Quality Assurance Project Plan: Major Lakes Profiling Platforms

May 2018

King County

Department of Natural Resources and Parks
Water and Land Resources Division
Science and Technical Support Section
King Street Center, KSC-NR-0600
201 South Jackson Street, Suite 600
Seattle, WA 98104
206-477-4800 TTY Relay: 711
www.kingcounty.gov/EnvironmentalScience

Alternate Formats Available

Quality Assurance Project Plan: Major Lakes Profiling Platforms

Submitted by:

Curtis DeGasperi
King County Water and Land Resources Division
Department of Natural Resources and Parks

King County
Department of
Natural Resources and Parks
Water and Land Resources Division

Citation

King County. 2018. Quality Assurance Project Plan: Major Lakes Profiling Platforms. Prepared by Curtis DeGasperi, Water and Land Resources Division, Science and Technical Support Section. Seattle, Washington.

Table of Contents

Approvals iv
1.0 Introduction 6
2.0 Organization and Schedule 8
3.0 Monitoring Equipment 10
4.0 Data Management 15
5.0 Standard Operating Procedures 16
5.1 Service Visits 16
5.2 System Troubleshooting 16
6.0 Data Quality Control 18
6.1 Profiling Data 18
6.1.1 Data Qualification 18
6.1.2 Profile Comparisons 19
6.2 Weather Data 20
7.0 Maintenance 21
7.1 Profiler Maintenance 21
7.2 Sonde and Probe Maintenance 24
7.3 Weather Station Maintenance 24
7.4 Licenses and Permits 26
8.0 References 27

Figures

Figure 1. Map illustrating historical and current locations of monitoring platforms on Lake Sammamish and Lake Washington. 7
Figure 2. Sketch of monitoring platform and anchoring system. 10
Figure 3. Photo of monitoring platform. Deck is approximately 6x12 feet and is supported by two pontoons. Weather station height is approximately 10 feet. 11
Figure 4. Profiling system components. 12

Tables

Table 1. Team Member Contact Information 8
Table 2. Schedule of Routine Tasks 9
Table 3. YSI EXO2 Sonde Sensor Specifications 13
Table 4. Weather Station Sensor Specifications 14
Table 5. Profiling Frequency Schedule 18
Table 6. Post-deployment calibration end check limits 18
Table 7. Parameter range limits 19
Table 8. YSI Profiling Equipment Maintenance and Replacement Schedule. 22
Table 9. YSI EXO2 Multi-parameter Sonde Maintenance and Replacement Schedule. 24
Table 10. Weather Station Sensor Maintenance and Replacement Schedule 24

APPROVALS

Curtis DeGasperi, King County — 5/16/2018 — Date
Science and Technical Support Section, Program Manager

Christopher Barnes, King County — 5/21/2018 — Date
Environmental Laboratory, Field Lead

Colin Elliott, King County — May 21, 2018 — Date
Environmental Laboratory Quality Assurance Officer

Ben Budka, King County — 5/21/18 — Date
Environmental Laboratory Field Services Unit Supervisor

Distribution List

Curtis DeGasperi .....King County Science and Technical Support Section
Dave Funke.....King County Science and Technical Support Section
Christopher Barnes .....King County Environmental Laboratory
Colin Elliott .....King County Environmental Laboratory
Ben Budka .....King County Environmental Laboratory
Charlie Zeng .....King County Information Technology

This page intentionally left blank.

1.0 INTRODUCTION

The King County Water and Land Resources Division operates near-continual water quality profiling platforms on Lake Sammamish and Lake Washington (Figure 1). A multi-parameter sonde collects near-real-time water quality data at programmed depth increments and time intervals. The parameters measured by the profiling equipment at each location include depth, temperature, dissolved oxygen, pH, specific conductance, turbidity, chlorophyll fluorescence, and blue-green algae fluorescence. In addition to water column profiling data, the platforms are equipped with weather stations that collect near-real time data at programmed time intervals. The weather data collected include air temperature, relative humidity, wind speed, wind direction, atmospheric pressure, and solar radiation.

The objectives of the program are (1) collect near-continuous (every 4 to 8 hours depending on the season) depth dependent measurements of selected field parameters at central locations on Lake Washington and Lake Sammamish, (2) assess temporal trends in water quality parameters measured at each location, and (3) report near real-time water quality and weather data through a public King County web site.

This Quality Assurance Project Plan (QAPP) is based on established field and laboratory procedures and U.S. Geological Survey (USGS) standards for continuous water quality monitoring (Wagner et al., 2006). A QAPP prepared by the USGS for water quality profiling on Lake Mead was also used as guidance (USGS, 2010).

Detailed profiling platform operation and maintenance procedures are provided in manuals provided by YSI (2006, 2016a, and 2016b).[1] Project procedures for calibration and care of the multi-parameter sondes are based on laboratory standard operating procedures (SOP #245v1). Standard Operating Procedures for the profiling platform are detailed in SOP #240v0. All personnel that work on this program must review this QAPP, the Xylem operation and maintenance manuals, the referenced SOPs, and Wagner et al. (2006).

This document presents the overall QAPP for operation and maintenance of the system (i.e., profiling platform, SQL database, and publicly facing website) and the methods used to assess the quality of the data collected.

[1] YSI is a Xylem brand which developed and manufactured the two profiling systems purchased by King County in 2008.

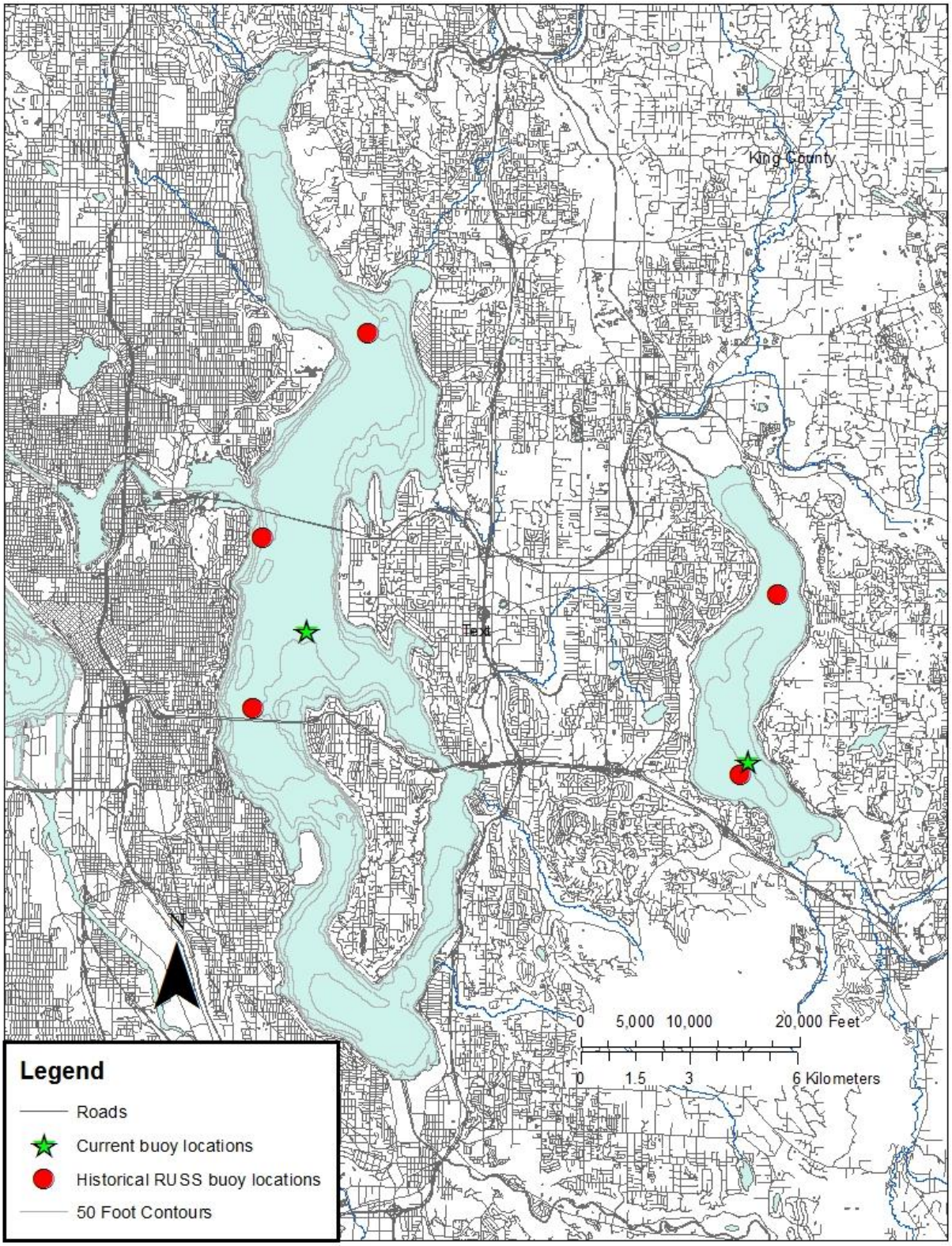

Figure 1. Map illustrating historical and current locations of monitoring platforms on Lake Sammamish and Lake Washington.

2.0 ORGANIZATION AND SCHEDULE

The project team consists of personnel from King County's Water and Land Resources Division (WLR Division) including a program manager and King County Environmental Laboratory (KCEL) Field Services Unit (FSU) staff that services and maintains the profiling equipment. The project is also supported by King County Information Technology (KCIT) personnel who maintain the database and publicly-facing web site. Team member contact information is provided in Table 1. Table 2 provides a schedule of tasks and team responsibilities.

King County WLR Division, Science Section

- Curtis DeGasperi – Program Manager
- Dave Funke – Communications Manager

This group is responsible for overall project planning, permitting, communicating between involved parties, reviewing and synthesizing data, and communicating results.

King County WLR Division, King County Environmental Laboratory

- Christopher Barnes – FSU Technical Manager
- Ben Budka – FSU Supervisor

This group is responsible for operation and maintenance of the platform, including routine calibration and long term maintenance of sensors, data loggers, power supply system, communication equipment, and platform.

King County Information Technology

- Charlie Zeng – database and web developer

This group is responsible for maintenance of database and public-facing website.

Table 1. Team Member Contact Information

Organization	Name	Contact Information
King County	Curtis DeGasperi	206-477-4677; curtis.degasperi@kingcounty.gov
King County	Dave Funke	206-477-4692; dave.funke@kingcounty.gov
King County	Christopher Barnes	206-477-7143; christopher.barnes@kingcounty.gov
King County	Ben Budka	206-477-7142; ben.budka@kingcounty.gov
King County	Charlie Zeng	206-296-1988; dongcharlie.zeng@kingcounty.gov

Table 2. Schedule of Routine Tasks

Activity	Frequency	Responsibility
Spot-check profiler web site for data	Daily	KCEL
Sonde calibration/swap	Monthly	KCEL
Entry of post-calibration check data	Monthly [a]	KCEL
Data review	Monthly [b]	Science
Data management troubleshooting and maintenance	~Quarterly	KCIT
Capital asset management	~Annual	KCEL
Report indicator metrics	Annual [c]	Science
Work with appropriate agencies to obtain needed permits	As required	Science

[a] *Within 1 week of sonde calibration/swap*
[b] *Within 1 week after entry of post-calibration check data*
[c] *Within 3 months of the end of the calendar year*

Technical support (and pricing/purchasing information) is also available from YSI, Inc. and Campbell Scientific (CR1000 data logger and scripting/telemetry). The most frequently contacted personnel and their roles are identified below:

- Randy Hadland, Xylem (YSI is a Xylem brand) Senior Manager [randy.hadland@xyleminc.com; 1.360. 915.7331]
- Dylan Bedortha, Xylem Northwest Representative (AK, ID, MT, OR, WA) [dylan.bedortha@xyleminc.com; 1.503.536.3851]
- YSI Integrated Systems and Services [YSISystems.Support@xyleminc.com; 1.727.565.2201 or 1.877.392.9950 option 5]
- Collin Daly, Campbell Scientific Sales Engineer [cdaly@campbellsci.com; 1.435.227.9000]

3.0 MONITORING EQUIPMENT

Each platform consists of a 6x12-ft aluminum deck supported by two plastic pontoons (Figure 2). The platform supports the profiling system which consists of a winch, data logging/communication equipment, and battery contained in a steel frame covered by a fiberglass housing. The housing supports a weather station and two solar panels. The total height of the platform is about 3 m (~10 ft) including the weather mast and it is lighted with a Coast Guard compliant beacon (Carmanah 2NM Marine Lantern, model M601 visible for no less than two nautical miles). A single mooring line and anchor are used to secure the system on station (Figure 3).

The profiling system consisting of the following hardware:

- YSI variable profiler winch assembly
- YSI EXO2 multi-parameter sonde
- Two Campbell Scientific CR1000 data loggers/sensor control modules
- One 12 volt, 95 amp hour battery
- Sierra Wireless RV 50 Airlink Modem
- Two 30 watt solar panels for charging the battery

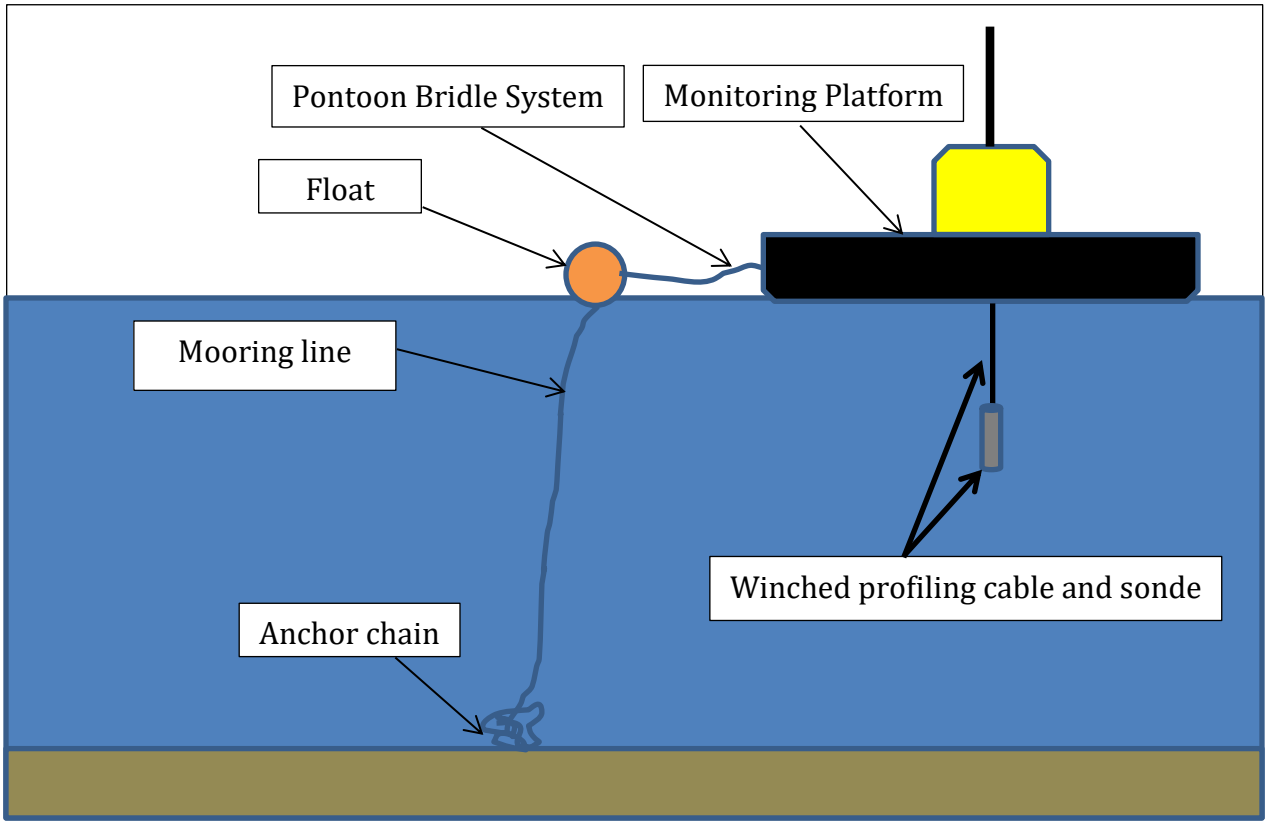

Figure 2. Sketch of monitoring platform and anchoring system. Pontoon bridle assembly 10 feet long. Mooring line length is approximately 1.5 times the depth of water. Anchor is composed of approximately 500 pounds of chain.

Figure 3. Photo of monitoring platform. Deck is approximately 6x12 feet and is supported by two pontoons. Weather station height is approximately 10 feet.

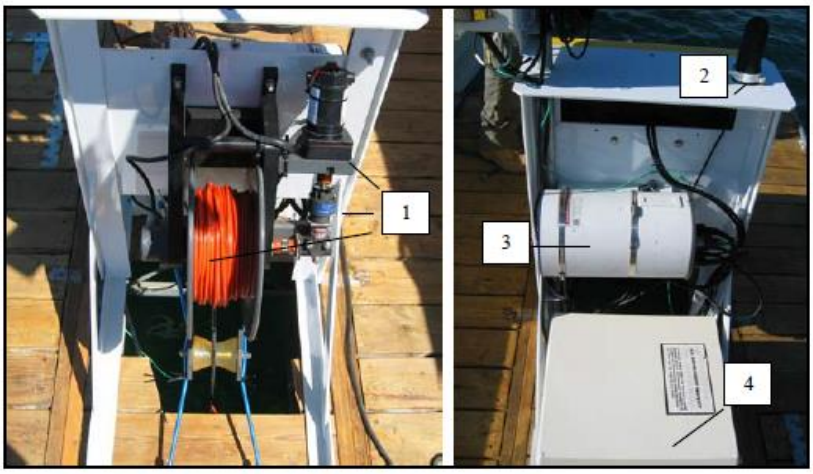

Figure 2. Profiling system components.

(1, variable profiler winch assembly; 2, modem antenna; 3, water tight housing for CR10X and wavecom modem; and 4, water tight housing for 12 volt, 95 amp hour battery)

Figure 4. Profiling system components.

1, variable profile winch assembly; 2, modem antenna; 3, water tight housing for CR1000 and Sierra RV50 modem, and 4, water tight housing for 12 volt, 95 amp hour battery)

The YSI EXO2 multi-parameter sonde is equipped with an anti-fouling wiper and the sensors described in Table 3. The YSI EXO user's manual provides detailed information regarding communication and power options, sensor principles of operation, maintenance, and calibration (YSI, no date). The details of the calibration and maintenance of the YSI EXO for this program are provided in Standard Operating Procedure (SOP) #245v1.

The variable profiler winch assembly controls the movement of the sonde to programmed depths. Sampling depths are every meter from 1 m below the surface to near bottom; 55 m depth in Lake Washington and 25 m depth in Lake Sammamish. The CR1000 is the microprocessor that controls the winch assembly, operates the sonde, stores the data collected by the sonde, and controls the modem that transmits the data to a King County server. In this QAPP, the equipment package, including the sonde, will be referred to as a profiling system.

Table 3. YSI EXO2 Sonde Sensor Specifications

Sensor, Reporting Units	Range	Accuracy	Response	Resolution
Depth, m	0 to 100 m (0 to 328 ft)	±0.04% FS (±0.04 m or ±0.13 ft)	T63<2 sec	0.001 m (0.001 ft) (auto-ranging)
Temperature, °C	-5 to 35°C 35 to 50°C	±0.01°C ±0.05°C	T63<1 sec	0.001 °C
Specific Conductance, µS/cm	0 to 200 mS/cm	±0.5% of reading or .001 mS/cm, w.i.g.	-	0.001, 0.01, 0.1 mS/cm (auto-scaling)
pH	0 to 14 units	±0.2 pH units for entire temp range	T63<3 sec	0.01 units
Dissolved Oxygen, mg/L	0 to 50 mg/L	0 to 20 mg/L: ±0.1 mg/L or 1% of reading, w.i.g.	T63<5 sec	0.01 mg/L
Turbidity, NTU [a]	0 to 4000 FNU	0 to 999 FNU: 0.3 FNU or ±2% of reading, w.i.g.;	T63<2 sec	0 to 999 FNU = 0.01 FNU
Chlorophyll, µg/L [b]	0 to 400 µg/L	Linearity: R^2 >0.999 for serial dilution of Rhodamine WT solution from 0 to 400 µg/L Chlorophyll a (Chl a) equivalents	T63<2 sec	0.01 µg/L
Phycocyanin, µg/L [b] (blue-green algae pigment)	0 to 100 µg/L	Linearity: R^2 >0.999 for serial dilution of Rhodamine WT solution from 0 to 100 µg/mL BGA-PC equivalents	T63<2 sec	0.01 µg/L

Source: https://www.ysi.com/EXO2

NTU = Nephelometric Turbidity Units; FNU = Formazine Nephelometric Units; BGA-PC = Blue Green Algae – Phycocyanin; w.i.g = whichever is greater

[a] *The turbidity sensor measures turbidity in formazine nephelometric units (FNU) but we report nephelometric turbidity units (NTU) so as to be consistent with historical data and data collected as part of the routine monitoring program. See: https://www.ysi.com/ysi-blog/water-blogged-blog/2016/01/turbidity-measurements-tips-and-precautions and https://www.ysi.com/File%20Library/Documents/Technical%20Notes/T627_Turbidity_Units_and_Calibration_Solutions.pdf*

[b] *Measured simultaneously by a Total Algae Sensor.*

The weather stations are equipped with the instruments identified in Table 4.

Table 4. Weather Station Sensor Specifications

Parameter, Reporting Units	Sensor	Range	Accuracy	Resolution
Temperature, °C	HMP45C-L9	-39.2° to +60°C	±0.2°C @ 20°C	0.1 °C
Relative Humidity, %		0.8% to 100% RH	±2% (0% to 90% RH) ±3% (90% to 100% RH)	0.1%
Barometric Pressure, mb	Vaisala CS105	500 to 1100 hPa (mb)	±0.6 mb (@ 0° to 40°C)	±0.03 mb
Solar Radiation, W/m^2	LiCor LI-200R pyranometer	1 to 3000 W/m^2	± 3% typical, within ± 60° angle of incidence	Typically 75 µA per 1,000 W/m^2
Wind Speed, m/sec	RM Young 05106	0-100 m/sec (224 mph)	± 0.3 m/sec (0.6 mph) or 1% of reading	Propeller: 1.0 m/s (2.4 mph) Vane: 1.0 m/sec (2.4 mph)
Wind Direction, degrees magnetic N		0 to 360°	± 3 degrees	

Source: https://www.ysi.com/EXO2

w.i.g = whichever is greater; RH = Relative Humidity

The meteorological instruments are controlled by a second CR1000 data logger. Meteorological data stored by the CR1000 are 5 minute averages of readings taken every 60 seconds and recorded every 15 minutes on the quarter hour.

4.0 DATA MANAGEMENT

Data are transferred from the sonde and meteorological instruments to a Campbell Scientific CR1000 data logger. Through an automated cellular modem, the data from the logger are transferred hourly to a King County data server. The data file is then parsed at the same frequency and loaded into SQL data tables on a dedicated server where the data are maintained. A web site has also been developed to provide information about the monitoring system and allow access to graphical and tabular displays of the stored data (see: http://green.kingcounty.gov/lake-buoy/default.aspx). Another feature of the web site is a web form that is used to enter sonde probe end check data that are then used to assess the quality of the data collected during the deployment of that particular sonde. Alerts are also sent to project team members when data exceed minimum or maximum values and these data are automatically flagged as being out of their expected range. Current range check values and sonde end check conditions used for data quality control can be found on the program web site (http://green.kingcounty.gov/lake-buoy/parameters.aspx) and their use is documented in Section 6.0 of this QAPP.

KCIT staff will support the profiling systems operationally by maintaining the program web site and database and perform upgrades as needed. An upgrade to the web and data management systems is currently needed to allow the blue-green algae sensor data to be transferred to the data logger and added to the SQL data tables as well as a few other minor improvements as follows:

- Change the source of the voltage data extracted from the logger file.
- Improve historical surface temperature graph.
- Update the buoy specifications page which is out of date.
- Increase the frequency that the logger data tables are parsed and uploaded to the SQL database.
- Add ability to qualify weather data, particularly wind direction data.
- Automate email alert when profile and/or weather data have not been reported for a specified time interval.

The Science program manager is ultimately responsible for ensuring the quality of the data. In addition to the post-calibration checks performed and entered by the KCEL FSU staff, all data will be reviewed graphically by the program manager on a monthly basis and erroneous data not already appropriately flagged (see Section 6.0) will be flagged by the project manager using the web tools provided by KCIT.

5.0 STANDARD OPERATING PROCEDURES

SOP #240v0 provides detailed profiling system standard operating procedures followed by the KCEL. Overall system standard operating procedures and responsibilities are described below.

5.1 Service Visits

- Calibrate sonde within one week of planned service visit
- Upon arrival inspect the platform for damage or items in need of repair.
- Perform needed steps to disconnect deployed sonde and swap with recently calibrated sonde

Upon arrival at the platform, a basic inspection will be completed by FSU personnel. The condition of the solar panel, anchor chain attachment points, platform surface, and weather box shall be noted evaluated. If there are items that need repair and cannot be repaired during the service visit, they need to be brought to the attention of the FSU supervisor and program manager as soon as possible. Equipment on the platform that is not maintained could be dangerous and may damage the profiling system.

Prior to swapping the sonde establish a connection either locally or remotely by using the Campbell Scientific LoggerNet software and put the profiling unit in 'Setup' mode. This step should be done while the sonde is parked and not profiling. Once the unit is in 'Setup' mode the sonde can be swapped. To swap the sonde, retrieve the cable from beneath the platform with a boat hook and bring it to the surface. Once the sonde is secure on the deck of the platform or vessel detach it from the EXO-Link cable adapter. It is not necessary to detach the profiling cable from the EXO-Link cable adapter. Detach the safety clips from the old sonde and transfer them to the new sonde, then attach the wet-pluggable cable from the EXO-Link cable adapter to the new sonde. Make sure all connections are securely fastened. Remove the sonde weight from the old sonde and transfer it to the new sonde. Deploy the new sonde to the water and let it return to the 10 m parking depth. At this point you can return the profiling unit to 'Run' mode locally with a diagnostic cable and laptop, or wait and do it remotely. This final step usually depends on weather. If conditions are windy, rough and/or wet, it is not a good option to open up the fiberglass housing.

5.2 System Troubleshooting

Potential system problems will be identified and resolved by the technical manager using the following guidelines:

1. **Spot-checking profiler web site** – The web page will be checked in the morning and evening during work hours each day for recent data by mousing over the

marker for a particular platform or buoy. If data do not appear to be updating; Step 3 is triggered.

2. **Range check email** [2]– The web server performs range checks on uploaded data and sends an email to the program manager and the FSU technical manager. Step 4 is triggered.
3. **Fix platform problems via Web** – Platform web problems would happen if, during the daily spot check, recent data were not on the web page. The response protocol consists of the following:

    a. Determine if it is profile data, meteorological data, or both that are not updating.

    If it is only profile data, go to 5b. If it is only meteorological data, then 5b. If it is both, go to 5b, but expect 6d.

    b. Check Loggernet to see if the profiler was in setup mode.

    If not, then go on to step 5c. If in setup mode, troubleshoot problem.

    c. Check the network drive for new data

    If new data are there, contact web site and database operations manager. If no new data were available on the drive, go to 5d.

    d. Contact communications manager to see if servers are down

    If they are down, bringing them up should fix the problem. If they are still up, go back to LoggerNet and troubleshoot expecting the profiler will probably need on-site power reset.

4. **Fixing platform problems on lake:**

a. If one parameter is anomalous At monthly sonde swap

b. If more than one parameter is anomalous When crew are available-low priority

c. If sonde data is down, but met is up When crew are available-low priority

d. If all data are down and can't fix remotely When crew are available-higher priority

Monthly data review by the program manager can also trigger system troubleshooting by the technical manager.

[2] Range check table: https://green2.kingcounty.gov/lake-buoy/Parameters.aspx

6.0 DATA QUALITY CONTROL

6.1 Profiling Data

The objective of this program is to collect sufficient data of known quality to meet study data collection targets. The data collection targets are as follows:

- Collect at least 95% of expected data on an annual basis based on target profiling frequencies (see Table 5).
- At least 75% of collected profiling data meet data quality objectives (DQOs) on an annual basis.

Currently, data qualified as "Good" and "Fair" are considered to have met program DQOs. The following section describes the procedures used to qualify the profiling data.

Table 5. Profiling Frequency Schedule

Period	Frequency
November to March	3 profiles per day
April to October	6 profiles per day

6.1.1 Data Qualification

Data are automatically qualified by the web database system based on post-deployment calibration end checks entered by KCEL through the web site. The relative difference from the end check standards classify the data as "Good", "Fair", or "Poor" as outlined in Table 6.

Table 6. Post-deployment calibration end check limits

Parameter (Standard)	Good	Fair	Poor
Dissolved Oxygen (saturated reverse osmosis [Reverse Osmosis] water)	±5%	±10%	>±10%
pH (6.86 pH buffer)	±0.15 units	±0.20 units	>±0.20 units
Specific Conductance (73.9 µS/cm)	±5%	±10%	>±10%
Turbidity (10 NTU)	±15%	±25%	>±25%
Chlorophyll (0.625 mg/L Rhodamine)	±15%	±25%	>±25%
Phycocyanin (0.625 mg/L Rhodamine)	±15%	±25%	>±25%

Note: Limits can be changed and are applied dynamically to all of the data in the database. The latest limits can be found here: https://green2.kingcounty.gov/lake-buoy/Parameters.aspx

Calibration end checks are not performed for temperature. The probes are checked annually in the laboratory against NIST-certified temperature probes. The YSI EXO2 temperature probes are certified to be more accurate than the laboratory NIST-certified temperature probe. FSU personnel are investigating the possibility of an annual calibration certification with YSI similar to that performed for the SeaBird CTD temperature sensors.

In addition to data qualifiers based on post-deployment calibration end checks, the data are also flagged as "out of range" if the results exceed plausible ranges. These ranges are shown in Table 7.

Table 7. Parameter range limits

Parameter	Minimum	Maximum
Air Temperature (°C)	-10.00	35.00
Atmosphere Pressure (mb)	900.00	1100.00
Battery (V)	11.00	15.00
Chlorophyll (µg/L)	-2.00	50.00
BGA-PC (blue-green algae)	-2.00	50.00
Depth (m)	0.00	65.00
DO Concentration (mg/L)	0.01	22.00
DO Percent Saturation (%)	0.10	190.00
pH	4.00	10.00
Relative Humidity (%)	10.00	100.00
Solar Radiation (W/m^2)	0.00	1200.00
Specific Conductance (µS/cm)	20.00	200.00
Temperature (°C)	0.00	30.00
Turbidity (NTU)	-5.00	50.00
Wind Direction (degrees)	0.00	360.00
Wind Speed (m/sec)	0.00	30.00

Note: Limits can be changed and are applied dynamically to all of the data in the database. The latest limits can be found here: https://green2.kingcounty.gov/lake-buoy/Parameters.aspx

6.1.2 Profile Comparisons

Simultaneous profiles (hand held EXO1 profile vs buoy EXO2 profile) are completed within 30 minutes of each sonde swap.[3] Comparison profiles are collected using a calibrated EXO1sonde. This will allow comparison of the EXO1 profile to the buoy EXO2 profiles before and after the sonde swap. The purpose of these comparisons is to verify water quality trends in the profile, such as the depth of the epilimnion, metalimnion, and hypolimnion.

Data are then loaded into the KCEL's Laboratory Information Management System (LIMS) by FSU personnel. Note that turbidity data is not collected by the EXO1 sonde, so comparisons to the profiling platform turbidity profiles will not be possible at this time. Using the data provided in LIMS, graphical profile comparisons are made by the program manager and shared with the KCEL.

[3] Sonde swaps occur approximately once per month.

6.2 Weather Data

Weather data quality is checked monthly by the program manager. These checks are conducted by graphing data on a monthly basis and comparing to hourly data from nearby weather stations maintained by the National Oceanic and Atmospheric Administration (NOAA). These stations include Sea-Tac International Airport, Boeing Field, and Renton Airport.

7.0 MAINTENANCE

In addition to the routine operation of the profiling platforms and data management system, the platforms require routine maintenance and replacement parts as a result of normal wear and tear (and possibly as the result of intentional vandalism). Functional maintenance tasks conducted by FSU personnel include the following:

- Maintain and calibrate sondes
- Swap sondes
- Check platform signals and positions
- Inspect and replace platform mooring systems
- Position platforms accurately
- Replace platform power systems and associated hardware
- Locate and retrieve overturned or sunken platforms within equipment capabilities
- Obtain and update appropriate permits as necessary

The planned service life of the profiling platforms is 12 to 15 years when following the prescribed routine maintenance in the YSI profiler users and maintenance manuals (YSI; 2006, 2016a, 2016b). During the profiling platform's service life cycle, replacement and alterations will be required to various systems since the various commercial systems have service lives of less than 12 to 15 years. Replacement of the electric winch motor and profiling cable will be needed every 3 to 5 years. The pontoon raft will need to be replaced every 8 to 10 years. Alteration projects may include electronics, machinery, platform, and/or anchoring system.

The overall logistics support objective for the profiling platforms is to ensure that support is in place when and where needed, and at minimal cost, throughout the platforms' service life. The logistics support system will improve the reliability of each profiling platform so that usable data are available almost every day of the year with routine maintenance executed on a not to interfere basis.

7.1 Profiler Maintenance

Table 8 includes a description of the profiler equipment and a schedule of routine maintenance activities adapted from Section 6.0 of the YSI Profiler User Manual (YSI, 2006).

Table 8. YSI Profiling Equipment Maintenance and Replacement Schedule.

Part	Description	Maintenance Schedule	Replacement Schedule
Profile Pontoon/Raft Assembly	6x12 ft pontoon raft	Deck cleaned as needed during monthly sonde swap, inspection every 6 months	Every 8 years
T-Frame Assembly	Two 30 Watt solar panels, fiberglass covers, cover guides, powder coated t-frame, service handles, cable wind bungee assembly	Inspect every 3 months. Clean panels and check output voltage	As required
Profiler Power Assembly [a]	95 amp hr lead acid battery, battery box, cables and connectors, solar regulator with splash flap	Inspect every 6 months	Every 3 years (battery)
Winch controller [b]	Data logger and telemetry system in sealed PVC pressure case electronics enclosure	Inspect every 6 months. Check desiccant every 3 months	As required
Winch Assembly [c]	Vertical profiler level wind winch assembly (ruggedized winch operating up to 50 meters, DC motor (Sammamish) Deep variable vertical profiler level wind winch assembly (ruggedized winch operating up to 50 meters, DC motor (Lake Washington)	Inspect brushes and gear every 3 months. Inspect set screws and spider every 6 months. Inspect flange screws every year.	Every 5 years
Profiler Cable [d]	Non-vented: 53 m (Sammamish) Non-vented: 50-100 m (Washington)	Inspect every 6 months	Backup cables available when needed. Replace every 5 years
Buoy Antenna Assembly	CDMA, North America, buoy antenna assembly, brass grounding plane, DG O'Brien long cable, watertight	None scheduled	As required

Part	Description	Maintenance Schedule	Replacement Schedule
	enclosure, integral lightening surge diode		
Cellular Modem [e]	CDMA cellular modem, fixed IP or Airlink DNS, 224 mWatt RF output, full duplex transciever, dual band support 800Mhz and 1.9GHz bands, fully compliant with CDMA2000 1X, operating temperature -30 to +70o C	Inspect antennae every 3 months	As required
Meteorological Station Mast	Aluminum with mount for MET sensors, service slide for easy sensor access	None scheduled	As required
Meteorological Suite	MET junction box (200136) Compass in PVC case (200078) RM Young wind monitor (05106) Vaisala CS105 barometer Temperature/RH sensor (HMP45C-L9) Radiation shield (41003) Pyranometer	See Table 9 below for instrument maintenance requirements	See Table 9 below for instrument maintenance requirements
Beacon	Beacon, 155M, Amber, Flasher, Changer	Inspect every 3 months	As required
Mooring System and anchor	Anchoring system, mooring lines, floats, and anchor	Inspect every 3 months	As required

[a] Ensure posts are corrosion free. Check battery for secure connections. Check battery voltage capacity.
[b] Check all connectors and cables for proper fit. Check seals. Check desiccant for color changes.
[c] No direct maintenance required. Ensure motor mounts remain tight. Inspect housing/hardware for damage or corrosion. Check axle for excessive wear on the pillar blocks. Check drum flanges for damage and excessive wear. Check tolerance fit of Slip Ring Cover. Inspect O-ring and slip ring.
[d] Backup cables were purchased in 2010.

[e] Check cable and cable connectors for secure fit. Check cables for damage. Check antenna rubber boots for damage.

7.2 Sonde and Probe Maintenance

The KCEL currently maintains four YSI EXO2 sondes as part of the lake profiling program, which facilitates calibration and swapping of sondes on a routine basis. Sonde calibration is described in SOP #245v1. Sonde and sensor maintenance and replacement schedule is outlined in Table 9.

Table 9. YSI EXO2 Multi-parameter Sonde Maintenance and Replacement Schedule.

Part	Description	Maintenance Schedule	Replacement Schedule
599502-00	7-Port Multi-parameter Water Quality Sonde	As required	Every 6 years
Integrated with sonde	Non-vented Depth Sensor (0-100 m)	-	-
599101-01	Conductivity / Temperature Sensor	As required	Every 6 years
599100-01	Optical Dissolved Oxygen Sensor	yearly	Every year
599701	pH Sensor	yearly	Every year
599101-01	Turbidity Sensor	As required	Every 6 years
599102-01	Total Algae Sensor	As required	Every 6 years

7.3 Weather Station Maintenance

The maintenance and replacement schedule for the weather station sensors is outlined in Table 10.

Table 10. Weather Station Sensor Maintenance and Replacement Schedule

Part	Description	Maintenance Schedule	Replacement Schedule
HMR 3300	Honeywell Digital Compass	None scheduled	As required
HMP45C-L9	Campbell Scientific Temperature/Relative Humidity sensor The probe requires minimal maintenance. Check monthly to make sure the radiation shield	Yearly calibration recommended by manufacturer	As required

Part	Description	Maintenance Schedule	Replacement Schedule
	is free from debris. The black screen at the end of the sensor should also be checked for contaminants.		
05106-L	RM Young Wind Monitor Every month do a visual/audio inspection of the anemometer at low wind speeds. Verify that the propeller and wind vane bearing rotate freely. Inspect sensor for physical damage. Replace the anemometer bearings when they become noisy or the wind speed threshold increases above an acceptable level. The condition of the bearings can be checked with a paper clip as described in the RM Young manual. Replace the potentiometer when noise or non-linearity of response becomes unacceptable.	None scheduled	As required
CS106	Vaisala Barometric Pressure Sensor Since the sensor is semi-sealed, no physical maintenance is required.	Manufacturer recommends recalibration every 2 years	As required
LI-200SZ	LI-COR total solar radiation pyranometer Clean the sensor with water and/or a mild detergent such as dishwashing soap. The vertical edge of the diffuser must be kept clean in order to maintain appropriate cosine correction.	Manufacturer recommends recalibration every 2 years	As required

7.4 Licenses and Permits

Licenses and permits for the deployment and maintenance of the platforms are required by state and federal laws. The predecessor RUSS (robotic underwater sampling system) system was permitted and licensed in 2002. The Aquatic Lands Right of Entry Agreement expired January 31, 2016 and work has been ongoing to secure a new agreement with the Washington State Department of Natural Resources. In addition to the Aquatic Lands Right of Entry Agreement, the following permits were needed for each platform:

- Hydraulic Project Approval (HPA) from the Department of Fish and Wildlife (required whenever a platform anchor is deployed or removed).
- Army Corps of Engineers Nationwide Permit 5 (required whenever a platform anchor is deployed or removed).
- U.S. Coast Guard (USCG) Private Aids to Navigation (PATON) application (USCG must be notified in writing 30 days prior to making changes (i.e., relocating, replacing, removing platform).

The program manager is ultimately responsible for obtaining the necessary permits. When the new Aquatic Lands Right of Entry Agreement is obtained, the agreement reference number and expiration date will be incorporated into this QAPP.

8.0 REFERENCES

Wagner, R.J., R.W. Boulger, Jr., C.J. Oblinger, and B.A. Smith. 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. + attachments. http://pubs.water.usgs.gov/tm1d3

KCEL. 2010. YSI Freshwater Profiler. Standard Operating Procedure #240v0. Implemented August 2006. Approved November 2, 2010. King County Environmental Laboratory, Seattle, WA.

KCEL. 2017. Attended YSI EXO Multiprobe Operations #245v1. Implemented January 2015. Approved June, 2017. King County Environmental Laboratory, Seattle, WA.

USGS. 2010. Water Quality Monitoring at Lake Mead, Arizona and Nevada - Quality Assurance Plan, U.S. Geological Survey, Nevada Water Science Center, Henderson, NV.

YSI. no date. EXO User Manual. Item# 603789REF, Revision G. YSI Incorporated, Yellow Springs, OH. https://www.ysi.com/File%20Library/Documents/Manuals/EXO-User-Manual-Web.pdf

YSI. 2006. YSI Floating Profiler System User's Manual. YSI Incorporated, Yellow Springs, OH.

YSI. 2016a. Vertical Profiler System User Manual. YSI Integrated Systems & Services, St. Petersburg, FL.

YSI. 2016b. Profiler Systems Preventative Maintenance. YSI Integrated Systems & Services, St. Petersburg, FL.