional* to the absolute temperature in degrees Kelvin. Thus, if the slope of the plot is experimentally determined to be 59 mV/pH unit at 298 K (25°C), then the slope of the plot at 313 K (40°C) must be (313/298) * 59, or 62 mV/pH unit. At 283 K (10°C), the slope is calculated to be (238/298) * 59, which is 56 mV/pH unit. Determination of the slope of pH vs. mV plots at temperatures different from the calibration temperature is thus straightforward.

How can one apply this information for QC?

First, use the temperature compensation to determine what the slope should be for the calibration that was just performed. A calibration performed at 23°C, for instance, should have a slope of (296/298)*59.16, or 58.76. The calibration worksheet shows "mV per decade" between calibration points, such as from 4 to 7 and 7 to 10.

It is not unusual for the mV per decade to deviate from the ideal predicted by the Nernst equation, but typically it should not deviate more than 4 to 5 mV per decade. In this example, if the mV per decade is 56.51, that would be acceptable to most users. If it were instead 53.43, that could be cause for concern.

Another valuable piece of information on the calibration worksheet is in the "Delta slope," which is the change in mV per decade across the range being measured. As stated above, in an ideal scenario at standard temperature, the "delta slope" going from pH 7 to pH 4 would be +177.3, and going from pH 7 to pH 10 it would be -177.3. If, as in our example here, the calibration was performed at 23°C, and therefore the a slope of 58.75 were calculated, then the delta slope from pH 7 to pH 4 would be 3 * 58.75 = 176.25, and the delta slope from pH 7 to pH 10 would be -176.25.

In general it is advisable that the delta slope should not deviate more than about 12-15 from the ideal. So a delta slope for pH 7 to pH 4 of 161 would be considered unacceptable to most users in the present example.

In practice, people don't usually do these calculations, but rather apply a rule of thumb that states, for a laboratory-based calibration where temperature is often near 25°C, the delta slope should always be ≥165.

With a better understanding of the Nernst equation, however, users can monitor the changes in the mV per decade and delta slope, and look for big changes from prior calibration worksheets. These changes, even when the SmartQC score is green, can be useful indicators of changes in the performance of the pH module with age.

4.20 ORP Calibration

Review the basic calibration description in Section 4.2.

Pour the correct amount of standard with a known oxidation reduction potential value (we recommend Zobell solution) in a clean and dry or pre-rinsed calibration cup. Carefully immerse the probe end of the sonde into the solution.

In the Calibrate menu, select pH/ORP, then select ORP to Calibrate.

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point.

> **NOTICE:** Do not leave sensors in Zobell solution for a long time. A chemical reaction occurs with the copper on the sonde (sonde bulkhead, central wiper assembly, copper tape). While the reaction does not impact calibration, it will degrade the sonde materials over time. Discard the used standard.

Click Complete. View the Calibration Summary screen and QC score. Click Exit to return to the sensor calibration menu.

Rinse the sonde in tap or purified water and dry the sonde.

Effect of temperature on ORP

The oxidation reduction potential value shows an inverse relationship with temperature. This effect must be accounted for when calibrating the EXO ORP sensor with an ORP standard. YSI recommends using Zobell solution for calibration, but other standards may be used. Refer to the table included with your ORP standard instrutions for the mV value that corresponds to the temperature of the standard.

SmartQC for ORP Sensors

The SmartQC Score for ORP is based on an offset from 0 mV.

Green: Offset is within acceptable limits. Calibration was performed successfully and results are within factory specified limits.

Yellow: The sensor offset is slightly outside of factory specified limits.

1. Perform a Factory Reset Calibration. Complete a recalibration using freshly-prepared Zobell solution. Incorrect mixing of the Zobell solution can cause errors in calibration.
2. The electrolyte solution in the sensor may be partially depleted causing shifts to the millivolt readings. This is not a user-addressable problem, but to prevent it make sure that sensor modules are stored in the same bottle of solution that was shipped with the new modules. Avoid storage of sensor modules in distilled or deionized water.
3. ORP calibration is temperature- dependent so make sure that the correct standard value was entered, using the instructions that came with the Zobell solution.
4. Ensure that the sensor is free of debris. Refer to Section 5.12 for information on proper sensor cleaning in order to avoid damaging the sensor.

If the QC Score returns to yellow, the sensor is still able to be used, but the user should monitor this sensor during calibrations for any further drift. Consideration should be made to eventually replacing the pH/ORP sensor module.

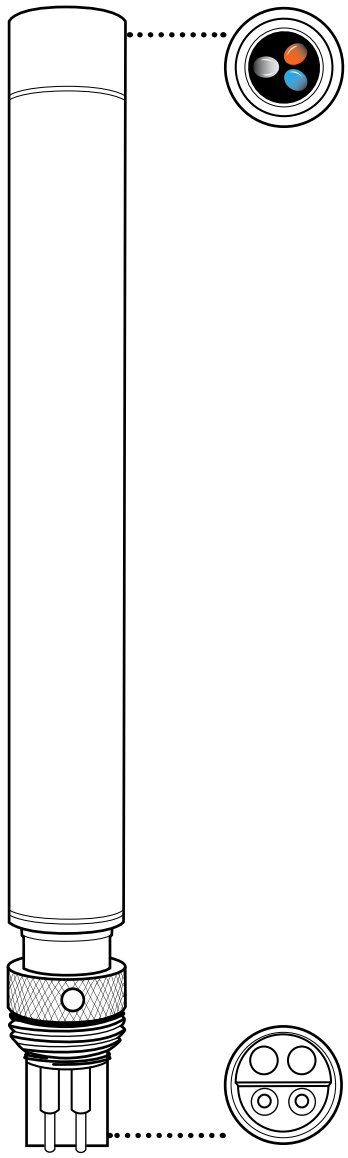
Red: The sensor offset is significantly outside of factory specified limits. Follow the same four steps described above for a Yellow QC Score.

If the QC Score remains red after the Factory Reset Calibration and recalibration, or after replacement of the module and performing a calibration, please contact YSI Technical Support for further assistance.

4.21 Total Algae
Sensor Overview

The Total Algae (TAL) sensors are dual-channel fluorescence sensors. The "channels" are for chlorophyll and phycocyanin (TAL-PC), or chlorophyll and phycoerythrin (TAL-PE), which are measured in the water. Each sensor thus yields two data sets: for TAL-PC, one results from a blue-emitting LED that excites the chlorophyll *a* (chl) molecule and the second results from an orange excitation beam that excites the phycocyanin (PC) accessory pigment. The TAL-PE sensor is similar, also having the chlorophyll channel, but rather than an orange-emitting LED there is a slightly blue-shifted beam that excites phycoerythrin (PE).

(continued)



599102-01 (TAL-PC)
599103-01 (TAL-PE)

Specifications

Units	
Chlorophyll	RFU, µg/L Chl
PC	RFU, µg/L PC
PE	RFU, µg/L PE
Temperature	
Operating	-5 to +50°C
Storage	-20 to +80°C
Range	*Chl:* 0-100 RFU, 0-400 µg/L Chl*; *PC:* 0-100 RFU, 0-100 µg/L*; *PE:* 0-100 RFU, 0-280 µg/L*
Response	T63<2 sec
Resolution	*Chl:* 0.01 RFU, 0.01 µg/L Chl; *PC:* 0.01 RFU, 0.01 µg/L; *PE:* 0.01 RFU, 0.01 µg/L
Sensor Type	Optical, fluorescence
Linearity	*Chl:* R^2>0.999 for serial dilution of Rhodamine WT solution from 0-400 µg/L Chl equivalents *PC:* R^2>0.999 for serial dilution of Rhodamine WT solution from 0-100 µg/L PC equivalents; *PE:* R^2>0.999 for serial dilution of Rhodamine WT solution from 0-280 µg/L PE equivalents
Optics: Chl Excitation	470±15 nm
PC Excitation	590±15 nm
PE Excitation	525±15 nm
Emission	685±20 nm

*Pigment concentration ranges of algae sensors were determined in monocultures of specific algae species. This range will vary depending on algae assemblage and environmental conditions. The best accuracy of pigment measurements can be obtained by user-built correlations between RFU and pigment concentrations measured by an independent method, and using samples from the site or sites of interest with representative algal populations.

Total Algae Sensor Units

The TAL sensors generate data in RFU or µg/L of pigment (chl, PC or PE) units, with RFU as the default. When using either RFU or µg/L, the sensor's response is highly linear: a reading of 50 of either unit represents twice as much fluorescence detected as a reading of 25, for example, if the temperature is constant.

However, users are advised to use default RFU, which stands for Relative Fluorescence Units. RFU is used to set sensor output relative to a stable secondary standard, rhodamine WT dye, which normalizes the sensor's output on a 0-100% scale. RFU calibration allows for the best comparisons of data from sensor to sensor, and also enables users to monitor for sensor drift and edaphic factors such as biofouling or declining sensor optical performance over time as the LEDs age. Another reason to use RFU is the excellent linearity once the channels are calibrated with Rhodamine WT, which translates to optimized accuracy of measurements.

The µg/L output generates an estimate of pigment concentration that is based upon correlations we built between sensor outputs and extracted pigments from laboratory-grown blue-green algae. Synonymous with parts per billion (ppb), µg/L is still in common use by regulatory agencies, but has the drawback that it is very dependent upon the composition of the algal population, the time of day, the physiological health of the algae, and a number of other environmental factors. So if two populations of algae yield a reading of 50 µg/L of chlorophyll, it does not mean that those populations are equivalent in the number of cells, for instance. Further, since algal populations can regulate their intracellular pigment concentrations, the µg/L of pigment per cell changes with season, time of day, and population dynamics. Thus the challenge with the µg/L unit is user expectations: it should not be expected that µg/L will necessarily correlate well with pigment extractions that customers perform themselves, and it should not be expected that a doubling of µg/L necessarily represents a doubling of the algal population.

RFU is likewise affected by these dynamics: a doubling of RFU does not necessarily mean there has been an exact doubling of an algal population. But it is generally more clear to users that an RFU is detecting a change in relative fluorescence signal, which can occur for a number of reasons in situ.

In any case, many users are required for regulatory compliance to deliver data in µg/L, and in waters where the algal populations are fairly predictable or stable from year to year, with respect to species compositions, good correlations can be built. So users are advised to assess whether the pigment concentration delivered by the sensor is reasonable and acceptable for the algal populations and environment with which they work.

That assessment should start with calibration of both RFU and µg/L channels with rhodamine WT, as described in the next section. Next, with samples collected from the site of interest, measure both RFU and µg/L with the sensor(s). Observing careful handling and preservation of the samples, as soon as possible extract the pigments from the samples, using standardized or preferred methods to determine pigment µg/L in each sample. The extraction data may be used to assess how RFU and µg/L delivered by the sensor compare with the extracted µg/L of pigment that would be predicted by the sensor. Ideally this would be done with a dilution series of the original sample or at the very least multiple samples. The user's requirements for how well µg/L delivered by the sonde must correlate with their own extraction data will determine whether the µg/L output should be used for reporting.

Measuring cells/mL with EXO TAL Sensors

Similar to µg/L, some users have a requirement to report cell/mL data for blue-green alga monitoring, even though in reality these measurements vary widely from algal population to algal population in situ. Within KorEXO 2.0 and later software versions, there is the capability to have the sonde deliver this unit for the PC and PE channels, based upon user-applied correlations.

When selecting the TAL sensor in the Calibration module of the software, there is a "TAL-PC Phycocyanin Settings" window (or TAL-PE if that is the sensor in use). There are two radio buttons that appear when that window is opened:

- Use legacy cells/mL relationship
- Build my own cells/mL relationship

The first option was designed for users that were accustomed to this unit in our legacy 6-Series sondes, and who want their EXO data to tightly match the cells/mL data generated by these older sondes. The algorithm applied to "match" these outputs across sonde platforms is proprietary, and it is highly advisable that when using this unit at some point users actually test the validity of the outputs for their applications. This can be done by collecting grab samples and comparing actual cells/mL using microscopy or plating as appropriate.

A better method would be to use the second option of building one's own cells/mL relationship. This makes a module appear wherein users can enter an RFU measurement alongside a corresponding cells/mL measurement that has been made for the exact same sample, using microscopy or whatever method the user prefers. The software will derive the relationship between the columns entered by the user and will apply that equation to all subsequent measurements to deliver the cells/mL unit in the sonde's output.

From time to time and place to place, the validity of this correlation can be tested, verified, or validated by collecting grab samples and comparing in vitro measurements of cells/mL with the in situ values delivered by the sonde.

In all cases, proper calibration of the sensor with Rhodamine WT is necessary for the most reliable outputs, and for comparison of data from sensor to sensor.

4.22 Total Algae
Calibration

For best performance assure that the sensor face is clean prior to calibration. We advise that new sensors should be calibrated before use, and calibration checks and the user's own tolerance of drift should be used to determine when recalibration is necessary.

Users will prepare their own calibration standards. Rhodamine WT is a secondary standard (the actual pigments would be primary standards). It is used because of its stability and affordability. The units that the sensor delivers are in either RFU (recommended) or µg/L pigment equivalent units. We strongly recommend using RFU, but in either case Table A below must be used to derive the calibration values that the user will enter during the process outlined below. Use of this table requires a temperature measurement, and the best way to do this is to have an EXO conductivity/temperature sensor on the sonde bulkhead during calibration. In general fluorescence is inversely related with temperature, and this effect will be accounted for to optimize the accuracy of your calibration by using Table A.

Table A. Temperature-compensated standard solution values for TAL sensors.

	Chlorophyll 0.625 mg/L Rhodamine		Phycocyanin 0.625 mg/L Rhodamine		Phycoerythrin 0.025 mg/L Rhodamine	
Solution Temperature (˚C)	Chl RFU	µg/L chlorophyll	PC RFU	µg/L phycocyanin	PE RFU	µg/L phycoerythrin
30	14.0	56.5	11.4	11.4	37.3	104.0
28	14.6	58.7	13.1	13.1	39.1	109.0
26	15.2	61.3	14.1	14.1	41.0	115.0
24	15.8	63.5	15.0	15.0	43.0	120.0
22	16.4	66	16.0	16.0	45.0	126.0
20	17.0	68.4	17.1	17.1	47.0	132.0
18	17.6	70.8	17.5	17.5	49.2	138.0
16	18.3	73.5	19.1	19.1	51.4	144.0
14	18.9	76	20.1	20.1	53.6	150.0
12	19.5	78.6	21.2	21.2	55.9	157.0
10	20.2	81.2	22.2	22.2	58.2	163.0
8	20.8	83.8	22.6	22.6	60.6	170.0

Steps 1-3 below describe a standard two point calibration performed with Kor EXO 2.0 software. Calibration can also be performed using the EXO Handheld, the main differences simply being the references to windows. In some cases users may prefer to perform a re-zeroing of the sensor, sometimes referred to as a "one point calibration," and that is described later in this section.

Step 1: Prepare Rhodamine WT Dye Solution

Purchase Rhodamine WT as a 2.5% solution to follow the procedure below. Note that there are many types of Rhodamine—make sure Rhodamine WT is selected. If a 2.5% solution cannot be obtained commercially, prepare it from a solid or liquid solution to a 2.5% final concentration, or adjust the dilutions below accordingly. Kingscote Chemicals (Miamisburg, OH, 1-800-394-0678) has historically had a 2.5% solution (item #106023) that works well with this procedure. It should be stored in the refrigerator when not in use.

1. **For any TAL sensor calibration, prepare a 125 mg/L solution of Rhodamine WT**. Transfer 5.0 mL of the 2.5% Rhodamine WT solution into a 1000 mL volumetric flask. Fill the flask to the volumetric mark with deionized or distilled water and mix well to produce a solution that is approximately 125 mg/L of Rhodamine WT. Transfer to a storage bottle and retain it for future use.

   *This solution can be stored in the refrigerator (4°C). Its degradation will depend upon light exposure and repeated warming cycles, but solutions used 1-2 times a year can be stored for up to two years. Users should implement their own procedures to safeguard against degradation.

2. **For calibration of any chlorophyll channel (on either the TAL-PC or the TAL-PE sensor) and the TAL-PC phycocyanin channel, prepare a 0.625 mg/L solution of Rhodamine WT.** Transfer 5.0 mL of the 125 mg/L solution prepared in step one into a 1000 mL volumetric flask. Fill the flask to the volumetric mark with deionized or distilled water. Mix well to obtain a solution that is 0.625 mg/L of Rhodamine WT. Use this solution within 24 hours of preparation and discard it after use.

3. **If using a TAL-PE sensor, additionally prepare a 0.025 mg/L solution of Rhodamine WT for calibration of the phycoerythrin channel.** Transfer 0.2 mL of the 125 mg/L solution prepared in step one into a 1000 mL volumetric flask. Fill the flask to the volumetric mark with deionized or distilled water. Mix well to obtain a solution that is 0.025 mg/L of Rhodamine WT. Use this solution within 24 hours of preparation and discard it after use.

Step 2: Select the pigment and channel to be calibrated.

In the Kor software or on the handheld, select the channel you want to calibrate (chl, PC, or PE) and the units you intend to use (RFU or µg/L).

Note that each channel of the sensor must be calibrated independently. Calibration of the chlorophyll channel does not set the calibration for the PC channel or the PE channel. Likewise, even just for the chlorophyll channel, calibration of RFU does not automatically calibrate the µg/L units. Calibration must be performed for each channel of interest, each unit of interest, and each calibration point (zero and the second point). It is thus possible that Step 3 below will be performed up to 8 times total, if one wants reading for all units from all channels. This is cut in half if only RFU are used, which is YSI's recommendation.

Step 3: Perform a two-point calibration.

Step 3a: Calibration at zero.

The zero point is always calibrated first. Place the sonde, loaded with a TAL and an EXO temperature sensor, into a clean calibration cup containing clean water. It is not required that this be deionized or even distilled water; it must be free of any particles that might fluoresce and interfere with the calibration process. Thus distilled water is typically what users prefer to have that assurance.

The software or handheld will show a graph while the sensor is stabilizing, and the temperature will also be shown. Temperature is not needed for the zero point; the user must enter a "Standard Value" of 0. When the Data Stability indicates "Stable", click to "Apply" the calibration. Next select "Add Another Cal Point" and proceed to Step 3b.

Step 3b: Calibration with Rhodamine WT

The same basic procedure will be followed, but using either Kor software or the EXO handheld will require that users enter the temperature-compensated standard value for the calibration solution. In all cases, the reading from the EXO temperature sensor is the most reliable to use, and the value for the standard can be derived from the Table A provided above.

As an example, assume that you will calibrate the chlorophyll RFU channel, and that the temperature measured in the 0.625 mg/L rhodamine WT solution is 22°C. This temperature will show up on the calibration screens using the KorEXO software, and can be seen on the handheld's dashboard screen as well. The first standard value entered during calibration will be 0, since that standard will be water (see Step 3 below). The second standard value will be 16.4, as derived from Table A using a temperature of 22°C. Alternatively, if you intend to use the µg/L unit, the second standard value would be 66 for this example. Using the same 0.625 mg/L rhodamine WT solution to calibrate the PC channel will yield a second standard value of 16.0 RFU or 16 µg/L. You will enter these values when you perform the calibration.

Upon entering the Table A-derived value, wait for the sensor to show "Stable" and then click on "Apply". Now choose "Complete Calibration" and then "Exit."

Note that throughout this process users had options to "Redo a cal point" or to "View Calibration Worksheet." So for any channel and a given unit of interest, a point can be redone at any time without having to exit out to the beginning of the process.

However, to now calibrate other units for either the same or different pigment channels, this process must be started again at Step 2.

Re-zeroing the TAL Sensor.

Oftentimes users will perform a "cal check" in water to assess if the sensor has drifted beyond an acceptable limit defined by that user. When drift has occurred ideally a two-point calibration should be performed. However, when there isn't an opportunity to prepare the rhodamine solutions and perform a two-point calibration, or if users are mainly interested in accuracy at the lower end of the sensor's range, they may choose to re-zero the sensor.

Historically referred to as a "single-point calibration," doing a calibration with water only resets the zero value, called here "re-zeroing" the sensor. The main advantage of doing this is speed, and users should be aware that re-zeroing the sensor does not reset the second point entered during the most recent two-point calibration. The consequence is that drift error will be alleviated at and near zero, but more error can accumulate in the measurement the farther away from zero the measured value is. The amount of that error can be different from sensor to sensor, and use case to use case. It is dependent upon how much that second point may drift, which is not always equivalent to how much the zero point drifts.

For many users, especially those with sites where pigment is rarely detected and values are at or near zero most of the time, the far-from-zero accumulation of error is a non-issue. For others, a single point calibration may not be acceptable. A single-point calibration is an option in the software and is performed exactly the same way as the two- point calibration, using water as the standard and waiting for the value to stabilize before applying it. Rather than adding a second calibration point, the user would exit after the water calibration.

SmartQC for TAL Sensors

The SmartQC Score for any TAL sensor is based on an offset from 0 RFU, and a gain factor. Each individual channel (Chl, PC, PE) has a unique offset and gain factor. It is possible to have a green SmartQC score for calibration of one channel, but a yellow or red SmartQC score for the second channel. In this case the TAL sensor Soft QC that is shown in Kor Software will appear as the worst QC score (yellow or red), and one must look at the individual channels to investigate where the issue is. Thus the steps outlined here are for each channel, and for each unit calibrated within that channel.

Green: Gain and offset are within acceptable limits. Calibration was performed successfully and results are within factory specified limits.

Yellow: The sensor gain or offset is slightly outside of calibration limits.

1. Perform a Factory Reset Calibration and complete a recalibration.
    a. If performing a 1-point calibration, use fresh, clear water.
    b. If performing a 2-point calibration, use fresh, clear water and freshly made Rhodamine WT solution.
2. Ensure that the standard value was entered correctly. Calibration of TAL channels is temperature-dependent; make sure the appropriate value from the table in Section 4.22 was entered during calibration for either RFU or µg/L.
3. Ensure that the sensor is free of debris. Refer to Section 5.6 for additional information on how to properly clean the sensor in order to avoid damage.

If the QC Score returns to yellow, the sensor is still able to be used, but the user should monitor this sensor during calibrations for any further drift.

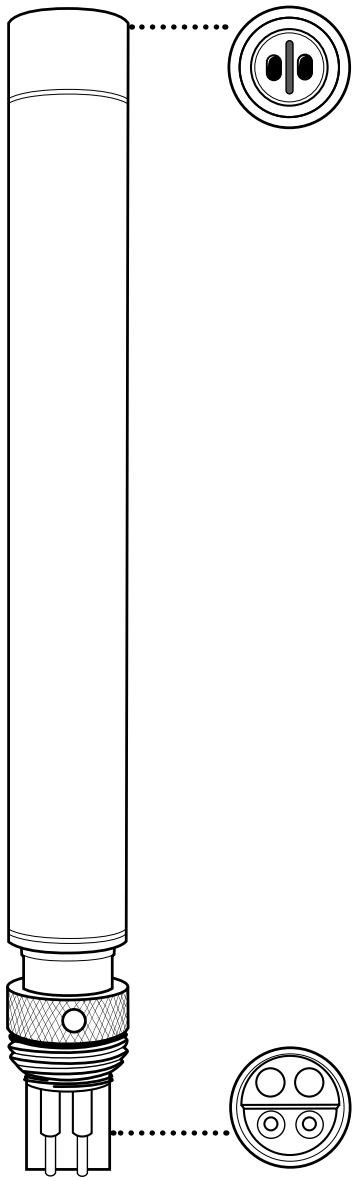
Red: The sensor gain or offset are significantly outside of factory specified limits. Follow the same three steps described above for a Yellow QC Score.

If the QC Score remains red, please contact YSI Technical Support for further assistance.

4.23 Turbidity
Sensor Overview

Turbidity is the indirect measurement of the suspended solid concentration in water and is typically determined by shining a light beam into the sample solution and then measuring the light that is scattered off of the suspended particles. Turbidity is an important water quality parameter and is a fundamental tool for monitoring environmental changes due to events like weather-induced runoff or illicit discharges. The source of the suspended solids varies (examples include silt, clay, sand, algae, and organic matter) but all particles will impact light transmittance and result in a turbidity signal.

(continued)



599101-01

Specifications

Default Units	FNU
Temperature *Operating* *Storage*	 -5 to +50°C -20 to +80°C
Range	0 to 4000 FNU
Accuracy	0-999 FNU: 0.3 FNU or ±2% of reading, whichever is greater; 1000-4000 FNU: ±5% of reading[2]
Response	T63<2 sec
Resolution	0-999 FNU: 0.01 FNU 1000-4000 FNU: 0.1 FNU
Sensor Type	Optical, 90° scatter
Optics: Excitation	 860±15 nm

1 *ASTM D7315-07a "Test Method for Determination of Turbidity Above 1 Turbidity Unit (TU) in Static Mode."*

2 *Performance based on 3-point calibration done with YSI AMCO-AEPA standards of 0, 124, and 1010 FNU. The same type of standard must be used for all calibration points.*

The EXO Turbidity sensor employs a near-infrared light source and has been characterized as a nephelometric near-IR, non-ratiometric sensor in accordance with ASTM Method D7315-07a.[1] This method calls for this sensor type to report values in formazin nephelometric units (FNU), which is the default calibration unit for the EXO sensor. Users are able to change calibration units to nephelometric turbidity units (NTU).

Turbidity is one of the most misunderstood measurements in environmental monitoring. In reality the turbidity sensor is not much different from other optical sensors: differences in outcomes with different standards, sensors and environments can be a result of differing optical components and geometries, and the impact of different environmental factors upon the measurement technologies themselves. Thus like many optical measurements, where a light beam is passing through a sample in an environment of changing temperature, etc., turbidity is best monitored with consistent use of standards, technology platforms, and practices to compare outcomes for scientific conclusions.

Among the many factors that can impact turbidity measurements, users should be aware of three over which they have some control. These are the use of recommended YSI standards, preventing fouling, and using sound and consistent calibration practices.

Turbidity Standards

Turbidity sensors of many types, from many manufacturers, are often calibrated with formazin. Considered the "gold standard" for turbidity calibration there is the perception that all turbidity sensors will read consistently in formazin. In practice this has led to the belief that two different sensors of different types (design or manufacturer, for instance), if calibrated in formazin, would yield the same FNU when used to measure a sample. When sensors are of the same fundamental design, using the same type of light source and with detection of scattering at the same angles of incident light, this is more likely to be true, especially if measuring an actual formazin solution. However, with field samples this rule does not always hold; different manufacturer's sensors calibrated with the same formazin solutions can yield slightly different readings from the same field samples. There can be a number of reasons for this, including how the raw data are post-processed.

Due to the challenges of preparation and disposal of formazin, polymer-based standards are now preferred as turbidity standards. As with formazin, it is the case that field readings will vary between different models of turbidity sensors even when they are calibrated with the same standards. This is true of the popular AMCO-AEPA standards upon which YSI's standards solutions are based, and which were used to determine the Specifications shown below.

Further, if YSI sensors are calibrated with the non-YSI standard AMCO-AEPA solutions, sensor specifications may differ from those shown in the Specification table, and thereby turbidity measurements may differ. For the best consistency, EXO users should use the YSI-labeled turbidity standards throughout the lifetime of their sensors, and use the FNU values on the labels of these standards during calibration.

While formazin can be used to calibrate YSI's EXO turbidity sensors, the specifications were determined with YSI-labeled AMCO-AEPA turbidity standards, and the factory-defined limits for the SmartQC tool were also determined with YSI standards.

Preventing Fouling

Turbidity measurements are vulnerable to both biofouling and non-biological fouling. This is because of the high sensitivity and resolution of measurements, which can be affected by any changes to the sensor face that light must pass through. Any obstruction of that light path will affect measurements, and even bubbles on the sensor's face can affect measurements. Low-range measurements (e.g. <100 FNU) are especially susceptible to these effects.

As such it is imperative in continuous monitoring applications that antifouling tools be employed. The central wiper on the EXO 2, 2^{S}, and 3 sondes is highly effective in combating fouling during continuous monitoring, and can be aided by strategies like C-spray and copper tape on the sensors. Even during spot-sampling applications such as with EXO 1 it is very important that users pay attention to the sensor faces so that they are not trapping bubbles during measurements.

Calibration Practices

The following section describes in detail how to calibrate EXO turbidity sensors. Before calibrating, be certain that the probe is very clean and free of debris. Solid particles, particularly those carried over from past deployments, will contaminate the standards and can cause either calibration errors and thereby errors in measurement.

The cleaning instructions in Section 5.6 should be helpful for preventing contamination, but another recommendation we make is to have a sonde guard and a calibration cup devoted solely to turbidity calibration.

Finally, never calibrate turbidity *without* the sonde guard. If one is using the copper antifouling guard for a deployment, then that is the guard that should be used during turbidity calibration (don't use the standard black guard).

4.24 Turbidity
Calibration

Tools and Practices

YSI Turbidity standards that are based upon AMCO-AEPA polymer are the basis of SmartQC and EXO turbidity sensor specifications, and therefore should be used for turbidity sensor calibration. Gallon bottles are available as follows:

Item No.	Description
608000	0 FNU
607200	12.4 FNU
607300	124 FNU
607400	1010 FNU

Standards should be selected based upon the range in which one is expected to work. For low-turbidity waters, one might use 0 and 12.4 for a two-point calibration. If turbidities might exceed the lower ranges 0 and 124 should be used for a two-point calibration (not 0 and 1010 for reasons described below), and 0, 124 and 1010 for a three-point calibration. There is not a calibration standard beyond 1010 FNU at this time.

The FNU of each bottle can change with production batches, and as such the label of the bottle should always be checked for the FNU that should be entered into the software or handheld during calibration.

In some cases it may be acceptable to use deionized or distilled water rather than YSI's 0 FNU standard. Beware, however, that distilled water from some sources has been shown to not be 0 FNU. Calibration with a non-zero standard can cause negative readings when the sensor is used in waters that actually are clear. Non-zero readings also can occur if the calibration equipment (e.g. sonde guard, calibration cup) is not sufficiently clean.

Some users will have a preference, if not a requirement, for use of formazin standards. Examples may be formazin prepared according to *Standard Methods for the Treatment of Water and Wastewater* (Section 2130 B), or Hach StablCal™ of various NTUs. These standards are acceptable for a two-point calibration. However, users who anticipate working in higher turbidities and who choose to use a formazin standard for the third point may see yellow SmartQC scores during that calibration. The sensor can still be used, but since the algorithms for calibration were developed with YSI's polymer beads there may be less perfect alignment of the gain factors when using formazin.

Note also that if doing a three-point calibration, one should not use formazin for the second point, and polymer for the third point. Rather, one should only use the polymer for all points of a three point calibration (or water for 0 FNU and polymer for the second and third points), or formazin for all three points.

In all cases, due to the non-linear response of turbidity sensors and YSI's proprietary algorithms for post-processing of the data, the points of a two or three point calibration must be within the limits outlined here:

First Point	> 0 and ≤1 FNU
Second Point	>5 and ≤200 FNU
Third Point	>400 and ≤4200 FNU

The second calibration point, whether one is using formazin or YSI's polymer, should not be out of the 5-200 FNU range. If one tries to use a standard that is in the 400-4200 FNU range for the second calibration point, accuracy cannot be assured and often a yellow QC score will result.

Performing a 2-point calibration

Pour the 0 FNU standard (or deionized or distilled water) into the clean calibration cup and immerse the probe end of the sonde into the standard. The sonde should have the sonde guard on, and if one will deploy with the copper antifouling guard that is likewise the guard that should be used during calibration. Pay careful attention while submersing the sensors to not trap bubbles on the face of the turbidity sensor(s).

In either KorEXO Software or the handheld's Calibration menu, select Turbidity to calibrate.

Enter 0.0 (or some offset value between 0.0 and 1.0) as the first calibration value. While the sensor is still stabilizing one may wipe the sensors (using the button in the software or menu option on the handheld) to remove any bubbles. When the data are Stable, select the option to "Apply calibration" for this point.

It is advised at this point that the sensors, sonde guard, and calibration cup be rinsed with a small amount of the standard that will be used for the second calibration point. Discard this rinse, adn then fill the cup with the second calibration standard. Click Add Another Cal Point in the software.

Place the sensors into the second calibration standard, adn follow the same steps to wipe and obtain a stable reading. Use the value on the label of the YSI standard bottle for the FNU of the second calibration point.

When the data are Stable, select the option to "Apply calibration" for this point. Select the option to complete the calibration and observe the SmartQC score in the calibration worksheet. In KorEXO Software, color indicators will also make the QC score apparent.

Rinse the sonde with water and discard all used turbidity standards.

Performing a 3-point calibration

The steps for a three-point calibration are the same as describe above, but note that:

- The first point must always be 0 FNU, followed by the second standard (5-200 FNU) and then third (400-4200 FNU).
- Always use the same type of standard for the two non-zero points. Both must be YSI polymer, or both must be formazin.
- It is critically important, between the second and third calibration points, to rinse the sensors, sonde guard, and calibration cup with water, blot them dry with a lint-free material, and then do a rinse (at least once) with the standard for the third calibration point.

SmartQC for Turbidity Sensors

The turbidity response is nonlinear across the sensor's range, and a proprietary algorithm that employs up to five terms is used during calibration and for generation of the SmartQC score. Three of those terms are the actual calibration points, and those calibration points must read within an absolute range set within the sensor (this is slightly different than the concept of an offset that is used for SmartQC on most sensors). Two of the terms are calculated from the ratios of the calibration points, and likewise must be within an absolute range set within the sensor. The result is that the SmartQC calculation for turbidity is slightly different depending upon whether one does a 1, 2, or 3 point calibration. Since each individual term used by the algorithm must fall within an absolute range SmartQC is most reliable when the YSI standards, upon which these algorithms were built, are used.

Green: A Green SmartQC score means that the point for a single-point calibration is within the specified range. For a two-point calibration a Green SmartQC score means that both calibration points, as well as the slope between them, is within the specified range for each term. For a three-point calibration a Green SmartQC score means that all three calibration points, as well as the slope between the first two points and the slope between the second two points, are within the specified ranges for each term.

Yellow: A Yellow SmartQC score can result if any one of the five terms of interest is outside of the factory-specified range. In the case of a Yellow SmartQC score check the following:

1. Perform a Factory Reset Calibration and re-do the calibration.
2. If a two-point calibration was performed, make sure that the second point is between 5-200 FNU. If the second point was the 1010 FNU standard rather than the 124 FNU standard, for instance, a Yellow QC score might result.
3. If a three point calibration was performed with formazin, make sure that each calibration point was within the specified ranges of 0-1 FNU, 5-200 FNU, and 400-4200 FNU.
4. If a three point calibration was performed with YSI's polymer standards, make sure the correct values from the bottles were entered during calibration. For example, make sure the EXO values, and not the 6-Series values, were entered from the label
5. Make sure you are using YSI's polymer standards. Difficulties in calibration may occur if AMCO-AEPA standards that were not produced for YSI instruments are used. These will not have a YSI label on them.
6. It is imperative that the sensors, calibration cup, and sonde guard are all very clean when calibrating turbidity.
7. Customers who use the 12.4 NTU standard to calibrate will often see a yellow QC score, even with a perfect calibration.

Red: Any of the five terms of interest may be outside of the factory-set specifications. Follow the same steps described above for a Yellow QC Score. If the QC Score remains red, please contact YSI Technical Support for further assistance.

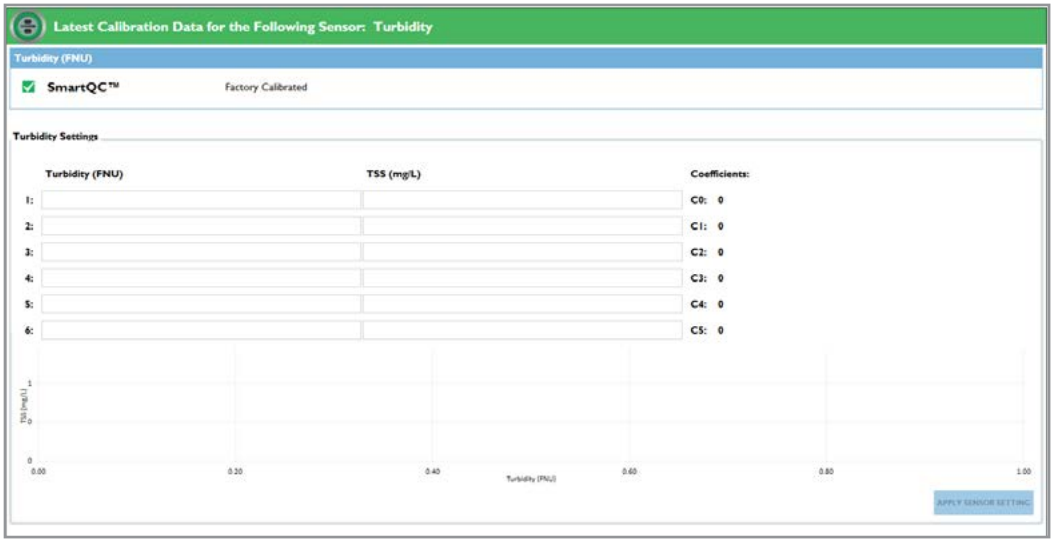
4.25 Total Suspended Solids
Calculation

Please follow the process below to calculate TSS.

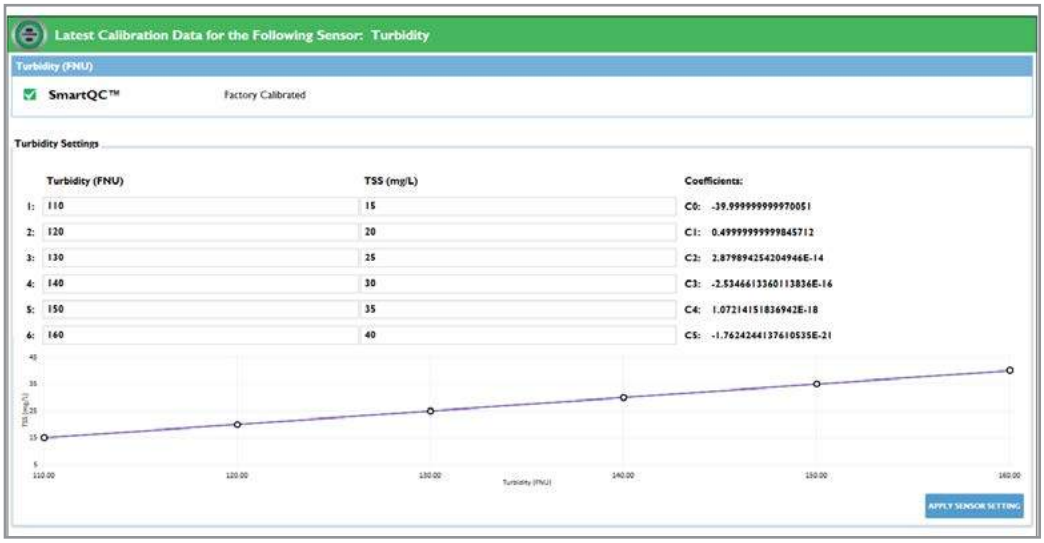
NOTE: *This process cannot be performed via the EXO handheld. It must be done using KorEXO Software.*

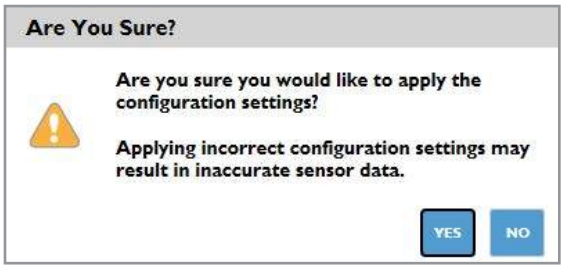
Step 1
Make sure the turbidity probe is installed in the sonde.

Step 2
In KorEXO Software, connect to the sonde, and navigate to Instruments and Sensors>Turbidity. The correlation table appears under the Turbidity Settings header.



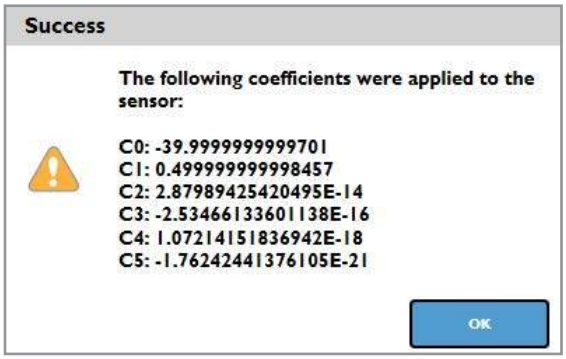
Step 3
Type in the turbidity NTU/FNU values and the corresponding TSS values obtained through lab analysis into the table. The coefficients will automatically calculate and a graph will be generated as additional values are added. Click Apply Sensor Setting.





Step 4

The message below will be displayed, asking for confirmation that the settings should be applied. Click Yes.



Step 5

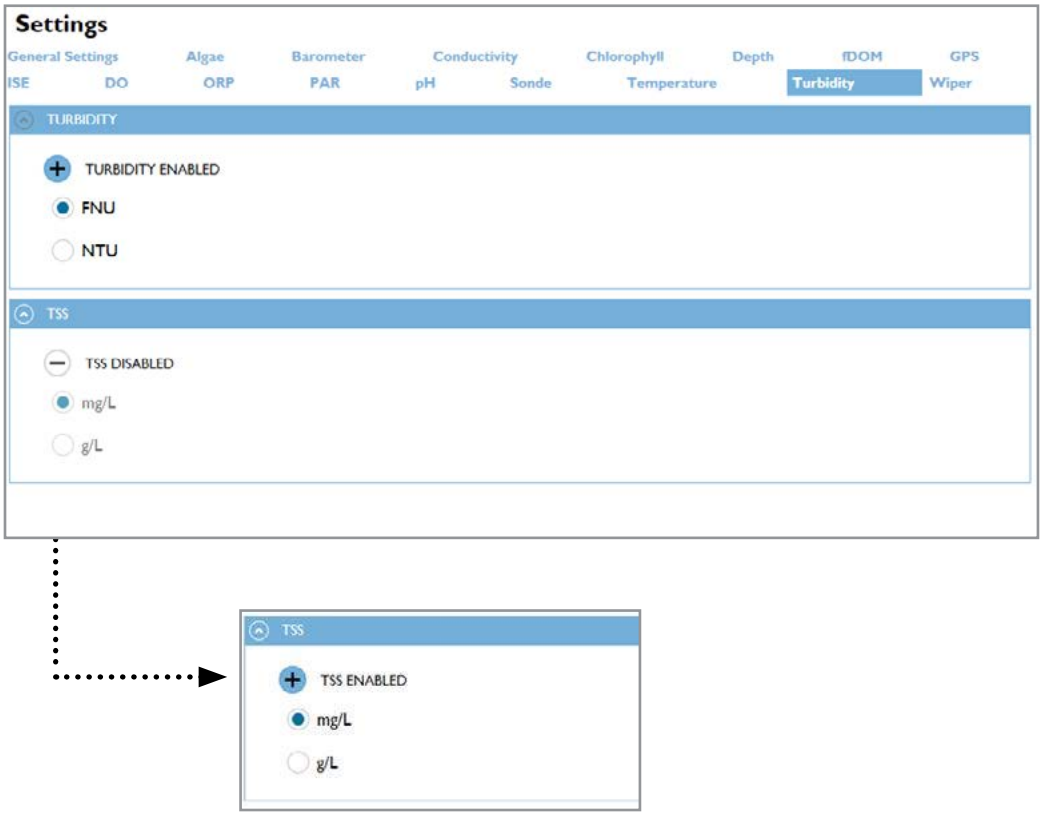
A message box appears which states that the coefficients have been successfully applied to the sensor. The coefficients are also displayed.

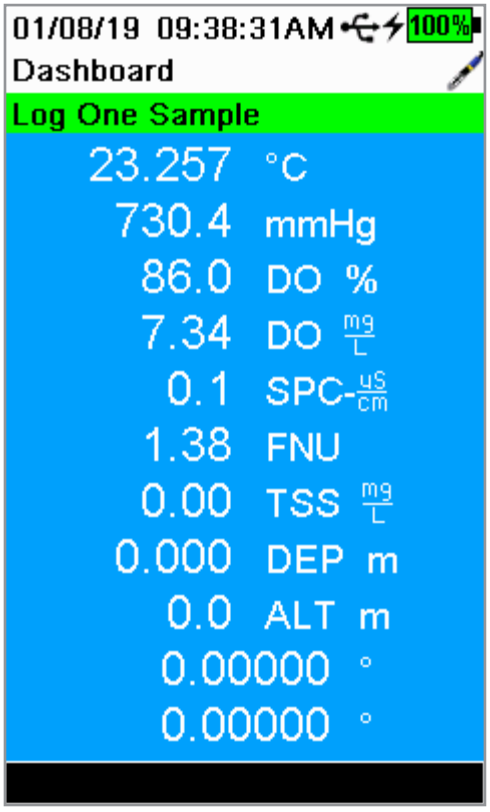
Step 6

TSS values will now be displayed on the Dashboard based on the values entered via KorEXO and saved to the turbidity probe.

Step 7

If the TSS parameter is not displayed on the Dashboard, go to File>Settings>Turbidity, and click the "-" sign next to TSS Disabled to activate the TSS parameter. A "+" sign will appear and TSS Enabled will be displayed. Click Save and return to the Dashboard.





Step 8

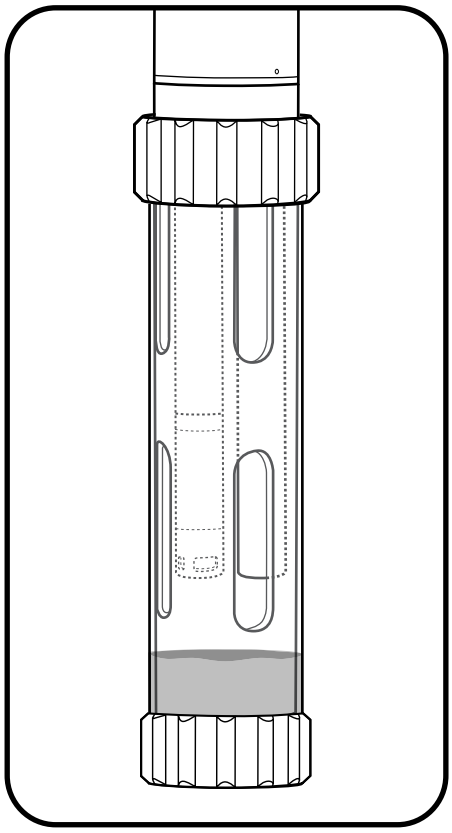
The units to display TSS will need to be activated separately in the EXO handheld. To add the TSS parameter to the handheld, navigate to Handheld> Display>Units>Turbidity>TSS and choose which unit to display. Click "Esc" to return to the live data dashboard. TSS will be displayed.

If you wish to view the TSS coefficients in the handheld, navigate to Calibration>Turbidity>Setup and the TSS coefficients will be displayed.

Section 5
Maintenance

5.1 Sonde
Storage

Proper sonde storage helps to ensure proper sonde operation. To keep sondes in their best working order, users must follow these instructions. This section will identify storage as "long-term" or "short-term." Long-term denotes storage during times of long inactivity (over winter, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.).



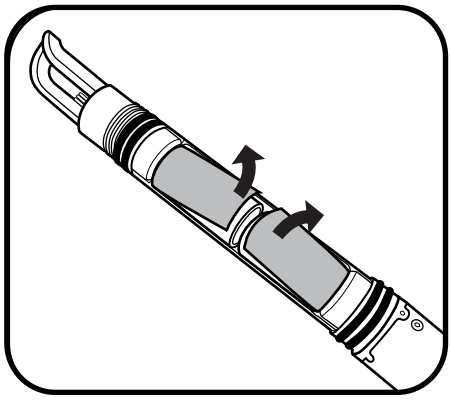
1 Short-term storage

For interim storage, users should keep sensors moist, but not submerged; submersion during storage may produce sensor drift. Users should aim for a storage environment of water-saturated air (100% humidity) for the sensors.

Place approximately 0.5 in (1 cm) of water (deionized, distilled, tap, or environmental) in the bottom of the calibration cup. Then place the sonde with all of its sensors into the cup and close it tightly to prevent evaporation. Users can also use a moist sponge to create a humid environment.

Ensure that unused sensor ports are properly protected with port plugs. The sonde itself should be stored in dry air.

To protect the cable connector, either leave the cable installed on the connector, or install the port plug. This is especially important for sondes with level; users should always keep the cable connector of vented sondes dry. (See Section 6.5)



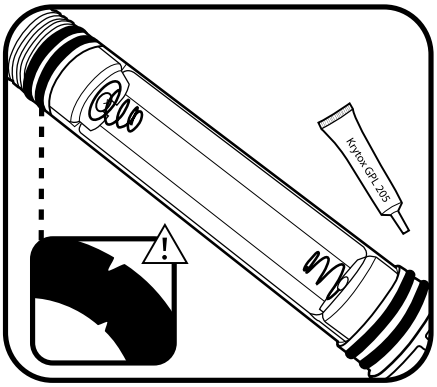
2 Long-term storage

Store all removed sensors according to the specific instructions in their sensor storage section. Plug all open ports, and store the sonde according the above instructions for short-term sonde storage.

NOTICE: Always remove batteries from sondes during long periods of inactivity to prevent potentially harmful battery leaks.

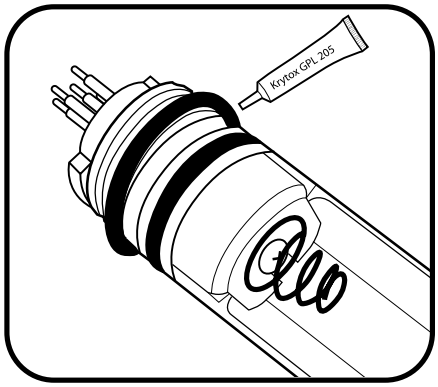
5.2 Sonde
Maintenance

Like all precision equipment, EXO sondes work most reliably when users maintain them properly. A proper inspection and cleaning can prevent several issues, including leaks. When performing general maintenance on the sonde, also check this manual's depth and connector sections. Use only the recommended materials to service instruments. Each sonde comes with a maintenance kit, including proper lubricants and replacement o-rings. Users can order replacement o-ring kits (599680 or 599681) or tool kit (599594) from the manufacturer or an authorized distributor.



1 Inspect and service o-rings

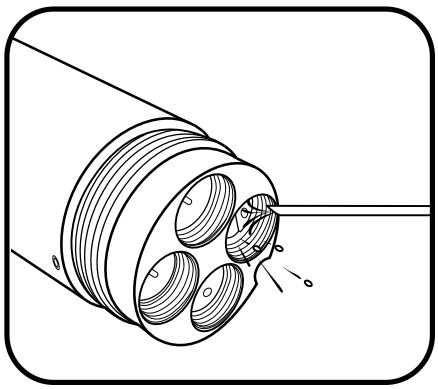
User-serviceable o-rings are located in the EXO sonde battery compartments. Perform a thorough visual inspection of o-rings each time they are exposed. Carefully look for grit, hair, etc. on the o-ring and mating surfaces and wipe away any contamination with a lint-free cloth. Without removing them from their grooves, *lightly* grease each o-ring with Krytox. Replace any damaged o-rings.



2 Replace o-rings

If the above inspection reveals a damaged (split, cracked, or misshapen) o-ring, remove it. Wipe the groove clean with alcohol and a lint-free cloth. Grease the o-ring by drawing it between your *lightly* greased thumb and index fingers. Place the o-ring in its groove, being careful to not roll or twist it, and lightly grease the surface. Inspect the o-ring for contamination.

NOTICE: Do not apply excess grease to the o-rings. This can cause contamination and seal failure.



3 Inspect, clean, and grease ports

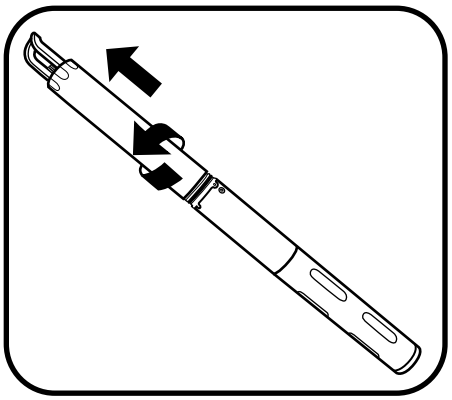
Visually inspect each port for contamination (grit, hair, etc.). Should the user detect contamination, remove it with a blast of compressed air. When the port's rubber appears dry, lightly grease the sensor connector before insertion.

NOTICE: Never insert solid objects into the sonde ports. This could permanently damage the connectors.

5.3 Sonde

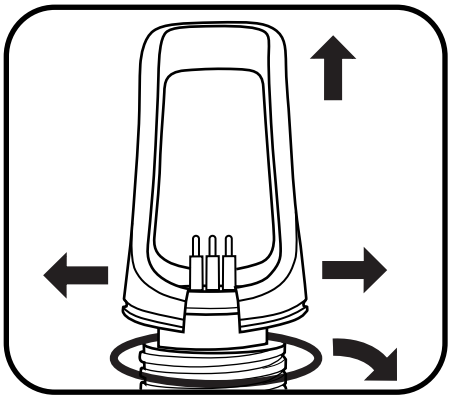
Replace EXO1 Sonde Bail

Sonde bails provide users with a handle for convenient transport and an attachment point for cable strain reliefs. If an EXO1 bail breaks due to impact or standard wear and tear throughout the life of the sonde, a user can easily replace it. We also recommend attaching the cable's strain relief mechanism to the bail.



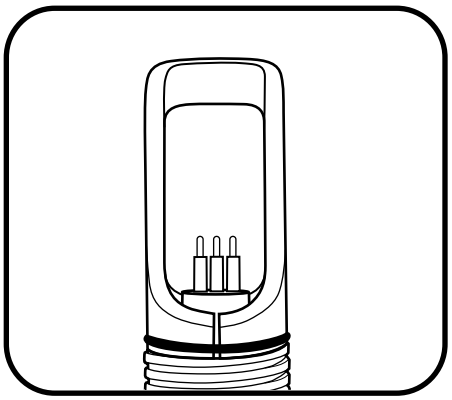
1 Remove battery cover

Twist the battery cover counterclockwise until free. Then slide off the battery cover.



2 Remove bail

Spread the sides of the bail away from the connector, pull the bail over the posts on top of the sonde, and remove the o-ring from its groove and discard.



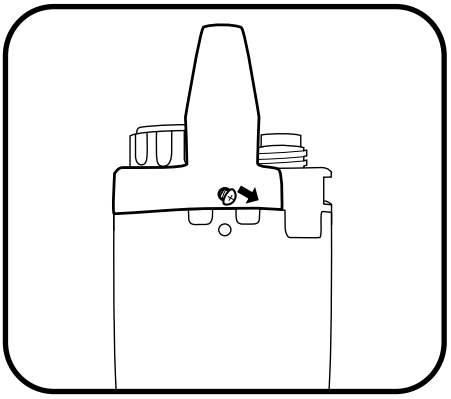
3 Install new bail

Install a new o-ring in the groove at the base of the bail. Then carefully spread the bail open and seat its sockets over the posts around the connector.

5.4 Sonde

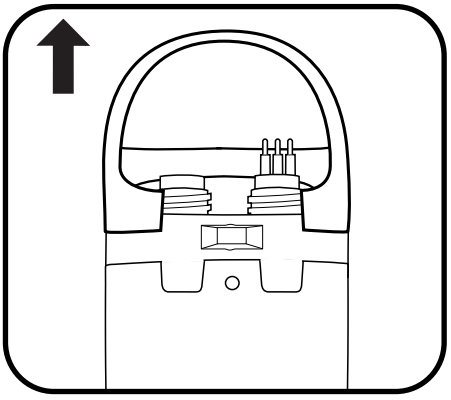
Replace EXO2 and EXO3 Sonde Bail

Sonde bails provide users with a handle for convenient transport and an attachment point for cable strain reliefs. If an EXO2 or EXO3 bail breaks due to impact or standard wear and tear throughout the life of the sonde, a user can easily replace it. We also recommend attaching the cable's strain relief mechanism to the bail.

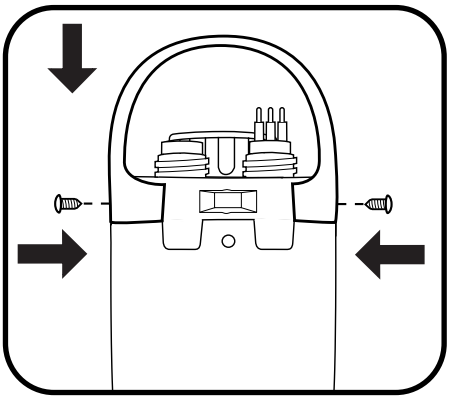


1 Remove bail

Use a small screwdriver to remove two screws on the sides of the bail.



Once screws are removed, lift the bail off the sonde.



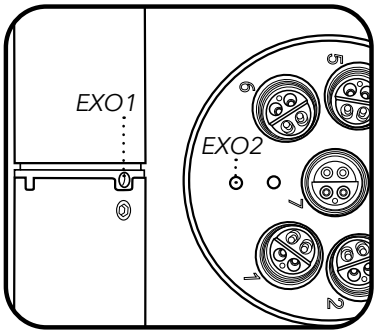
2 Install new bail

Place the new bail onto the sonde, aligning holes for the screws. With one side of the bail aligned, push on the other side to snap it into place. Use a small screwdriver to insert two screws on the sides of the bail. Tighten until snug.

5.5 Depth and Level Sensor

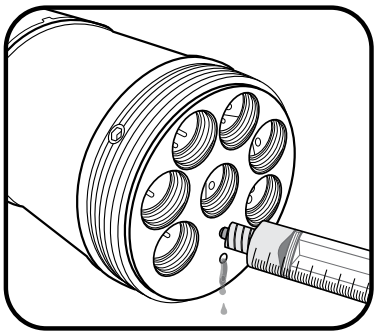
Maintenance and Storage

EXO depth and level sensors access the water through small holes (ports) located in the sonde body or bulkhead. Although users cannot access them directly, proper storage and maintenance will help to ensure reliable operation. Depth sensors can be stored dry, in water-saturated air, or submerged in clean water. However, be sure that the water does not contain solutions that are corrosive. This can cause damage to the sensor's strain gauge.



1 Locate depth ports

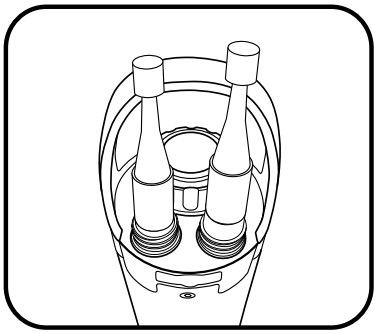
The two EXO1 depth ports are located in the yellow-plastic section between the bulkhead tube (labeled area) and the blue plastic battery cover. The EXO2 / EXO3 depth ports are located on the metal bulkhead face itself, in the largest open area between ports.



2 Clean depth ports

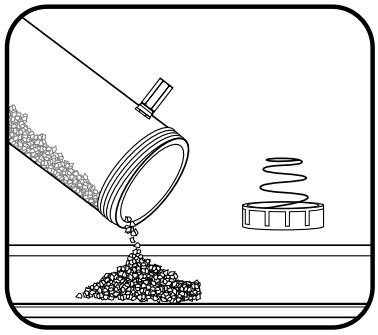
Although users cannot directly access the depth/level sensors, they should periodically clean them with the syringe included in the EXO tool kit (599594). Fill the syringe with clean water and gently force water through one of the ports. Ensure that water flows from the other hole. Continue flushing the port until the water comes out clean.

NOTICE: Do not insert objects in the depth ports, as this may cause damage to the transducer not covered under the warranty.



3 Level sensor storage

Users can store these sensors either dry or submerged in clean water. However, regardless of storage method or length, ensure the vent tube remains dry. Always attach the port plug to the cable connector, or leave the cable installed with a cap over the desiccant's vent.



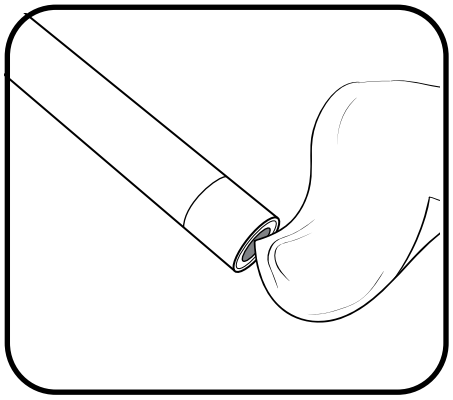
4 Level desiccant maintenance

Active desiccant is blue; saturated desiccant is pink. When the desiccant closest to the sonde begins to turn pink, you should replace (YSI 6108), or regenerate (YSI 6109) the desiccant cartridge. To regenerate desiccant, remove it from the cartridge and heat it for one hour at 200°C (about 400°F); then cool it in an airtight container before refilling. Also heat the felt filters at 100°C (about 200°F) for 30 minutes. The desiccant will turn blue following a successful recharge.

5.6 Standard Optical Sensors

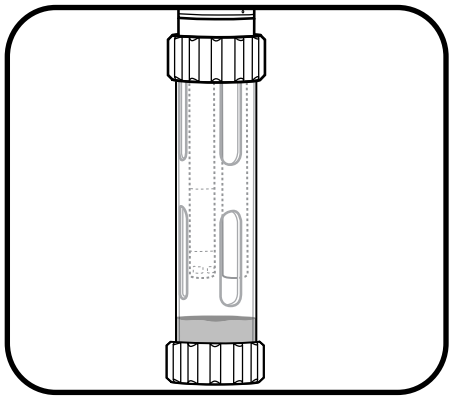
Maintenance and Storage

Standard optical sensors include Turbidity, Total Algae, and fDOM sensors; these optical sensors are very low maintenance. This section identifies storage as "long-term" or "short-term." Long-term denotes storage during times of long inactivity (over winter, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.). Maintain connectors as instructed in Section 5.17.



1 Clean sensing window

Turbidity, Total Algae, and fDOM require minimal maintenance. Users should periodically inspect the optical surface at the tip of the sensor and wipe it clean with a non-abrasive, lint-free cloth if necessary. As much as possible, prevent scratches and damage to the sensing window.



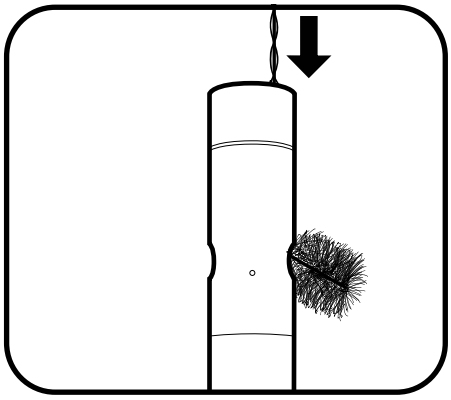
2 Long- and short-term storage

Turbidity, Total Algae, and fDOM require minimal precautions. Users can either remove the sensors or leave them installed in the sonde for long- and short-term storage. If left installed on the sonde, follow guidelines for sonde storage. If users remove them from the sonde, the sensors may be stored in dry air in their shipping cap (to protect against physical damage).

NOTICE: Do not store any sensor in quinine sulfate solution.

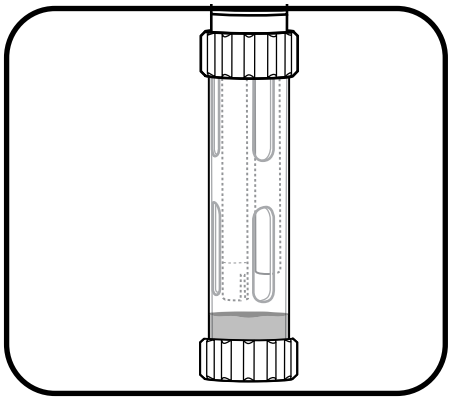
5.7 Conductivity/Temp Sensor
Maintenance and Storage

EXO conductivity and temperature (CT) sensors require little maintenance or special attention for storage. As much as possible, prevent impact to the sensor's exposed thermistor. This section will identify storage as "long-term" or "short-term." Long-term denotes storage during times of long inactivity (over-wintering, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.). Maintain connectors as instructed in Section 5.17.



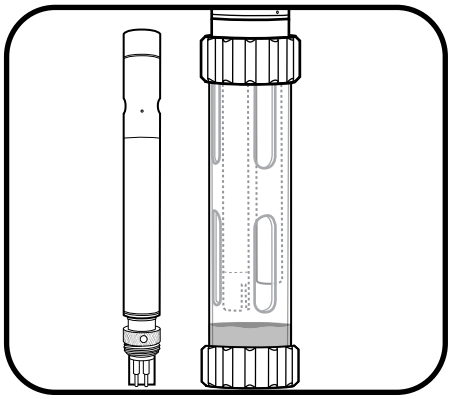
1 Clean electrode channels

The only parts of the CT sensor that require special maintenance are the channels leading to the internal electrodes. Dip the sensor's cleaning brush (included in the sonde maintenance kit) in clean water, insert at top of channels, and sweep the channels 15-20 times. If deposits have formed on the electrodes, use a mild solution of dish soap and water to brush the channels. If necessary, soak in white vinegar to aid cleaning. Rinse the channels with clean water following the sweepings or soak.



2 Short-term storage

When in regular field use, the sensor should remain installed on the sonde in an environment of water-saturated air. Place approximately 0.5 in (1 cm) of any water (deionized, distilled, tap, or environmental) in the bottom of the calibration cup. Insert the sonde and sensor into the cup and screw it on tightly to prevent evaporation. (More information in "Short-Term Sonde Storage" Section 5.1.)



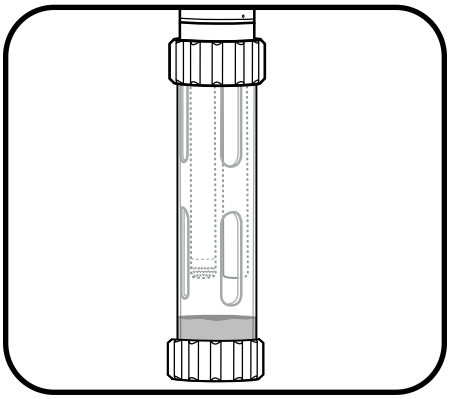
3 Long-term storage

Store the sensors either dry or wet, installed on the sonde or detached. However, before storage, perform the recommended maintenance (above) to ensure the sensor is in good working order for the next deployment season. If the sensor is submerged for storage, ensure that the liquid is not corrosive.

5.8 Dissolved Oxygen Sensor

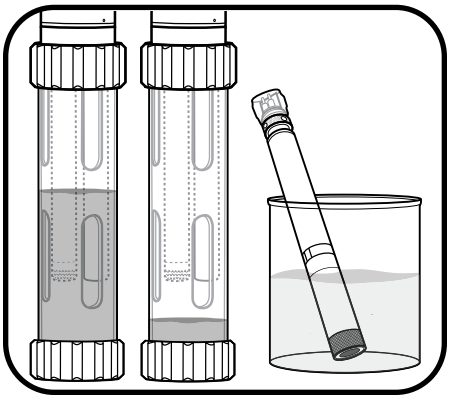
Storage

EXO DO sensors require separate storage instructions from other optical sensors due to their sensing membranes. This section will identify storage as “long-term” or “short-term.” Long-term denotes storage during times of long inactivity (over winter, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.).



1 Short-term storage

When in regular field use, the ODO sensor should remain installed on the sonde. Place approximately 0.5 in (1 cm) of any water (deionized, distilled, tap, or environmental) in the bottom of the calibration cup. Insert the sonde and sensor into the cup and screw it on tightly to prevent evaporation. (More information in “Short-Term Sonde Storage” Section 5.1.)



2 Long-term storage

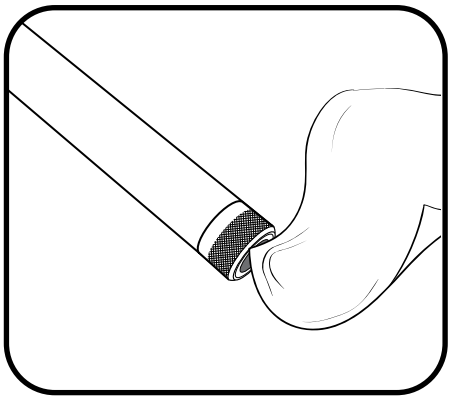
Leave the sensor installed in the sonde, and submerge it in clean water in the calibration cup. Screw the cup on tightly to prevent evaporation. Users may also store the ODO sensor by itself in two ways. One, submerge the sensing end of the sensor in a container of water; occasionally check the level of the water to ensure that it does not evaporate. Two, store the sensor in water-saturated air.

We do not recommend storing the sensor with the connector end unmated or exposed. If unmated, cover with plastic connector cap.

5.9 Dissolved Oxygen Sensor

Maintenance and Rehydration

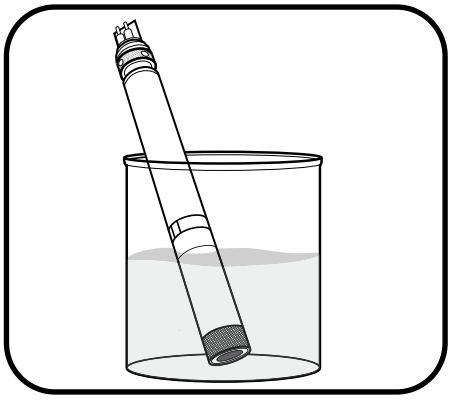
EXO optical Dissolved Oxygen (DO) sensors require unique maintenance instructions due to their sensing membranes. Users should routinely perform these steps in order to achieve the highest levels of sensor accuracy. DO sensor caps have a typical life of 12 months. After this point, users should replace the DO membrane cap. As caps age, accuracy may be reduced, ambient light rejection suffers, and response times can be affected. Maintain connectors as instructed in Section 5.17.



1 DO membrane maintenance

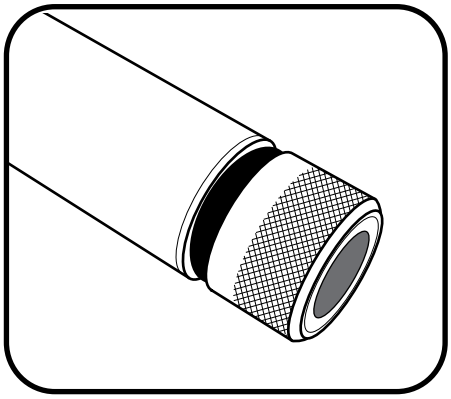
Users should periodically inspect the optical surface at the tip of the sensor and wipe it clean with a non-abrasive, lint-free cloth if necessary. Never use organic solvents to clean an EXO DO sensor.

As much as possible, prevent scratches and damage to the sapphire sensing window. Avoid getting fingerprints on the window. If necessary, wash with warm water and dish soap and rinse with DI water.



2 Sensor rehydration

Users should always store DO sensors in a moist or wet environment in order to prevent sensor drift. However, should DO sensors be left in dry air for longer than eight hours, they must be rehydrated. To rehydrate, soak the DO sensor cap in warm (room temperature) tap water for approximately 24 hours. Following this soak, calibrate the sensor and store it in a moist environment.



3 Sensor cap replacement

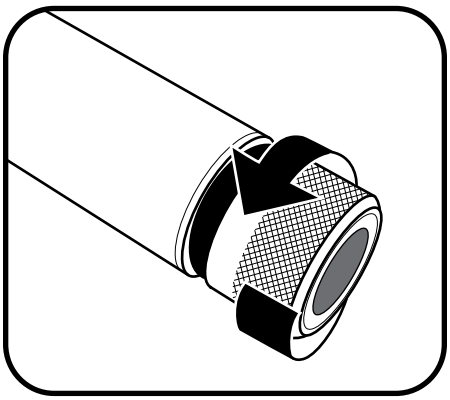
DO sensor caps have a typical life of 12 months. After this point, users should replace the DO membrane cap. To replace this cap, follow the directions in the "Sensor Cap Replacement" section found on the next page.

5.10 Dissolved Oxygen Sensor

Sensor Cap Replacement

Follow these instructions to replace the sensor cap on an EXO optical dissolved oxygen sensor once the previous cap has exhausted its usable life (typically about one year). The DO sensor cap (599110-01) is shipped in a humidified container, and should be stored in a 100% humid environment.

NOTE: *Keep the instruction sheet shipped with the DO sensor cap as it contains the unique coefficients required for calibration.* If the sensor cap dries completely, follow instructions to rehydrate it.



1 Remove current sensor cap

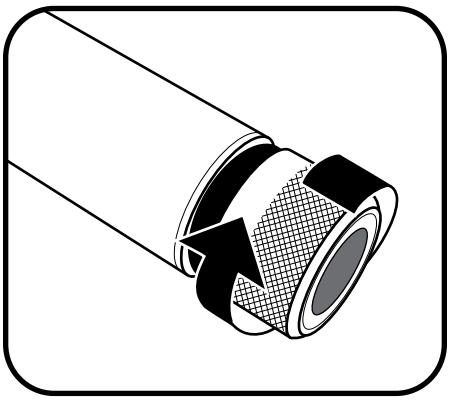
Rotate the sensor cap with your fingers counterclockwise until free.

If possible, do not use any tools during this process. However, should the cap be immovable after use, carefully twist the sensor cap with pliers until it breaks loose.

NOTICE: Do not use pliers on the sensor body, and take great care not to damage the sensor threads.

2 Replace o-ring

Without using tools, remove the previous o-ring (pinch the o-ring out, then roll it upwards over the threads) and discard it. Visually inspect the new o-ring for nicks, tears, contaminants, or particles; discard damaged o-rings. Without twisting it, carefully install the new o-ring over the threads and into its groove, then apply a thin coat of Krytox lubricant to the o-ring only.



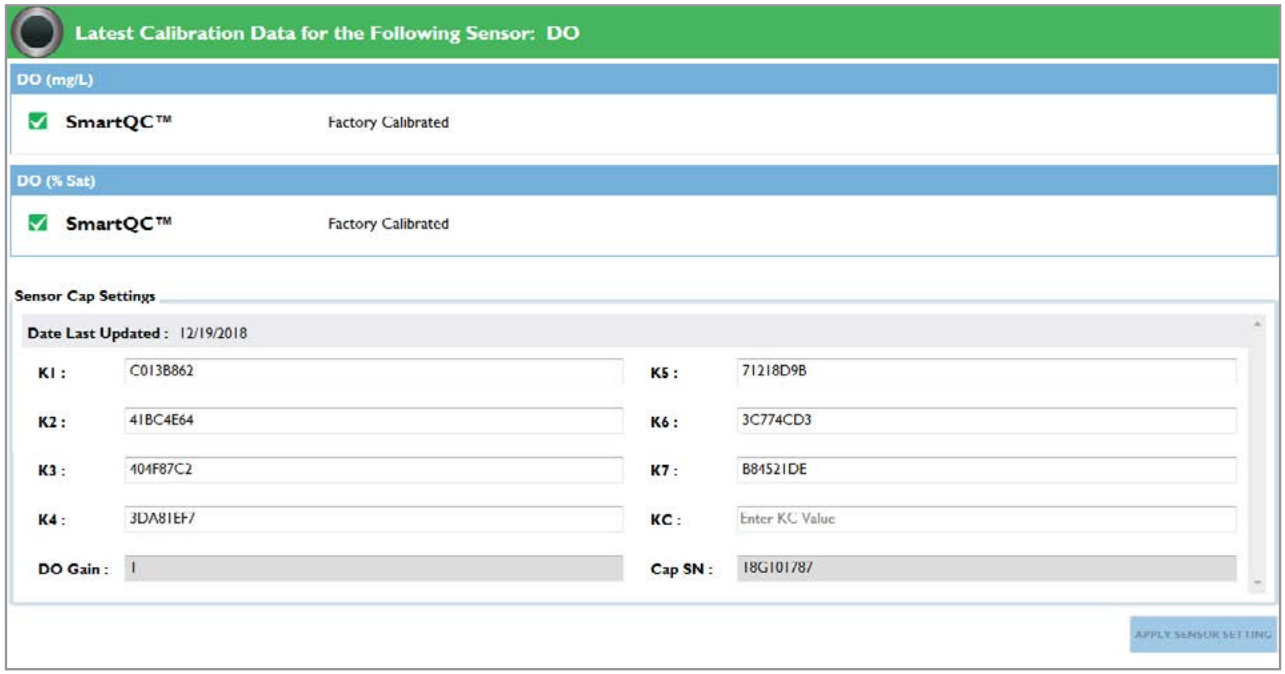
3 Install new sensor cap

After the o-ring is installed and lubricated, wipe the clear window at the end of the sensor with a lint-free cloth until clean. Then dry the inside cavity of the sensor cap with a lint-free cloth. With a clockwise motion, thread the new sensor cap onto the sensor until it is finger-tight. The o-ring should now be compressed between the sensor cap and sensor, and not pinched. If pinched, remove and discard the o-ring and repeat procedure.

NOTICE: Do not over-tighten the sensor cap. Do not use any tools for the installation process.

4 Configure sonde for new cap

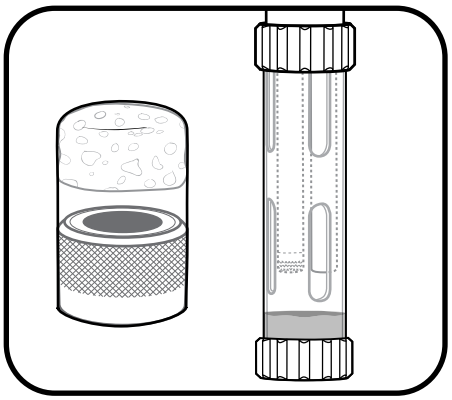
Connect the sonde to KorEXO and navigate to the Instrument and Sensors tab. Select the ODO sensor.



In the DO screen, enter the unique membrane cap coefficients found on the instruction sheet shipped with the DO sensor cap. Click Apply Sensor Settings to save the changes.

NOTE: *Calibration coefficients are associated with specific individual sensor caps. They cannot be used for other ODO sensors.*

Although measures are taken at the factory to ensure this, please check that the serial number with the calibration coefficients on the instruction sheet matches the serial number engraved on the outside of the sensor cap.



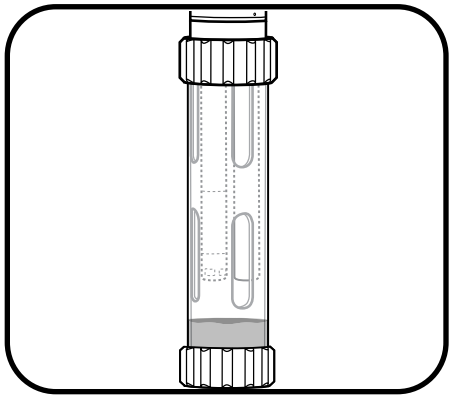
5 Store sensor cap

The sensor cap is shipped in a humidified container, and should be consistently stored in a 100% humid environment. Prior to installation, ensure the cap's container remains moist. Once the sensor cap is installed on the sensor, maintain this environment by placing approximately 0.5 in (1 cm) of water (deionized, distilled, tap, or environmental) in the bottom of the calibration cup and screw it tightly onto the sonde to prevent evaporation. You may also store the sensor by submerging the cap end in water.

NOTICE: If pH sensor is also installed, do not submerge it in *distilled* water.

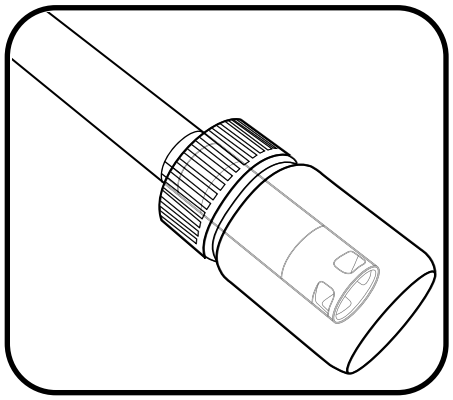
5.11 pH and pH/ORP Sensors
Storage and Rehydration

pH and pH/ORP sensors have two specific storage requirements: they should not be stored in distilled or deionized water and their reference electrode junction should never dry out. This section will identify storage as "long-term" or "short-term." Long-term denotes storage during times of long inactivity (over-wintering, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.).



1 Short-term storage

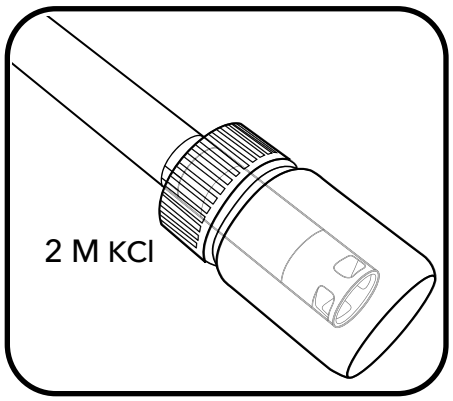
When in regular field use, the sensor should remain installed on the sonde in an environment of water-saturated air. Place approximately 0.5 in (1 cm) of any water (deionized, distilled, tap, or environmental) in the bottom of the calibration cup. Insert the sonde and sensor into the cup and screw it on tightly to prevent evaporation. (More information in "Short-Term Sonde Storage" Section 5.1.)



2 Long-term storage

Remove the sensor from the sonde and insert its sensing end into the bottle that the sensor was shipped in. Install the bottle's o-ring and cap then tighten. This bottle contains a 2 molar solution of pH 4 buffer. If this solution is unavailable, users may store the sensor in tap water.

NOTICE: Do not store the pH or pH/ORP sensor in Zobell solution, DI or distilled water.

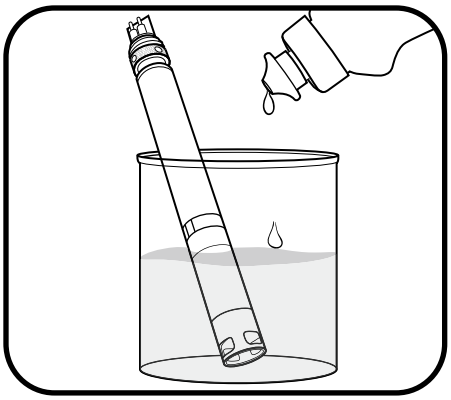


3 Rehydrate reference junction

If the pH sensor has been allowed to dry, soak the sensor for several hours (preferably overnight) in a 2 molar (2 M) solution of potassium chloride (KCl). In order to create a 2 M KCl solution, dissolve 74.6 g of KCl in 500 mL of distilled or deionized water. If KCl is unavailable, a tap water or pH 4 buffer soak may restore function. If the sensor is irreparably damaged, users must replace the sensor module.

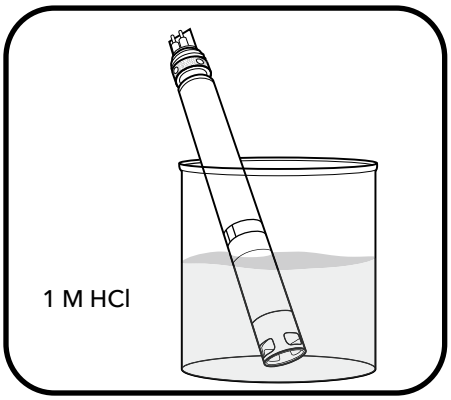
5.12 pH and pH/ORP Sensors
Maintenance

pH and pH/ORP sensors will require occasional maintenance to clear contamination from the sensing elements. These contaminants can slow the sensor's response time. Clean the sensors whenever deposits, biofouling, or other contamination appear on the glass, or when the sensor's response time slows perceptibly. Remove the sensor from the sonde before performing the following cleaning steps. Do not attempt to physically scrub or swab the glass bulbs. The bulbs are very fragile and will break if pressed with sufficient force. Maintain connectors as instructed in Section 5.17. Replace depleted sensor module as instructed in Section 5.14.



1 Soak in dishwashing liquid solution

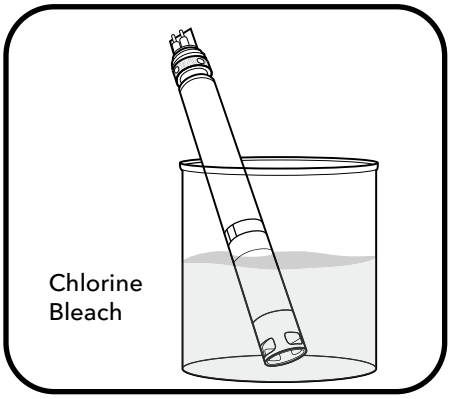
Soak the sensor for 10-15 minutes in a solution of clean tap water and a few drops of dishwashing liquid. Following the soak, rinse the sensor with clean water and inspect. If contaminants remain or response time does not improve, continue to the HCl soak.



2 Soak in HCl solution

Soak the sensor for 30-60 minutes in one molar (1 M) hydrochloric acid (HCl). This reagent can be purchased from most distributors. Following the HCl soak, rinse the sensor in clean tap water and allow it to soak for an hour in clean water. Stir the water occasionally. Then, rinse the sensor again in tap water and test response time. If response time does not improve or you suspect biological contamination of the reference junction, continue to the next soak. If HCl is not available, soak in white vinegar.

⚠ **WARNING:** Follow the HCl manufacturer's instructions carefully to avoid personal harm.

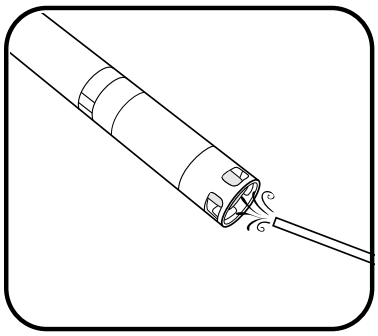


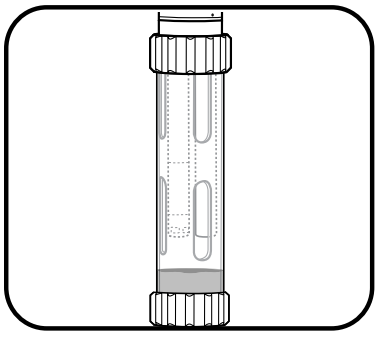
3 Soak in chlorine bleach solution

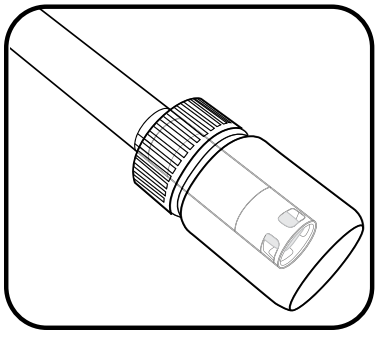
Soak the sensor for approximately one hour in a 1:1 dilution of chlorine bleach and tap water. Following the soak, rinse the sensor in clean tap water and allow it to soak for at least one hour in clean water (longer if possible). Then, rinse the sensor again in tap water and test response time.

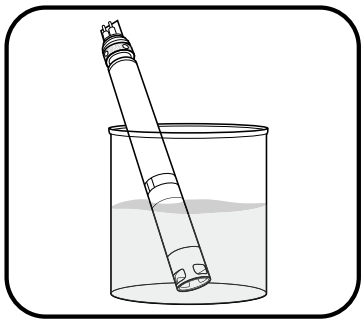
5.13 ISE Sensors
Maintenance and Storage

EXO ammonium, nitrate, and chloride sensors utilize ion-selective electrodes (ISEs) to monitor these parameters. One key requirement of storage, short or long-term, for these sensors is that their reference electrode junctions should never dry out. This section will identify storage as "long-term" or "short-term." Long-term denotes storage during times of long inactivity (over-wintering, end of monitoring season, etc.). Short-term denotes storage during times the sonde will be used at a regular interval (daily, weekly, biweekly, etc.) Replace depleted sensor module as instructed in Section 5.14.









1 Sensor maintenance

Ammonium or Nitrate sensor: When deposits, biofouling, or other contamination appear on the membrane, users should *gently* remove them with a fine jet of deionized water or rinsing in alcohol followed by soaking in the high standard calibration solution. Gently dab dry with a lint-free tissue.

Chloride sensor: When deposits, biofouling, or other contamination appear on the membrane, users should *gently* remove them by washing with alcohol and/or gently polishing with fine emery paper in a circular motion to remove deposits or discoloration, then thoroughly washing with deionized water to remove any debris.

NOTICE: The ion-selective membranes are very fragile. Do not use coarse materials (e.g. paper towels) to clean the membranes, as these could permanently damage the sensor. The exception is fine emery paper for the chloride sensor, noted above.

2 Short-term storage

When in regular field use, the sensor should remain installed on the sonde in an environment of water-saturated air. Place approximately 0.5 in (1 cm) of any water (deionized, distilled, tap, or environmental) in the bottom of the calibration cup. Insert the sonde and sensor into the cup and screw it on tightly to prevent evaporation. (More information in "Short-Term Sonde Storage" Section 5.1.)

3 Long-term storage

Users should remove the sensors from the sonde and place them in their storage bottle (installed on sensor during shipping) with a small amount of tap water or calibration standard. The sensors should not be immersed in water.

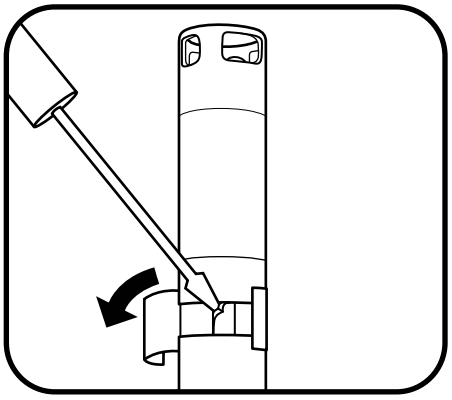
NOTICE: Do not store the ISE sensors in conductivity standard, pH buffer, salt water, or any solution with significant conductivity.

4 Rehydrate reference junction

If an ISE sensor has been allowed to dry, soak the sensor for several hours (preferably overnight) in the sensor's high-calibration solution. If the sensor is irreparably damaged, users must replace the sensor module.

5.14 Sensor Module Replacement

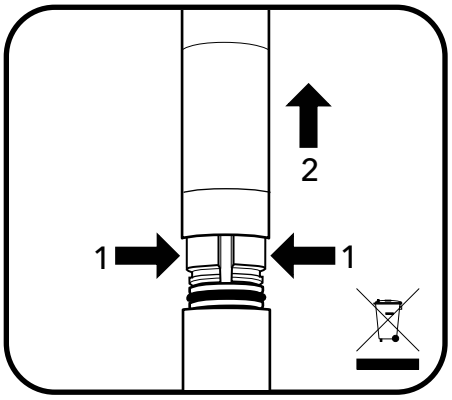
EXO pH, pH/ORP, ammonium, nitrate, and chloride sensors feature replaceable sensor modules (#599795, 599797, 599743-01, 599744-01, 599745-01) due to the electrolyte-depleting characteristics necessary to make such measurements. We recommend that users replace these modules as necessary–typically 12 to 18 months for pH and ORP and three to six months for ISEs, when stored properly. Working life will depend on the conditions of the deployment environment. Perform this procedure in a clean, dry laboratory environment.



1 Remove old sticker and plug

Peel off and discard the old sticker that covers the junction of the sensor body and the module. Then, with a small, flat-blade screwdriver, remove the small rubber plug from the gap in the hard plastic ring at the base of the sensor module.

⚠ **CAUTION:** Always exercise extra care when using sharp or potentially harmful instruments.

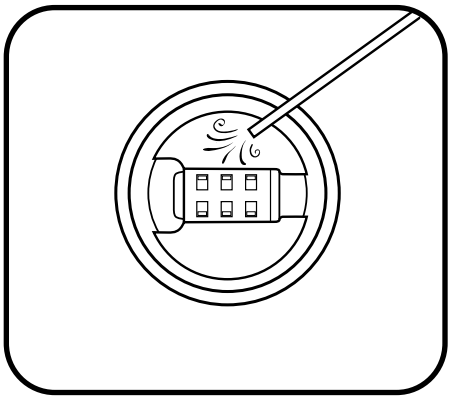


2 Remove and discard old sensor module

To remove, perform two motions simultaneously.

1. With your fingers, squeeze the sensor module's hard plastic ring so that it compresses the gap left by the rubber plug.
2. Steadily pull the sensor module straight back from the sensor body, rocking slightly if necessary.

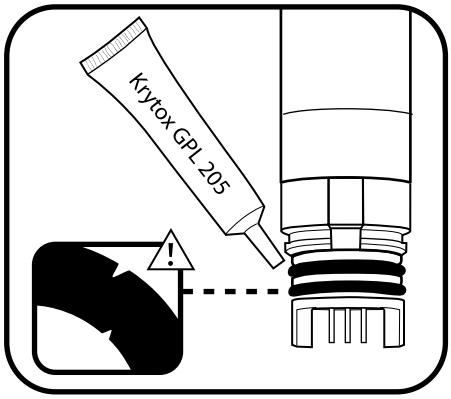
NOTICE: The act of removing the old sensor module renders the o-rings on the module unusable. To prevent catastrophic leaks, do not attempt to reinstall a module with damaged o-rings. Discard the module and the old o-rings according to your organization's guidelines, or return it to manufacturer for recycling.



3 Inspect and service connector cavity

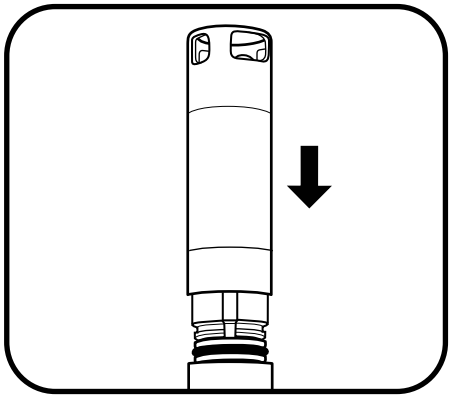
Inspect the connector cavity of the probe body for debris or moisture.

If detected, remove it with a lint-free cloth or a gentle blast of compressed air.



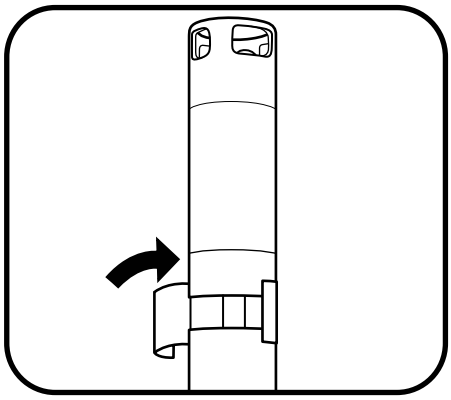
4 Inspect and service new sensor module's o-rings

Ensure that the two o-rings are not nicked or torn and have no contaminants or particles on them. If the user detects damage, carefully replace them with the extras included in the sensor module kit. Then apply a thin coat of Krytox® lubricant to each o-ring. If a user removes a sensor module that is in good working order, replace the o-rings before use.



5 Insert new sensor module

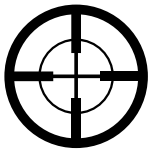
Align the prongs on the base of the module with the slots in the sensor body. The sensor module is keyed to insert in only one orientation. Once the module is aligned, press it firmly into position until it clicks. Wipe away any excess grease from the assembled components.



6 Apply new sticker

Wrap the junction of the sensor module and the body with the new sticker included in the sensor module kit. This sticker helps keep the sensor module junction clean and retains the rubber plug throughout deployment.

On the sticker, use a permanent marker to write the date the replacement module was installed, as a reminder.

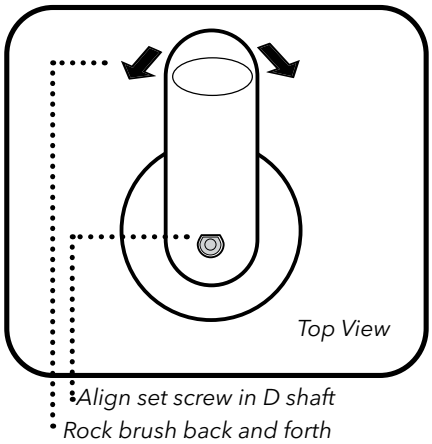


7 Re-calibrate the sensor

Using KorEXO software, calibrate the sensor following each sensor module replacement. After calibration, the sensor is ready for field use.

5.15 EXO Central Wiper
Maintenance and Storage

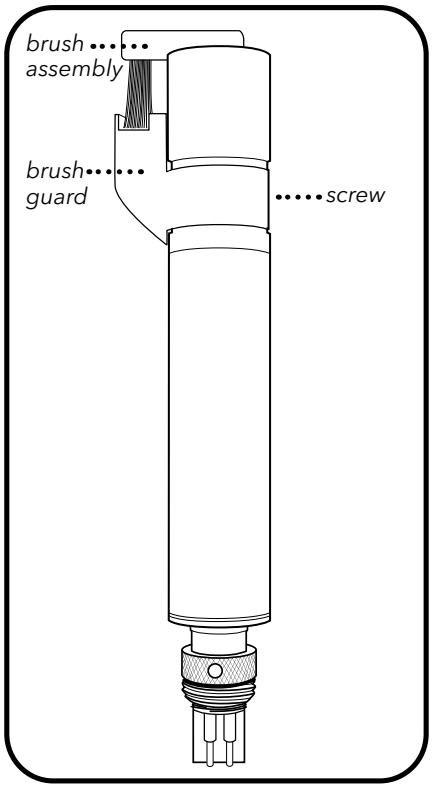
Follow these instructions to replace the wiper brush assembly or brush guard component on the central wiper.
We recommend changing the brush between deployments to avoid sediment carryover, which can compromise calibration and data collection. For long- and short-term storage, the wiper requires minimal precautions. Users can either remove the wiper or leave it installed in the sonde. If left installed on the sonde, follow guidelines for sonde storage. If users remove it from the sonde, the wiper may be stored in dry air in its shipping cap to protect against physical damage.



1 Replace wiper brush

Loosen set screw with a 0.050 inch Allen wrench. Remove old brush assembly and clean any residue from wiper shaft and wiper end cap.
Install new brush assembly, gently pressing the wiper arm down against the shoulder on the wiper shaft.

Tighten set screw to a torque of 4 inch-pounds. While tightening, gently and slowly rock the brush to ensure a tight fit against the D shaft.
Check snugness of wiper by gently rocking 5 degrees in either direction.



2 Replace brush guard

In KorEXO software, go to Run > Dashboard. Click the Wipe Sensors button to ensure proper wiper park position.

Mark the position of the old guard with a marker.

Loosen the #6 screw with a 7/64 inch Allen wrench, remove the old guard and clean any residue from motor housing.

Remove the cover on adhesive strip on the inside of the new brush guard.

Carefully install the new brush guard in same position as old guard—with brush centered in well. Tighten screw until snug, but do not overtighten. (The adhesive helps to hold the guard in place.)

If necessary, calibrate the position of the new wiper in the KorEXO Calibrate menu.

NOTE: *The adhesive on the guard strap, which facilitates installation, may make it difficult to re-position the wiper guard after it's been installed. Take caution to mark the position of the old guard before removing it and install the new one in the same location. Confirm that the new guard is aligned with the 4-pin connector at the bottom of the probe as shown, and properly centered between ports 1 and 6 after the wiper has been installed in the sonde.*

Central Wiper O-Ring Replacement

In order to minimize the chance of water infiltration, YSI recommends annual replacement of the wiper shaft o-rings inside the EXO Central Wiper. This replacement must be performed by a YSI Authorized Service Center. EXO Authorized Service Centers are located in the United States and around the world. Please refer to the YSI website (**YSI.com/Repair**) for your nearest Authorized Service Center.

SmartQC for the Central Wiper

The central wiper has a QC score based on the expected voltage of the sensor when seated in the central wiper housing.

Green: The voltage when the wiper is seated in its housing is within the factory specified limits.

Yellow: The voltage when the wiper is seated in its housing is slightly outside of the factory specified limits.

1. Perform a Factory Reset Calibration.
2. Calibrate the central wiper so that it seats itself in the correct location.
3. Perform a series of wipes on the sonde to ensure that the wiper continues to reseat itself in the correct location after each wipe. Do not manually adjust the central wiper. The wiper calibration will associate a voltage to a location. Manually moving the wiper will negate the calibration. To perform a sensor wipe:
    a. In KorEXO: On Live Data screen, click the "Start Wiping" button
    b. On the Handheld: Click "Calibration" button, select "Wipe Sensors".

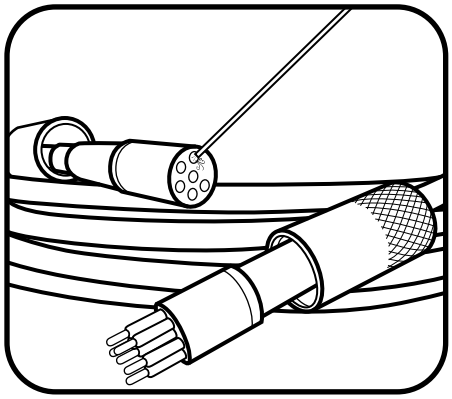
If the central wiper continues to show a yellow QC Score after recalibration, it is still able to be used and will wipe all of the sensors properly. However, the wiper may be nearing its time to be serviced in the factory.

Red: The voltage when the wiper is seated in its housing is significantly outside of the factory specified limits. Perform the same three steps described above for a Yellow QC score.

If the QC Score returns to red after the above procedures when performed, please contact YSI Technical Support for further assistance. It will possibly be recommended that the wiper should be returned to the factory for maintenance.

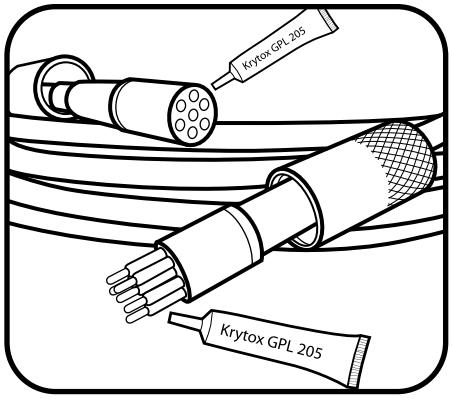
5.16 EXO Field Cable
Maintenance and Storage

EXO field cables are rugged and provide years of reliable service when properly maintained. As with all field cables, they are most vulnerable at their connectors. Take extra caution to protect the connectors from debris and physical harm.



1 Inspect and clean cables

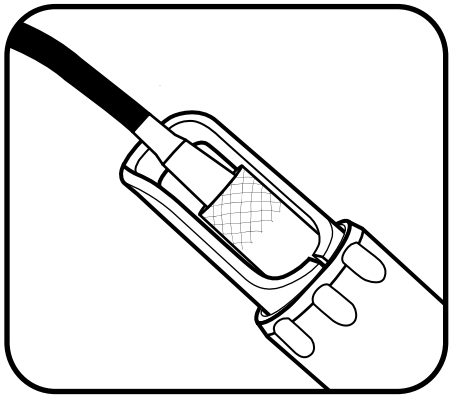
Inspect the cable's connectors for contamination and remove any detected debris with a blast of compressed air. Periodically inspect the cable for nicks and tears to ensure best performance.



2 Lubricate cable connectors

To maintain the cable assembly, users should also apply a thin coat of Krytox grease to both ends when they appear dried out.

NOTICE: It is better to apply too little grease than too much. Too much grease can encourage contamination.



3 Cable storage

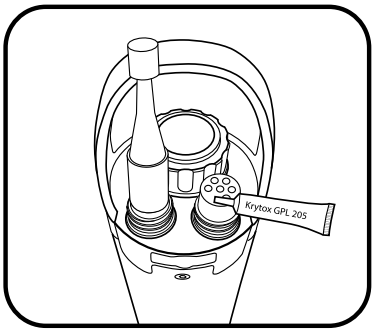
Users should leave the cable installed on the sonde to protect the connectors. If necessary users may remove it from the sonde, but extra care should be taken to protect the connectors. Store the cable in a safe location free from direct sunlight.

If the cable is vented, ensure the storage cap is affixed to the desiccant inlet. Store vented cables in a bag containing desiccant.

5.17 Connectors
Maintenance and Storage

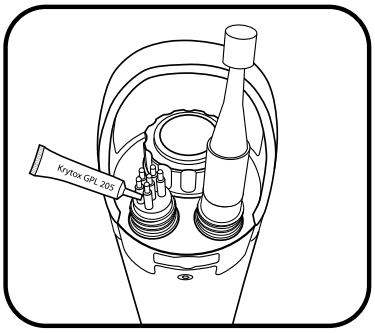
EXO sondes utilize wet-mate connectors that greatly reduce problems associated with traditional underwater connectors. However these connectors must be properly maintained to reap the full benefit of this design. Following these instructions will minimize most potential issues.

Never stick any foreign object into a female connector. Use only Krytox grease to lubricate the mating surfaces of the connectors.



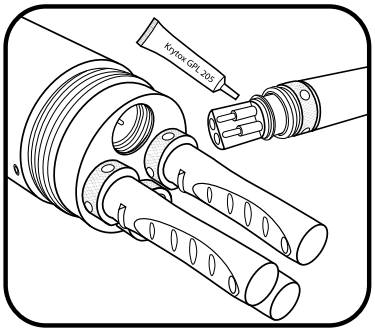
1 Female 6-pin connectors

These connectors are located on field cables, the EXO2 accessory connector, and the EXO Handheld. Periodically inspect the connectors for signs of contamination. If you detect debris, remove it with a gentle blast of compressed air. Prior to initial installation, or when dry, apply a light coat of Krytox grease to the flat rubber mating surface on top of the connector. When not in use, always install the connector's plug.



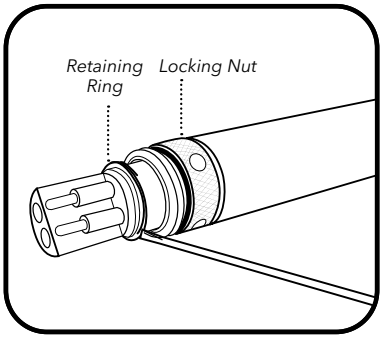
2 Male 6-pin connectors

These connectors are located on field cables and topside sonde connectors. Periodically inspect the connectors for signs of contamination. If you detect debris, carefully remove it. Prior to initial installation, or when dry, apply a light coat of Krytox grease to the rubber mating surfaces of the connector (including the rubber portions of the pins). When not in use, always install the connector's plug.



3 Sensor connectors (4-pin)

These connectors are located on sonde bulkheads (sockets) and sensors. Periodically inspect the female portions of these hermaphroditic connectors and the entire socket for contamination, and remove any debris with a gentle blast of compressed air. Prior to initial installation, or when dry, apply a light coat of Krytox grease to the rubber area of the sensor's connector.



4 Replace locking nut

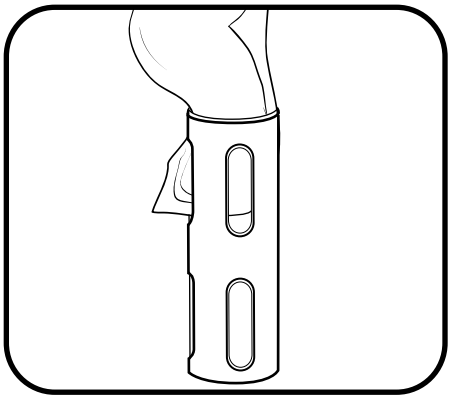
If the locking nut near the sensor connector wears out, users can replace it with 599668 (sensor) or 599669 (EXO central wiper).

First remove the retaining ring by inserting the tip of a small, flat-blade screwdriver under the lip of the ring and pry upward. Pull ring out of groove. Slide off locking nut and replace with new locking nut. Install new retaining ring by prying up one edge with screwdriver and fitting it into groove. Use the screwdriver to follow the diameter of the ring around the groove to seat it fully.

⚠ **CAUTION:** Wear eye protection when servicing the retaining ring.

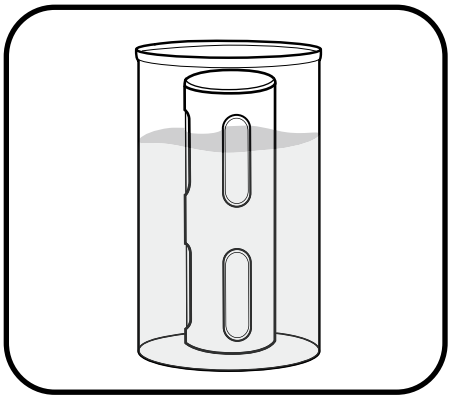
5.18 Antifouling Equipment
Maintenance

Many components on EXO sondes are made of an anti-fouling copper-alloy material that discourages the growth of aquatic organisms. However, longer deployment intervals and highly productive waters can result in biofouling of any equipment, so periodic cleaning may be required.



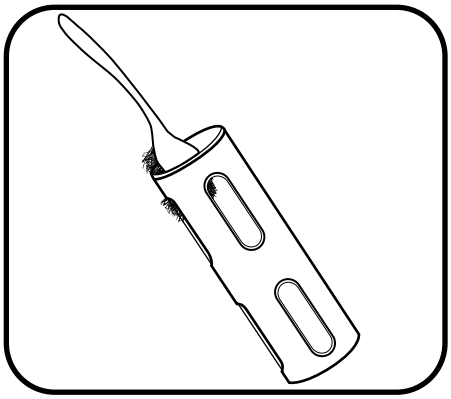
1 Remove minimal biofouling

Remove the antifouling sonde guard from the sonde. If the guard is covered in a thin layer of slime or filaments, wipe away the biofouling with a cloth soaked in clean water and a few drops of a dishwashing liquid that contains a degreaser. Rinse the guard with clean water and inspect.



2 Soak to remove heavy biofouling

Remove the antifouling sonde guard from the sonde. If the guard is covered in a thick layer of filaments or barnacles, soak the guard for 10-15 minutes in a solution of clean water and a few drops of a dishwashing liquid that contains a degreaser. Following the soak, rinse the guard with clean water and inspect.



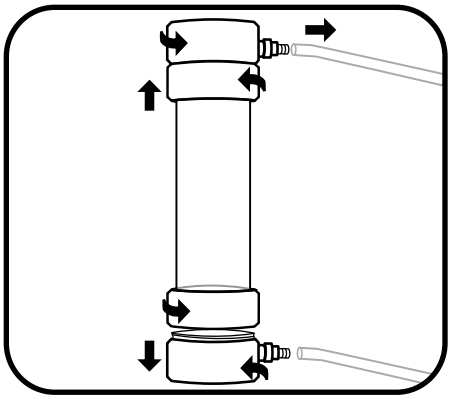
3 Scrub to remove heavy biofouling

If biofouling remains, use a small plastic scrub brush or plastic scraper to gently scrub the biofouling off the guard. Then wipe the guard with a wet, soapy cloth and rinse.

NOTICE: Do not sand or polish the inside of the guard bottom, as this may affect turbidity readings. (The guard bottom has a black coating that will eventually wear off.)

5.19 Flow Cell
Maintenance

There are two versions of the EXO flow cell: EXO1 flow cell (599080) and EXO2 / EXO3 flow cell (599201). Flow rate of the flow cell is typically between 100 mL and 1 L per minute. Maximum flow rate depends on tubing type, size, and length.
Maximum pressure for each is 25 psi.

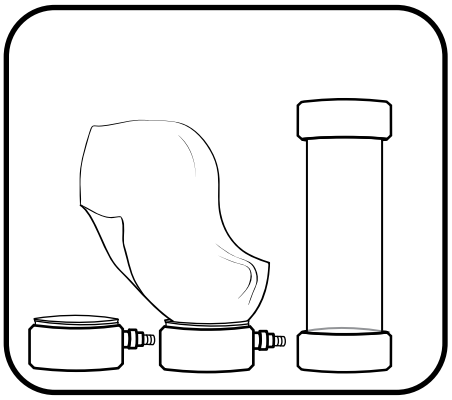


1 Disassemble flow cell

To clean the flow cell after use, unscrew and remove the sonde from the flow cell.

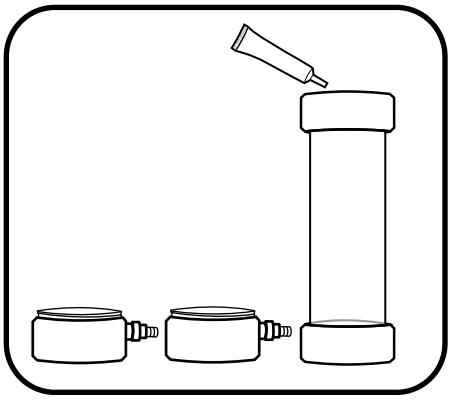
Take apart the flow cell by unscrewing the base from the locking ring. Remove the flow cell tube by gently pulling the base and the tube apart. The locking ring will remain on the tube due to the stainless steel retaining ring.

Repeat the same steps to remove the top of the flow cell from the flow cell tube.



2 Clean flow cell

Use water and a mild detergent and water to wipe clean the flow cell parts.



3 Reassemble flow cell

Make sure that the o-rings and threads are clean and free of any particles such as sand, grit, or debris. Apply a thin coat of Krytox grease to the two o-rings on the flow cell tube.

Make sure that the o-rings and stainless steel retaining rings are properly seated on the flow cell tube. Push the base of the flow cell onto the flow cell tube until it is firmly seated. This creates the watertight seal.

Screw the locking ring on to the base by turning it clockwise; do not use a tool and do not overtighten.

Repeat the same steps to reconnect the top of the flow cell to the flow cell tube.

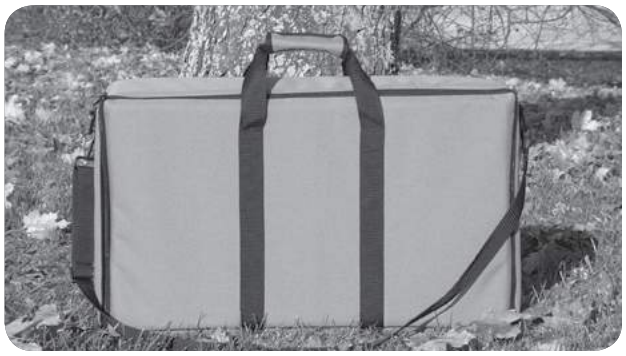
5.20 Storage Cases
Packing Options

EXO sondes are built with the most rugged and durable materials to safeguard against the risks of water monitoring. Out of the water, the EXO Hard-Sided Carrying Case provides a secure manner in which to store your EXO equipment for travel or until the next trip into the field. As seen below, the EXO Hard-Case provides the perfect safe storage solution, though we do offer several case options.

EXO Hard-Sided Wheeled Carrying Case
#599020-01 (**EXO1**) and #599020-02 (**EXO2 / EXO3**)

EXO1, EXO2 and EXO3 Storage Solutions

Within the heavy-grade plastic frame, protective foam form fits your EXO sondes. Additionally, the handheld and detached sensors rest safely within foam housing. The central portion of the case allows users to securely stow other miscellaneous items. There are two separate versions, one which will hold an EXO1 sonde, and another that holds an EXO2 or EXO3 sonde. Both versions include wheels for your convenience.



#696162 - 6-Series Soft-Sided Carrying Case

It is important to note, however, that with greater durability comes increased size and weight. The dimensions of the EXO Hard-Sided Carrying Case are larger than those of its 6-Series counterpart. Additionally, the new EXO case weighs approximately double that of the 6-Series cloth case.

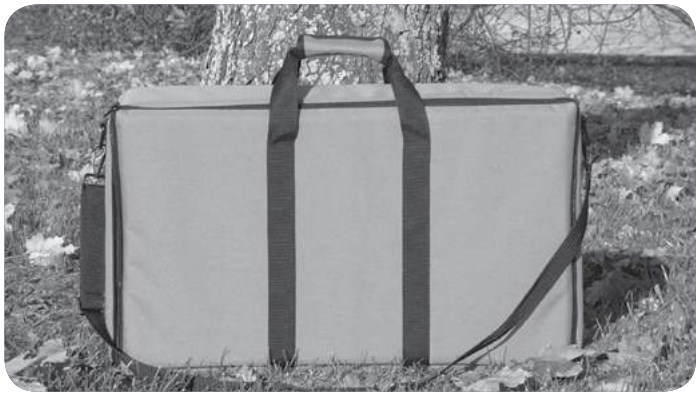
Our EXO sondes are compatible with both YSI carrying cases however, and users should choose the storage solution that is tailored to their individual circumstances. In terms of carrying capacity, both cases are unable to hold multiple EXO2 or EXO3 sondes, and the cloth YSI case can hold up to two EXO1 sondes. Thus, EXO1 users may find it advantageous to utilize that storage option.

EXO1 configuration, Soft-Sided Case

While the EXO case is designed exclusively for EXO sondes and equipment, the cloth YSI case was originally intended for use with the 6-Series product line. It is important to note that the cloth case is versatile in nature – allowing users the ability to configure their own storage structure with its Velcro lining and interlocking padded strips. This flexibility enables both EXO1 & EXO2 or EXO3 equipment to fit inside using configurations as seen in the photos.

EXO2 configuration, Soft-Sided Case

Ultimately, while the EXO equipment is built to withstand harsh field environments, we recommend users take care to safely store their systems while not in use. Both the EXO Hard-Sided Carrying Case and the cloth YSI case are viable options, but other non-YSI products may better suit more specialized user needs.
(See Appendix below for more information.)



Item Description	Part #'s
EXO1 Wheeled Carrying Case	#599020-01
EXO2 or EXO3 Wheeled Carrying Case	#599020-02

Item Description	Part #
6-Series Carrying Case, Soft-Sided (EXO1, EXO2 or EXO3 Sonde and equipment)	#696162

Appendix: Pelican Cases

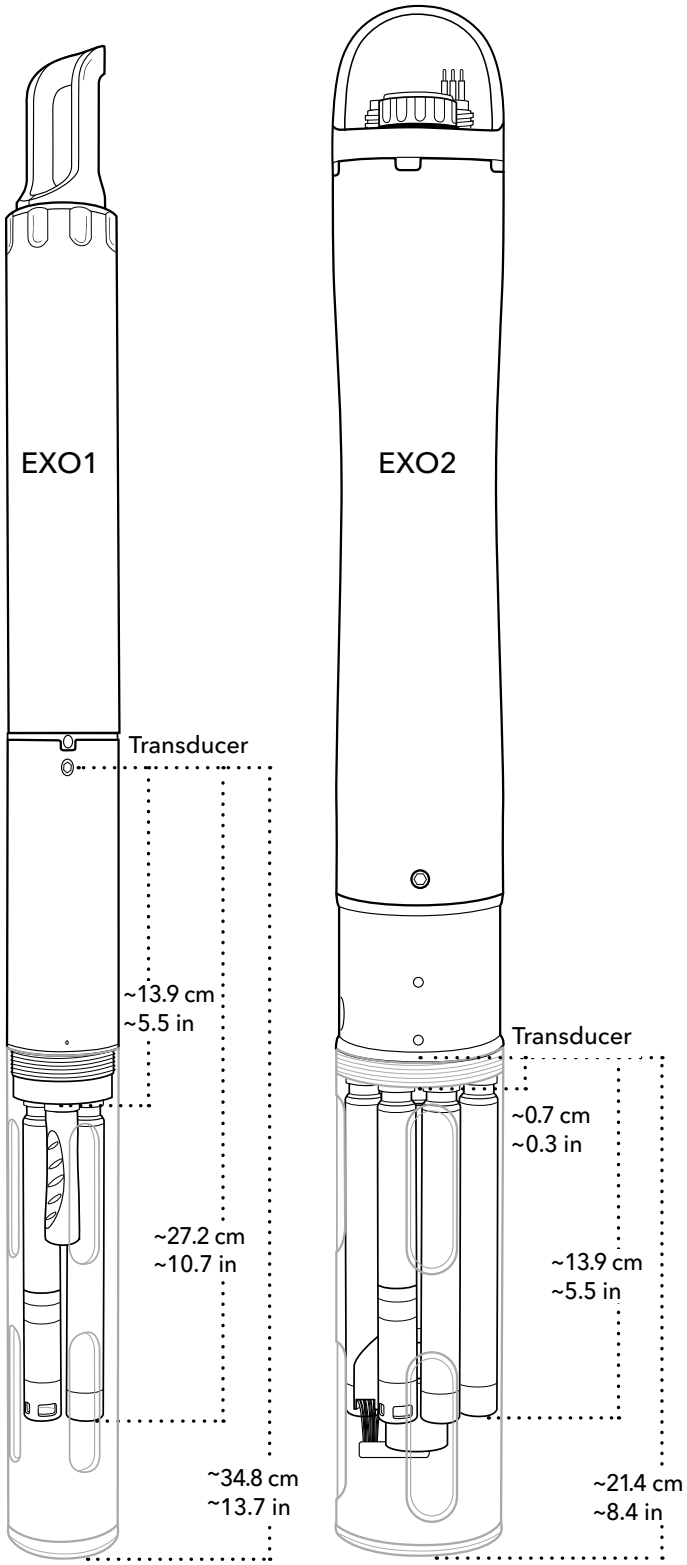
Pelican storage cases are another option for EXO users. This third party storage solution is an option for those that prefer to create their own cases for specific purposes. Two Pelican models work the best for storing EXO equipment, the Pelican 1600 and 1700. These cases can be purchased online through a number of portals but do require the user to personally customize the foam interior to fit our sondes and equipment.

Pelican-1600

Pelican-1700

Section 6
Vented Level Sonde

6.1 Vented Level Sonde
Overview



NOTE: *EXO3 sondes do not come equipped with a vented level option.*

Like EXO depth sensors, level sensors use a differential transducer with one side exposed to the water. However, unlike the depth sensors which have their back side sealed in a vacuum, the other side of the level transducer is vented to the atmosphere.

Because of this venting to the surface the transducer will only measure the water pressure exerted by the water column. Thus, the vented level option for depth measurement eliminates errors due to changes in barometric pressure because the barometric pressure is being seen on both sides of the pressure sensor. This is accomplished by using a special sensor that has been vented to the outside atmosphere by way of a tube that runs through the sonde and cable. This tube must remain open and vented to the outside atmosphere to function. No foreign objects can block the openings.

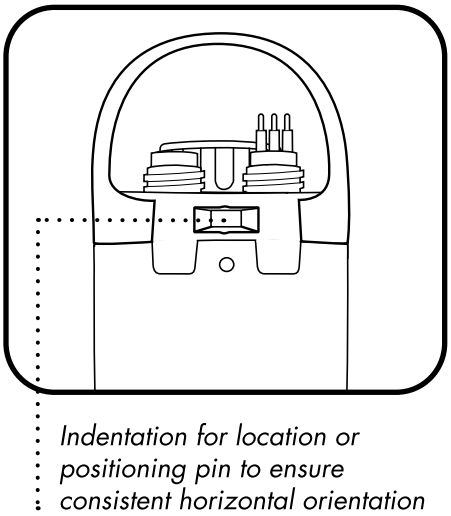
NOTICE: Never expose the sonde or the cable to the atmosphere for more than a few minutes without an active desiccant or connector dummy plug in place. Moisture or high humidity air entering the vent tubes can condense and block the tube, affecting accuracy; it could also cause damage to the transducer that is not covered by the warranty.

Special field cables are required for vented level measurements. These cables have a vent tube running through the center and connect to the EXO sonde at the connector near the bail. In the center of the sonde's connector is a matching vent hole. When attached, the vented cable allows the sonde to vent through the water column and thus gain a more accurate depth measurement.

6.2 Vented Level Sonde
Installation

When installing a vented level sonde, users must ensure that the sonde never exceeds an operational depth of 10 meters. Provisions for floods, astronomical tides and severe storm events should be factored in.

NOTICE: Exposing the depth sensor to depths greater than 10 meters could result in damage to the pressure sensor that is not covered by the warranty.



Indentation for location or positioning pin to ensure consistent horizontal orientation

Location of Depth Sensor

For best measurement accuracy when installing a sonde, the sonde's orientation and position must remain fixed.

When deploying the sonde vertically, take care to ensure the sonde is redeployed in the same position. Use a location pin or suspend the sonde using materials that cannot stretch (chain, wire rope) to ensure a fixed location.

Depth sensors on the EXO2 sondes are not on center. In horizontal deployments, take care to ensure the redeployments are always in the same orientation.

To assist with consistent horizontal orientation, the EXO2 sonde has an indentation at the top of the sonde for a location or positioning pin.

NOTICE: Never band clamp a sonde. This can lead to the sonde body becoming warped and taking on water.

EXO1 Depth Sensor Reference Points (see diagram in Section 6.1)

- From bottom of sensor guard (metal or plastic) to transducer diaphragm: ~34.8 cm / ~13.7 inches
- From face of sensor endcap to transducer diaphragm: ~27.2 cm / ~10.7 inches
- From face of connector bulkhead to transducer diaphragm: ~13.9 cm / ~5.5 inches

EXO2 Depth Sensor Reference Points (see diagram in Section 6.1)

- From bottom of sensor guard (plastic or metal) to transducer diaphragm: ~21.4 cm / ~8.4 inches
- From face of sensor endcap to transducer diaphragm: ~13.9 cm / ~5.5 inches
- From face of connector bulkhead to transducer diaphragm: ~0.7 cm / ~0.3 inches
- Horizontally positioned sonde, from outer case (location pin down) to transducer diaphragm: ~2.1 cm / ~0.8 inches

Ambient Light Interference

When deploying horizontally, it is best to keep the sonde's optical sensors out of direct sunlight. We suggest:

- Installing the sonde in a PVC pipe that has adequate openings for flow
- Aiming the sensors north in northern hemisphere or south in southern hemisphere
- Using a sun shield if the sonde is in the open

6.3 Vented Cables and Desiccants
Installation

Cables

Vented cables for EXO have a maximum length of 33 meters, so when connecting a sonde to a data logger, users should use a junction box to reach further distances. In the junction box, the EXO cable can connect to the desiccant, as well as another cable running to the data logger or DCP device.

- Avoid bending vented cables sharply to prevent the inner tube from kinking. (Min. bend radius 20.3 cm/8 in.)
- EXO vented cables have a reduced length to prevent tube damage from their own weight.
- EXO vented cables **do not** have wet-mate connectors—any water or humidity entering the vent tube will cause damage to the pressure sensor that is not covered by the warranty.
- EXO vented cables are not equipped with the barbed fitting for small desiccant cartridges.

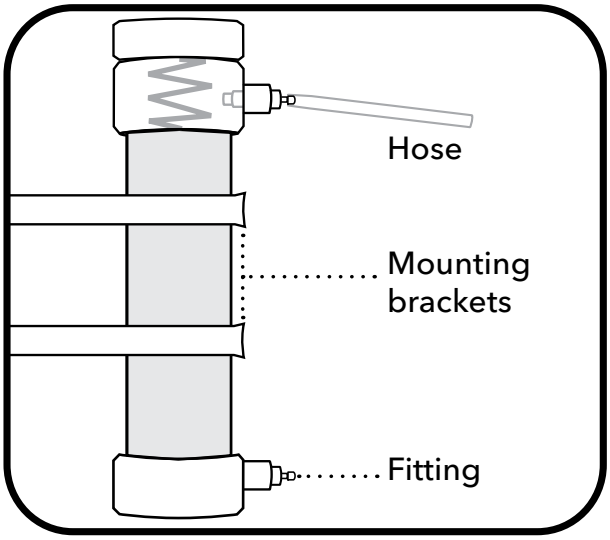
Desiccants

> **NOTICE:** All EXO sondes with vented level require the use of a desiccant. Any damage to the sensor due to the lack of desiccant use is not covered under warranty.

Two desiccant systems are available, a cartridge kit (YSI 6108) and a canister kit (YSI 6109). *For all EXO sondes we strongly recommend the 6109 canister kit*. The 6109 desiccant canister contains a larger amount of desiccant and is intended for long-term deployments (can last up to 1 year in severe conditions). It also contains mounting brackets for mounting the canister to a nearby structure. The smaller 6108 kit requires replacement frequently in high humidity environments.

> **NOTICE:** A desiccant or a connector dummy plug must always be attached to the sonde and cable to prevent moisture from entering into the vent tubes.

Users must also ensure that the desiccant always remains active. Active desiccant is a blue color, and when it can absorb no more moisture, it is a pink color. The end that is vented to the atmosphere will begin to change color first. As long as the desiccant closest to the sonde is blue, no maintenance is required. Local conditions will dictate how long the desiccant will last. In humid environments, the desiccant may need to be changed or regenerated before it is completely exhausted to ensure that it lasts the entire deployment.



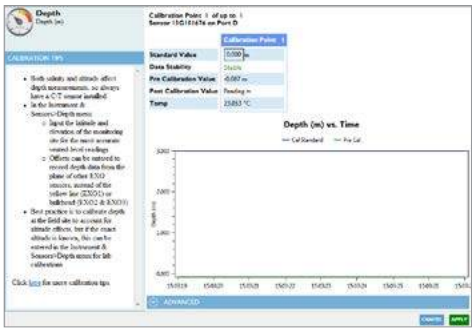
Installing YSI 6109 Desiccant Canister

- Remove the 1/8" NPT plugs from the stainless steel fittings on the canister.
- Install the 1/8" NPT to 1/8" hose fittings into the stainless steel fittings located on the side of the desiccant canister. Do not over-tighten.
- Place the plugs over the fittings on the canister until you are ready to use the canister.
- Using suitable screws fasten the canister mounting brackets to an appropriate support structure. The spacing between the brackets must accommodate the length of the canister. The canister must be located within a few feet of the cable end.
- Remove the plug from the top fitting of the canister. Remove the plug from the barbed fitting on the end of the cable. Using the tubing provided in the kit, connect the canister to the fitting on the end of the cable. Remember to remove the remaining plug from the canister when ready to begin sampling. When putting the sonde into service, remove the plug to ensure that the sensor in the sonde is vented to the atmosphere.

6.4 Calibration

NOTE: *This calibration option is available only if your sonde is equipped with a vented level sensor.*

For the calibration, make certain that the vented level sensor is in air and not immersed in any solution. Orient the sonde in the same position as it will be deployed. Also, never calibrate a vented level depth sensor with a non-vented cable.



In the desktop KorEXO Calibrate menu, select Depth, then select Depth m to calibrate.

NOTE: If a depth offset is entered, the output value will shift by the value of the offset. Users may use an offset if referencing a water elevation against a known datum.

Observe the Pre Calibration Value readings and the Data Stability, and when they are Stable, click Apply to accept this calibration point. This process zeros the depth sensor.

Click Exit to return to the sensor calibration menu.

For best performance of vented level measurements, users should ensure that the orientation of the sonde remains constant while taking readings. Keep the sonde still and in one position while calibrating.

Advanced

Mounting: Use the Advanced menu to select if a sonde will be mounted in a moving/profiling deployment instead of a fixed location.

Depth Offset: Enter a value in meters (m) to offset the depth at the point of measurement.

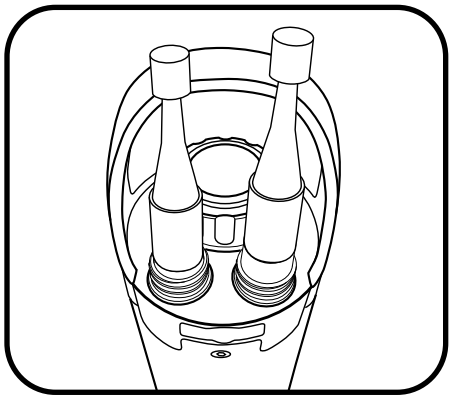
Altitude/Latitude: Enter the coordinates for the local altitude (in meters, relative to sea level) and latitude (in degrees) where the sonde is sampling. Latitude values are used in the calculation of depth and level to account for global variations in the gravitational field.

NOTE: *You must be within 500 feet (152.4 meters) and 1 degree, respectively.*

6.5 Maintenance and Storage

Short-term Storage

NOTICE: It is important that the air in a sonde's vent tube remains dry at all times.



Level Sensor Storage

Users can store these sensors either dry or submerged in clean water. However, regardless of storage method or length, ensure the vent tube remains dry. Always attach the port plug to the cable connector, or leave the cable installed with a cap over the desiccant's vent.

Level Desiccant Maintenance

Active desiccant is blue; saturated desiccant is pink or rose red. When the desiccant closest to the sonde begins to turn pink, you should replace (YSI 6108), or regenerate (YSI 6109) the desiccant cartridge.

To regenerate desiccant, remove it from the cartridge and heat it for one hour at 200°C (about 400°F); then cool it an airtight container before refilling. Also heat the felt filters at 100°C (about 200°F) for 30 minutes. The desiccant will turn blue following a successful recharge.

Connectors Maintenance

Connectors on vented level cables have five pins and a vent pin. Periodically inspect the connectors for signs of contamination. If you detect debris, carefully remove it. Prior to initial installation, or when dry, apply a *light* coat of Krytox grease to the rubber mating surfaces of the connector (including the rubber portions of the pins).

NOTICE: Do not allow grease to enter or block the vent tube on the cable connector or the vent opening on the sonde connector.

When not in use, always install the sonde and cable dummy plugs.

Cable Storage

Users should leave the cable installed on the sonde to protect the connectors. If necessary users may remove it from the sonde, but extra care should be taken to protect the connectors. For vented cables, ensure the storage cap is affixed to the desiccant inlet. Store vented cables in a bag containing desiccant.

NOTE: *Minimum bend radius for coiling cable is 8 inches (20.32 cm).*

Section 7
Accessories

7.1 Accessories
Ordering

Telephone: 800 897 4151 (USA)
+1 937 767 7241 (Globally) Monday through Friday, 8:00 AM to 5:00 ET
Fax: +1 937 767 9353 (orders)
Email: info@ysi.com
Mail: YSI Incorporated 1725 Brannum Lane
Yellow Springs, OH 45387 USA
YSI.com

When placing an order please have the following available:

1. YSI account number (if available)
2. Name and phone number
3. Purchase Order or Credit Card number
4. Model Number or brief description
5. Billing and shipping addresses
6. Quantity

EXO1 Sondes

YSI Item #	Description
599501-00	EXO1 Sonde, No Depth, 4 Sensor Ports
599501-01	EXO1 Sonde, 10 meter Depth, 4 Sensor Ports
599501-02	EXO1 Sonde, 100 meter Depth, 4 Sensor Ports
599501-03	EXO1 Sonde, 250 meter depth, 4 Sensor Ports
599501-04	EXO1 Sonde, 10 meter vented level depth, 4 Sensor Ports

EXO2 Sondes

YSI Item #	Description
599502-00	EXO2 Sonde, No Depth, 6 Sensor Ports, 1 Wiper Port
599502-01	EXO2 Sonde, 10 meter depth, 6 Sensor Ports, 1 Wiper Port
599502-02	EXO2 Sonde, 100 meter Depth, 6 Sensor Ports, 1 Wiper Port
599502-03	EXO2 Sonde, 250 meter depth, 6 Sensor Ports, 1 Wiper Port
599502-04	EXO2 Sonde, 10 meter vented level depth, 6 Sensor Ports, 1 Wiper Port

EXO3 Sondes

YSI Item #	Description
599503-00	EXO3 Sonde, No Depth, 4 Sensor Ports, 1 Wiper Port
599503-01	EXO3 Sonde, 10 meter depth, 4 Sensor Ports, 1 Wiper Port
599503-02	EXO3 Sonde, 100 meter Depth, 4 Sensor Ports, 1 Wiper Port
599503-03	EXO3 Sonde, 250 meter depth, 4 Sensor Ports, 1 Wiper Port

EXO Handheld

YSI Item #	Description
599622	EXO Classic Handheld, Rechargeable Lithium-Ion Battery Pack
599960	EXO Handheld (v2) Display

EXO Signal Output Adapters

YSI Item #	Description
599820	EXO Signal Output Adapter - Data Collection Platform (DCP) 2.0
599825	EXO Signal Output Adapter - Modbus
599810	EXO Signal Output Adapter - USB (Necessary for firmware updates.)

EXO Cables

YSI Item #	Description
599040-2	EXO 2 meter Field Cable
599040-4	EXO 4 meter Field Cable
599040-10	EXO 10 meter Field Cable
599040-15	EXO 15 meter Field Cable
599040-33	EXO 33 meter Field Cable
599040-66	EXO 66 meter Field Cable
599040-100	EXO 100 meter Field Cable
599040-150	EXO 150 meter Field Cable
599040-200	EXO 200 meter Field Cable
599040-250	EXO 250 meter Field Cable
599040-300	EXO 300 meter Field Cable
599008-10	EXO 10 meter Flying Lead Cable
599008-15	EXO 15 meter Flying Lead Cable
599008-33	EXO 33 meter Flying Lead Cable
599008-66	EXO 66 meter Flying Lead Cable
599008-100	EXO 100 meter Flying Lead Cable
599210-4	EXO 4 meter VENTED Flying Lead Cable
599210-10	EXO 10 meter VENTED Flying Lead Cable
599210-15	EXO 15 meter VENTED Flying Lead Cable
599210-33	EXO 33 meter VENTED Flying Lead Cable

EXO Sensors & EXO Central Wiper

YSI Item #	Description
599870	EXO Conductivity/Temperature Sensor
599827	EXO Wiped Conductivity/Temperature Sensor
599701	EXO pH Sensor Assembly, Guarded
599705	EXO pH/ORP Sensor Assembly, Guarded
599702	EXO pH Sensor Assembly, Unguarded
599706	EXO pH/ORP Sensor Assembly, Unguarded
599710	EXO Ammonium Sensor Assembly,Guarded
599711	EXO Chloride Sensor Assembly, Guarded
599709	EXO Nitrate Sensor Assembly, Guarded
599100-01	EXO Optical DO Sensor
599101-01	EXO Turbidity Sensor
599102-01	EXO Total Algae - PC Sensor
599103-01	EXO Total Algae - PE Sensor
599104-01	EXO fDOM Sensor
599090-01	EXO Central Wiper

EXO Replaceable Sensor Tips

YSI Item #	Description
599795-01	EXO pH Sensor Replacement Module, Guarded (User replaceable tip for 599701)
599795-02	EXO pH Sensor Replacement Module, Un-Guarded (User replaceable tip for 599702)
599797-01	EXO pH/ORP Sensor Replacement Module, Guarded (User replaceable tip for 599705)
599797-02	EXO pH/ORP Sensor Replacement Module, Un-Guarded (User replaceable tip for 599706)
599744-01	EXO Ammonium Sensor Replacement Module, Guarded (User replaceable tip for 599710)
599743-01	EXO Nitrate Sensor Replacement Module, Guarded (User replaceable tip for 599709)
599745-01	EXO Chloride Sensor Replacement Module, Guarded (User replaceable tip for 599711)

EXO General Accessories

YSI Item #	Description
599020-01	EXO1 Wheeled Carrying Case, Black
599020-02	EXO2 / EXO3 Wheeled Carrying Case, Black
599470	EXO C/T Sensor Cleaning Brush
599831	EXO Wiped C/T Sensor, Spacing Kit
599080	EXO1 Flow Cell
599201	EXO2 / EXO3 Flow Cell
599786	EXO1 Calibration/Storage Cup
599316	EXO2 / EXO3 Calibration / Storage Cup
599471	EXO1 Sonde Weight Kit
599472	EXO2 / EXO3 Sonde Weight Kit
599473	EXO1 Replacement Bail
599474	EXO2 / EXO3 Replacement Bail
599475	EXO 4-Pin Bulkhead Connector Port Plug
599594	EXO Tool Kit
599680	EXO1 Replacement O-Ring Kit
599681	EXO2 / EXO3 Replacement O-Ring Kit
599677	EXO Sensor O-Ring Kit

YSI Item #	Description
599110	DO Sensor Cap Replacement Kit
599595	EXO Coastal Anode Kit
599520	EXO1 Coastal Anode Guard Weight Kit
599521	EXO2 Coastal Anode Guard Weight Kit
599338	KorEXO User Interface Software USB
599668	EXO Sensor Retaining Nut Kit, Sensors
599669	EXO Sensor Retaining Nut Kit, Wiper
599666	EXO1 Guard Assembly Kit
599667	EXO2 / EXO3 Guard Assembly Kit
599673	EXO Central Wiper Brush Kit
599665	EXO Replacement 6-pin Female Dummy Plug
599664	EXO Replacement 6-pin Male Dummy Plug
599676	EXO Wiper Brush Guard replacement Kit
599469	EXO Sensor tool and magnet activation kit
599352	Krytox Lubricant
006109	Desiccant Canister Kit
006108	Desiccant Cartridge Kit

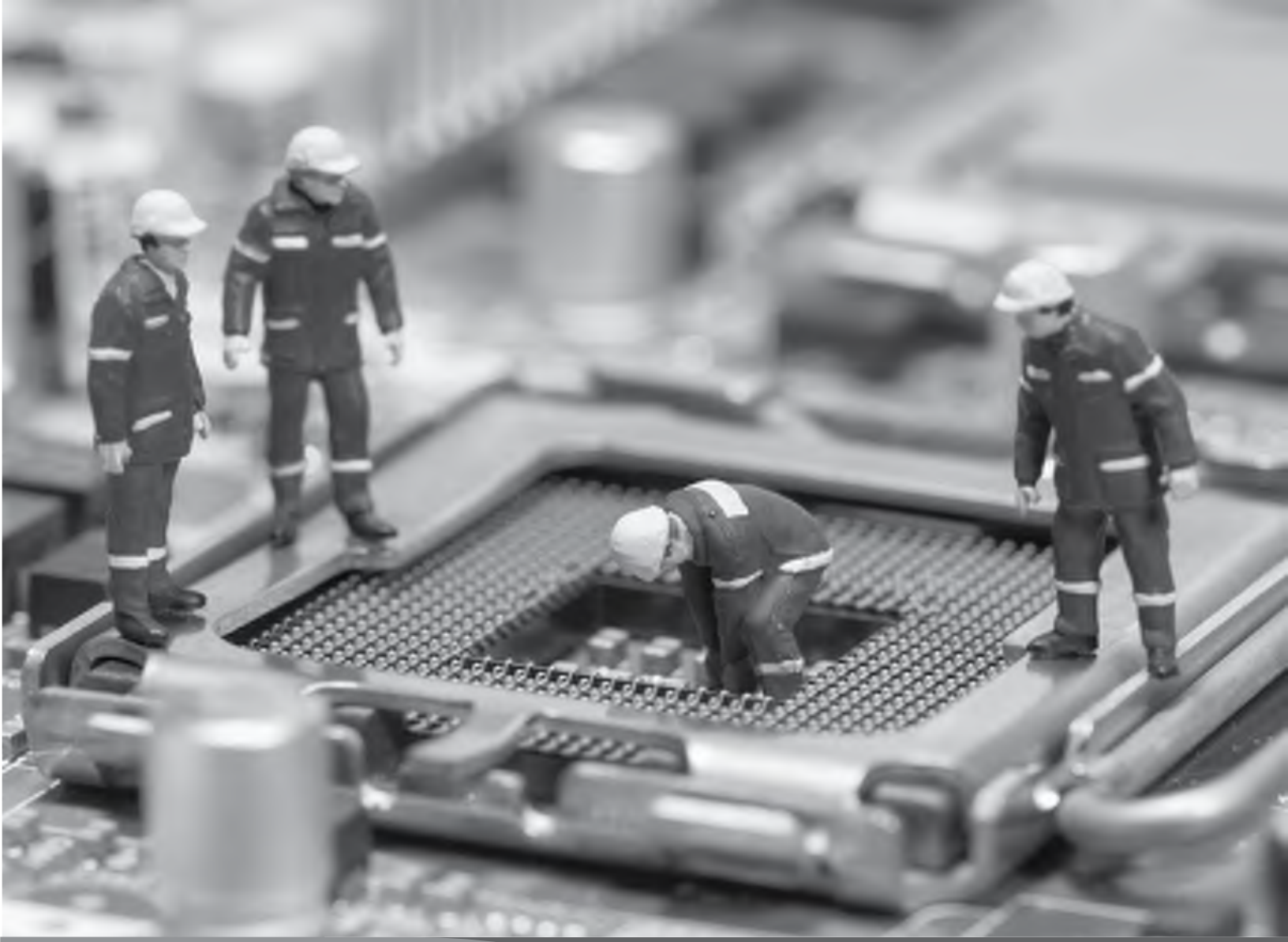
EXO Antifouling Accessories

YSI Item #	Description
599867	EXO Anti Fouling C/T Screen
599563	EXO1 Anti-Fouling Guard
599564	EXO2 / EXO3 Anti-Fouling Guard
599663	EXO2 / EXO3 Probe and Sonde protective sleeves
6189-AF	Copper tape kit
C-SPRAY	Protective probe solution, 100 mL bottle

Calibration Standards and Solutions

YSI Item #	Description
065270	Conductivity Cal. - 1,000 umhos/cm (quart)
065272	Conductivity Cal. - 10,000 umhos/cm (quart)
065274	Conductivity Cal. - 100,000 umhos/cm (quart)
060907	Conductivity Cal. - 1,000 umhos/cm (8 ea, pint)
060911	Conductivity Cal. - 10,000 umhos/cm (8 ea, pint)
060660	Conductivity Cal. - 50,000 umhos/cm (8 ea, pint)
061320	Zobell Solution - For ORP cal. - 125 mL
061321	Zobell Solution - For ORP cal. - 250 mL
061322	Zobell Solution - For ORP cal. - 500 mL

YSI Item #	Description
003821	pH 4 Buffer - Box of 6 pints
003822	pH 7 Buffer - Box of 6 pints
003823	pH 10 Buffer - Box of 6 pints
603824	Assorted pH Buffers - 2 pints of 4 - 2 pints of 7 - 2 pints of 10"
003841	Ammonium Cal Solution - 1 mg/L (500mL)
003842	Ammonium Cal Solution - 10 mg/L (500mL)
003843	Ammonium Cal Solution - 100 mg/L (500mL)
003885	Nitrate Standard - 1 mg/L (500mL)
003886	Nitrate Standard - 10 mg/L (500mL)
003887	Nitrate Standard - 100 mg/L (500mL)
608000	Turbidity Std. - 0 NFU, 0 NTU - 1 Gallon
607200	Turbidity Std. - 12.4 FNU - 1 Gallon
607300	Turbidity Std. - 124 FNU - 1 Gallon
607400	Turbidity Std. - 1010 FNU - 1 Gallon



Section 8
Health and Safety, Warranty, Service

8.1 Health and Safety
Chemicals

NOTE: *For additional health, safety, and disposal information about reagents, download the MSDS documents for the chemical in question from the EXO manufacturers' websites*: www.ysi.com or www.wtw.de.

First Aid for all solutions

Inhalation	Move to fresh air. If breathing is difficult, give oxygen. If symptoms persist, seek medical attention.
Skin Contact	Remove contaminated clothing and wash. Wash exposed area with soap and water for at least 15 minutes. If irritation persists, seek medical attention.
Eye Contact	Rinse eyes immediately with large amounts of water, also under eyelids, for at least 15 minutes. If irritation persists, seek medical attention.
Ingestion	Wash out mouth with water and then drink plenty of water. If symptoms persist, seek medical attention.

Ammonium Solutions

3841, 3842, and 3843

Ingredients: Water, Ammonium Chloride, Lithium Acetate Dihydrate, Sodium Azide, Hydrochloric Acid

Nitrate Solutions

3885, 3886, and 3887

Ingredients: Water, Potassium Nitrate, Magnesium Sulfate Heptahydrate, Gentamycin Sulfate

Inhalation: Avoid breathing vapors or mists. Ensure adequate ventilation is available before handling.

Skin: Wear lightweight protective clothing, gloves, and apron.

Eyes: Wear safety glasses with side-shields or face shield. Contact lenses should not be worn when working with these solutions.

Ingestion: May be harmful if swallowed. Wear a mouth cover or face shield when there is splashing. Keep away from food and drink.

First Aid: See box at left.

Conductivity Solutions

3161, 3163, 3165, 3167, 3168, and 3169

Ingredients: Water, Potassium Chloride

Inhalation: Avoid breathing vapors or mists. Inhalation of dust may cause irritation of respiratory tissues. Ensure adequate ventilation is available before handling.

Skin: Exposure may cause irritation with repeated exposure. Wear lightweight protective clothing, gloves, boots, and apron.

Eyes: Can cause irritation and potential eye damage with repeated exposure. Wear safety glasses with side-shields or face shield.

Ingestion: May cause irritation of mouth, throat, and an upset stomach. Wear a mouth cover or face shield when there is splashing. Keep away from food and drink. Do not swallow.

First Aid: See box at left.

pH 4.00, 7.00, 10.00 Buffer Solutions

3821, 3822, and 3823

pH 4 Ingredients: Water, Potassium Hydrogen Phthalate, Red food coloring

pH 7 Ingredients: Water, Potassium Phosphate Monobasic, Sodium Hydroxide, Yellow food coloring

pH 10 Ingredients: Water, Potassium Hydroxide, Disodium EDTA dihydrate, Potassium Borate, Potassium Carbonate, Bromphenol Blue Sodium Salt, Bromphenol Green Sodium Salt

Inhalation: Avoid breathing vapors or mists. Inhalation of dust may cause irritation of respiratory tissues. Ensure adequate ventilation is available before handling.

Skin: Exposure may cause irritation with repeated exposure. Wear rubber or neoprene gloves.

Eyes: Can cause irritation and potential eye damage with repeated exposure. Wear safety glasses with side-shields or face shield. Contact lenses should not be worn when working with these solutions.

Ingestion: May cause nausea, vomiting, or diarrhea. Wear a mouth cover or face shield when there is splashing. Do not swallow. Do not induce vomiting.

First Aid: See First Aid table.

Zobell Solution

3682

Ingredients: Potassium Chloride, Potassium Ferrocyanide Trihydrate, Potassium Ferricyanide

Inhalation: Inhalation of dust may cause irritation of respiratory tissues. Ensure adequate ventilation is available before handling.

Skin: Exposure may cause irritation. Wear lightweight protective clothing, gloves, boots, and apron.

Eyes: May cause irritation. Wear safety glasses with side-shields or face shield.

Ingestion: May cause an upset stomach. Wear a mouth cover or face shield when there is splashing. Keep away from food and drink. Do not swallow. If large amount is ingested and person is conscious, induce vomiting.

First Aid: See First Aid table.

Turbidity Standard

6073

Ingredients: Water, Styrene divinyl Benzene copolymer beads

The material is not volatile and has no known ill effects on skin, eyes, inhalation or ingestion. Therefore, no special precautions are required when using the standards. However, general precautions should be adopted as required with all materials to minimize unnecessary contact.

First Aid: See First Aid table.

Ultraviolet Light

The fDOM sensor radiates ultraviolet light (UV light) which can be harmful to the eyes even during brief periods of exposure. Do not look into the light at the tip of the probe and wear protective eyewear when handling UV LEDs.

Lithium-Ion Battery Handling

⚠ **WARNING:** Failure to exercise care when handling this product and to comply with the following conditions and guidelines could result in product malfunction, excessive heat, fire, property damage, and ultimately injury.

- **DO NOT** alter, puncture, or impact battery or related components.
- **DO NOT** directly connect the terminals with metal objects.
- **DO NOT** expose the battery to extreme temperatures or direct extended exposure to sunlight.
- Always disconnect batteries when not in use and for long term storage.
- Store batteries in a non-conductive and fireproof container.
- For best results, store the battery at approximately 50% of the capacity.

If at any time the battery becomes damaged, hot, or begins to balloon or swell, discontinue charging (or discharging) immediately. Quickly and safely disconnect the charger. Then place the battery and/or charger in a safe, open area way from flammable materials. After one hour of observation, remove the battery from service. **DO NOT** continue to handle, attempt to use, or ship the battery. Failure to follow these procedures can cause damage to the battery, personal property or cause serious injury.

Damaged or swollen batteries can be unstable and very hot. **DO NOT** touch batteries until they have cooled. In the event of a fire use a Class A, B, or C fire extinguisher. **DO NOT** use water.

If the internal battery fluid comes into contact with your skin, wash the affected area(s) with soap and water immediately. If it comes into contact with your eye(s), flush them with generous amounts of water for 15 minutes and seek immediate medical attention.

8.2 Radio Frequency

Xylem certifies that the EXO product line has been tested and complies with the following radio frequency (RF) interference standards and are approved for use in the following countries:

- United States: FCC Part 15 compliant
- Canada: RSS compliant
- European Union (EU): CE compliant
- Australia: CISPR 11 compliant
- New Zealand: CISPR 11 compliant
- Republic of Korea: Radio Waves Act compliant
- Japan: TELEC Radio Law compliant
- Brazil: Anatel certification compliant

Reference the Declaration of Conformity in the next section for further details.

Bluetooth wireless technology and similar approvals and regulations can be country-specific. Check local laws and regulations to insure that the use of wireless products purchased from Xylem or its subsidiaries are in full compliance.

8.3 Declarations of Conformity

The undersigned hereby declares that the products listed below conform with all applicable requirements of FCC Part 15 for the U.S. and Industry Canada (IC) ICES-003 for Canada.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO Sondes (EXO1, EXO2 and EXO3), EXO Handheld (V2) and EXO GO
Model numbers:	599501-xx, 599502-xx, 599503-xx, 599960, 577400
Intentional Radiators:	EXO Sondes (EXO1, EXO2 and EXO3) contain a *Bluetooth* module: FCC ID: T7VPAN10 IC: 216Q-PAN10 EXO GO contains a Wi-Fi/*Bluetooth* module: FCC ID: T9J-RN42 IC: 6514A-RN42
Regulations:	• FCC 47 CFR Part 15 • IC ICES-003

Gregory Popp, Quality Manager
January 14th, 2019

The undersigned hereby declares that the products listed below conform with all applicable Essential Requirements of the listed Directives and Standards and carry the CE mark accordingly.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO Sondes (EXO1, EXO2 and EXO3), EXO Handheld (v2) and EXO GO
Model numbers:	599501-xx, 599502-xx, 599503-xx, 599960, 577400
Accessories/Sensors:	599090-xx, 599100-xx, 599101-xx, 599102-xx, 599104-xx, 599118-xx, 599800, 599810, 599870, 599040-xx, 599008-xx
Intentional Radiators:	EXO Sondes (EXO1, EXO2 and EXO3) contain a *Bluetooth* module. The EXO GO (577400) contains a *Bluetooth* module. Nemko Certified Body ID#CE 2302.

Directives:

- EMC 2014/30/EU
- RED 2014/53/EU
- LVD 2014/35/EU
- R&TTE 1999/5/EC
- WEEE 2012/19/EU
- RoHS 2011/65/EU

Harmonized Standards:

- EN61326-1:2013, Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements
- EN 61326-2-3:2013, Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 2-3: Particular requirements - Test configuration, operational conditions and performance criteria for transducers with integrated or remote signal conditioning
- EN 60950-1:2006 + A11:2009 + A12:2011 + A1:2010 + A2:2013, Information technology equipment - Safety - Part 1: General requirements
- EN 300 328 V2.1.1:2017, Wideband transmission systems; Data transmission equipment operating in the 2,4 GHz ISM band and using wide band modulation techniques; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU
- EN 301 489-1 V1.9.2:2011, Electromagnetic compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements
- EN 301 489-17:2009, V2.1.1, Electromagnetic compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment; Part 17: Specific conditions for Broadband Data Transmission Systems
- EN61000-3-2:2014, Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)
- EN61000-3-3:2013, Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current <= 16 A per phase and not subject to conditional connection

Gregory W. Popp

Gregory Popp, Quality Manager
January 14th, 2019

The undersigned hereby declares that the products listed below conform with the Australian and New Zealand Electromagnetic Compatibility (EMC) requirements for generic products to be used in residential, commercial, and light industrial environments, and carry the C-Tick mark accordingly.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO Sondes (EXO1, EXO2 and EXO3), EXO Handheld (v2) and EXO GO
Model numbers:	599501-xx, 599502-xx, 599503-xx, 599960, 577400
Accessories/Sensors:	599090-xx, 599100-xx, 599101-xx, 599102-xx, 599104-xx, 599118-xx, 599800, 599810, 599870, 599040-xx, 599008-xx
Intentional Radiators:	EXO Sondes (EXO1, EXO2 and EXO3) contain a *Bluetooth* module. EXO GO (577400) contains a *Bluetooth* module. Nemko Certified Body ID#CE 2302.

Regulations:

- Australian ACMA Standards for C-Tick mark, Section 182 of the Radiocommunications Act 1992.
- New Zealand RSM Standards, Radiocommunications Act 1992.
- Telecommunications Labeling, Notice 2001 under section 407 of the Australian Telecommunications Act 1997.

Standards:

- EN61326-1:2006, Electrical equipment for measurement, control, and laboratory use – EMC requirements – Part 1: General Requirements.
- ACMA Radio Communications (Short Range Devices), 2004.
- AS/NZ 4268, 2008.
- Radio Communications (Electromagnetic Radiation - Human Exposure) Standard, March 2003.

Gregory Popp, Quality Manager
January 14th, 2019

The undersigned hereby declares that the products listed below conform with all applicable requirements of the Radio Waves Act of Korea, for intentional radiators.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO Sondes (EXO1, EXO2 and EXO3) and EXO GO
Model numbers:	599501-xx, 599502-xx, 599503-xx, 577400
Intentional Radiators:	EXO Sondes (EXO1, EXO2 and EXO3) contain the PAN1026 *Bluetooth* module. Broadcasting and certification number R-C-XYL-EXO1 (for EXO1), R-C-XYL-EXO2 (for EXO2) and R-C-XYL-EXO3-PAN1026 (for EXO3). EXO GO (577400) contains a *Bluetooth* module. Broadcasting and certification number KCC-CRI-AEP-RN-42.
Type Identification:	LARN8-IO2Y2402/2480TR0.000003F1D79 (EXO1) LARN8-IO2Y2402/2480TR0.00001F1D79 (EXO2) LARN8-IO2Y2402/2480TR0.001F1D79 (EXO3) LARN8-IO2Y2402/2480TR0.00003F1DG1D79 (EXO Handheld)
Regulation:	Radio Waves Act of the Republic of Korea.

A급 기기 (업무용 방송통신 기자재)
이 기기는 업무용 (A급) 전자파 적합기기로서
판매자 또는 사용자는 이 점을 주의하시기 바라
며, 가정 외의 지역에서 사용하는 것을 목적으 로 합니다.

Class A device (Broadcasting and communication equipment for office work).

Seller and user shall be noticed that this equipment is suitable for electromagnetic equipment for office work (Class A) and it can be used outside the home.

KCC notice 2012-12. Radio device using 2400-2483.5 MHz and 5725-5825 MHz.

해당 무선설비는 전파혼신
가능성이 있으므로 인명안전과
관련된 서비스는 할 수 없음.

Service related to human safety is not allowed because this device may have the possibility of the radio interference.

Gregory Popp, Quality Manager
January 14th, 2019

The undersigned hereby declares that the products listed below conform with all applicable requirements of the Radio Regulations of China, for intentional radiators.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO GO
Model numbers:	577400
Intentional Radiators:	The EXO GO (577400) contains a *Bluetooth* module.
CMIIT ID:	CMIIT ID: 2018DJ2145 (EXO GO)
Regulation:	Radio Regulations of the People's Republic of China.

A级设备（办公用广播和通讯设备）
销售商和使用者应注意本设备适用于办公条件下的电磁环境（A级）并可以在室外使用。

Class A device (Broadcasting and communication equipment for office work).
Seller and user shall be noticed that this equipment is suitable for electromagnetic equipment for office work (Class A) and it can be used outside the home.

Gregory Popp, Quality Manager
January 14th, 2019

The undersigned hereby declares that the products listed below conform with all applicable requirements of TELEC and Radio Law of Japan for intentional radiators.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO Sondes (EXO1,EXO2 and EXO3) and EXO GO
Model numbers:	599501-xx, 599502-xx, 599503-xx, 577400
Intentional Radiators:	EXO Sondes contain transmitter module with certification number: MIC ID: [R]202-LSE095 EXO GO contains transmitter module with certification number: MIC ID: [R]201-125709
Regulations:	TELEC; Article 38-24 Paragraph 1 of the Radio Law.

Gregory W. Popp

Gregory Popp, Quality Manager
January 14th, 2019

The undersigned hereby declares that the products listed below conform with all applicable requirements of the Anatel Regulations of Brazil for intentional radiators.

Manufacturer:	YSI Incorporated, a Xylem brand 1725 Brannum Lane Yellow Springs, OH 45387 USA
Equipment name:	EXO Sondes (EXO1, EXO2 and EXO3) and EXO GO
Model numbers:	599501-xx, 599502-xx, 599503-xx, 577400
Intentional Radiators:	Intentional Radiators: EXO Sondes (EXO1, EXO2 and EXO3) contain the PAN1026 *Bluetooth* module: Certificate of Homologation No. 01640-18-08838; Certificate of Conformity No. 00106288. EXO GO (577400) contains the RN42 *Bluetooth* module: Certificate of Homologation No. 00436-18-08838; Certificate of Conformity No. 00099335.
Regulations:	Anatel; Transceptor de Radiacao Restrita - Categoria II

Gregory W. Popp

Gregory Popp, Quality Manager
January 14th, 2019

8.4 Instrument Warranty

Warranty Card

Register your product with the online warranty card: www.YSI.com/warranty

Warranted against defects in workmanship and materials when used for their intended purposes and maintained according to instructions and exclusive of batteries and any damage caused by defective batteries.

Two years: cables; sondes (bulkheads); handheld; conductivity, temperature, depth, and optical sensors; electronics base for pH, pH/ORP, ammonium, chloride, and nitrate sensors; and accessories.

One year: optical DO membranes and replaceable reagent modules for pH and pH/ORP.

Three months: replaceable reagent modules for ammonium, chloride, and nitrate.

Regular maintenance of sondes and sensors, such as replacing damaged o-rings, is described in the Maintenance section of this manual. Users are expected to follow these guidelines to keep their equipment in good and proper working order and to protect the warranty on the product. Damage due to accidents, misuse, tampering, or failure to perform prescribed maintenance is not covered.

This warranty does not include batteries or damage resulting from defective batteries. As documented in the Maintenance section of this manual, batteries should be removed from all sondes and handheld when the product is not in use. Since many battery manufacturers will repair or replace any equipment that has been damaged by their batteries, it is essential that leaky or defective batteries be retained with the damaged product until the manufacturer has evaluated the claim.

The warranty period for chemicals and reagents is determined by the expiration date printed on their labels. Within the warranty period, we will repair or replace, at our sole discretion, free of charge, any product that we determine to be covered by this warranty.

To exercise this warranty, write or call your local representative, or contact Technical Support. Send the product and proof of purchase, transportation prepaid, to the Authorized Service Center selected by the manufacturer. Repair or replacement will be made and the product returned transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days from date of repair or replacement.

Limitation of Warranty

This Warranty does not apply to any EXO product damage or failure caused by (i) failure to install, operate or use the product in accordance with the written instructions, (ii) abuse or misuse of the product, (iii) failure to maintain the product in accordance with the written instructions or standard industry procedure, (iv) any improper repairs to the product, (v) use by you of defective or improper components or parts in servicing or repairing the product, or (vi) modification of the product in any way not expressly authorized by the manufacturer.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. YSI's LIABILITY UNDER THIS WARRANTY IS LIMITED TO REPAIR OR REPLACEMENT OF THE PRODUCT, AND THIS SHALL BE YOUR SOLE AND EXCLUSIVE REMEDY FOR ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY. IN NO EVENT SHALL YSI BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY.

EXO Authorized Service Centers are located in the United States and around the world. Please refer to the YSI website (www.YSI.com/Repair) for your nearest Authorized Service Center.

8.5 Instrument Service

Cleaning and Packing

Product Return Form

Find the product return form online:
www.YSI.com/Repair

Cleaning Certificate

Find the cleaning certificate on the back of the online product return form:
www.YSI.com/Repair

Cleaning Instructions

Before they can be serviced, equipment exposed to biological, radioactive, or toxic materials must be cleaned and disinfected. Biological contamination is presumed for any instrument, probe, or other device that has been used with body fluids or tissues, or with wastewater. Radioactive contamination is presumed for any instrument, probe or other device that has been used near any radioactive source.

If an instrument, probe, or other part is returned or presented for service without a Cleaning Certificate, and if in our opinion it represents a potential biological or radioactive hazard, our service personnel reserve the right to withhold service until appropriate cleaning, decontamination, and certification has been completed. We will contact the sender for instructions as to the disposition of the equipment. Disposition costs will be the senders responsibility.

When service is required, either at the user's facility or at the manufacturer, the following steps must be taken to insure the safety of our service personnel:

- In a manner appropriate to each device, decontaminate all exposed surfaces, including any containers. 70% isopropyl alcohol or a solution of 1/4 cup bleach to 1 gallon tap water are suitable for most disinfecting. Instruments used with wastewater may be disinfected with .5% Lysol® if this is more convenient to the user.

- The user shall take normal precautions to prevent radioactive contamination and must use appropriate decontamination procedures should exposure occur.

- If exposure has occurred, the customer must certify that decontamination has been accomplished and that no radioactivity is detectable by survey equipment.

- Cleaning must be completed and certified on any product before returning.

Packing Instructions

- Clean and decontaminate items to insure the safety of the handler.
- Complete and include the Product Return Form, found online.
- Place the product in a plastic bag to keep out dirt and packing material.
- Use a large carton, preferably the original, and surround the product completely with packing material.

8.6 Instrument Service
Recycling

Batteries

The user must remove and dispose of alkaline batteries when they no longer power the EXO1 sonde, EXO2 sonde, or EXO Handheld. Disposal requirements vary by country and region, and users are expected to understand and follow the battery disposal requirements for their specific locale.

The circuit board in these instruments may contain a manganese dioxide lithium "coin cell" battery that must be in place for continuity of power to memory devices on the board. This battery is not user serviceable or replaceable. When appropriate, an authorized service center will remove this battery and properly dispose of it, per service and repair policies.

Rechargeable Li-Battery Pack

(1) When the battery is worn out, insulate the terminals with adhesive tape or similar materials before disposal.

(2) Dispose of batteries in the manner required by your city, county, state or country. For details on recycling lithium-ion batteries, please contact a government recycling agency, your waste-disposal service, or visit reputable online recycling sources such as **www.batteryrecycling.com.**

This product must not be disposed of with other waste. Instead, it is the user's responsibility to dispose of their waste equipment by handing it over to a designated collection point for the recycling of waste electrical and electronic equipment. The separate collection and recycling of your waste equipment at the time of disposal will help to conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment.

For more information about where you can drop off your waste equipment for recycling, please contact your local city office, or your household waste disposal service. **DO NOT ship batteries to YSI.**

Manufacturer

We are committed to reducing the environmental footprint of our products. While materials reduction is the ultimate goal, we also make a concerted effort to responsibly deal with materials after a long, productive life-cycle. Our recycling program ensures that old equipment is processed in an environmentally responsible way, reducing the amount of materials going to landfills.

- Printed circuit boards are sent to facilities that process and reclaim as much material for recycling as possible.
- Plastics enter a material recycling process and are not incinerated or sent to landfills.
- Batteries are removed and sent to battery recyclers for dedicated metals.

Xylem |'zīləm|

1) The tissue in plants that brings water upward from the roots;
2) a leading global water technology company.

We're a global team unified in a common purpose: creating advanced technology solutions to the world's water challenges. Developing new technologies that will improve the way water is used, conserved, and re-used in the future is central to our work. Our products and services move, treat, analyze, monitor and return water to the environment, in public utility, industrial, residential and commercial building services settings. Xylem also provides a leading portfolio of smart metering, network technologies and advanced analytics solutions for water, electric and gas utilities. In more than 150 countries, we have strong, long-standing relationships with customers who know us for our powerful combination of leading product brands and applications expertise with a strong focus on developing comprehensive, sustainable solutions.

For more information on how Xylem can help you, go to www.xylem.com

xylem
Let's Solve Water

YSI, a Xylem brand
1725 Brannum Lane
Yellow Springs, OH 45387
Tel +1.800.897.4151
Fax +1.937.767.9353
www.xylem.com

Appendix C

Consultation Record

Consultation Record

Water Quality Management Plan				
Sub-Plan	**Agency**	**Date of Agency Plan Submittal**	**Agency Comments Received Date**	**Date of Call to Resolve Agency Comments**
Oregon Water Quality Management Plan	Oregon Department of Environmental Quality	January 25, 2021	February 11, 2021	February 11, 2021
	Oregon Department of Fish and Wildlife	January 25, 2021	Pending	February 11, 2021
California Water Quality Monitoring Plan	California State Water Resources Control Board	January 25, 2021	February 2, 2021	Pending
	California North Coast Regional Water Quality Control Board	January 25, 2021	Pending	Pending
	California Department of Fish and Wildlife	January 25, 2021	Pending	Pending
	Oregon Department of Environmental Quality	January 25, 2021	Pending	Pending