

# Waldo Lake Long-Term Monitoring Field Sampling Quality Assurance and Quality Control Project Plan

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## PROJECT MANAGEMENT

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### 1. Problem Identification and Background

Waldo Lake is one of the most pristine lakes in the United States. Waldo Lake is unique in its chemical and biological properties. The lake is extraordinarily clear and light penetrates deep into the water column, giving the lake an exceptional blue color. The lake watershed is very small; therefore, the nutrient input and lake primary production are low, accounting for the water transparency. Waldo Lake is home to very interesting biota of rare and unique species never identified before, including phytoplankton and zooplankton and highly productive deepwater bryophytes, particularly liverworts.

Waldo Lake is located in the Cascade Mountain Range in the Willamette National Forest. The lake sits at an elevation of 1,650 meters above sea level, is 9.6 km long, with a surface area of 25.5 km<sup>2</sup>. The location of Waldo Lake is shown in Figure 1.

The U.S. Forest Service has conducted sampling during ice-free months since 1986. This long-term sampling work has been very important in illustrating general trends in lake health and provides a baseline for evaluating changes in the lake.

Studies over the last 30 years suggest that the optical properties of the lake and plankton community structure are changing and phytoplankton primary production is increasing. Understanding the daily, seasonal, annual and decadal fluctuations of lake conditions is an important element in identifying ongoing long-term trends in lake eutrophication processes.

Data collection must follow stringent protocol to assure that information is scientifically accurate, repeatable and comparable to other monitoring efforts in similar lakes and that sampling strategies capture ongoing trends in the lake. With strict adherence to rigorous quality control protocol, research findings will lead to defensible products and conclusions that can be used to form scientifically based management decisions.

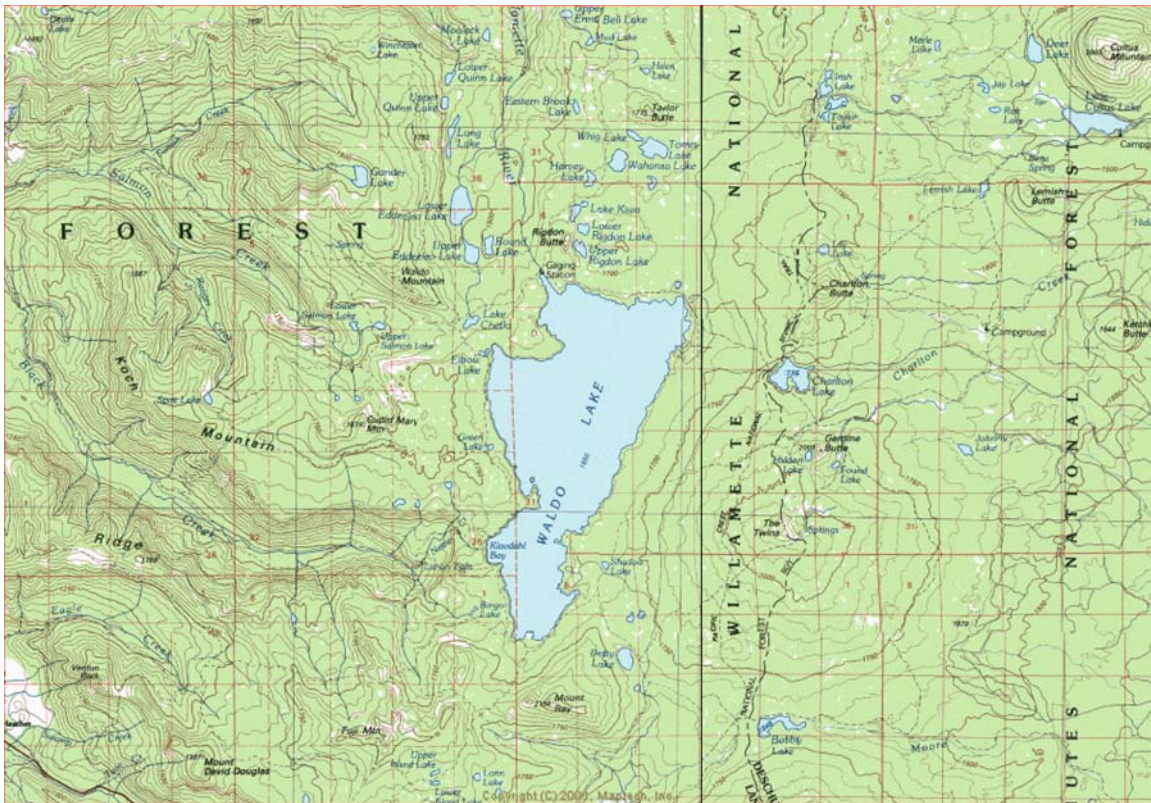


Figure 1: Waldo Lake Map

## 2. Project Description and Task Summary

Currently, monthly data collection includes monitoring water quality, light attenuation and primary productivity, and collecting phytoplankton and zooplankton samples.

The scope of this Quality Assurance/Quality Control Plan will include field practices for long-term monitoring activities. Laboratory quality assurance protocols have been explained in detail previously (Salinas, 1999). Currently, water quality analysis are completed by John Salinas of The Cascade Research Group, chemical laboratory analysis are carried out by Cooperative Chemical Analytical Laboratory (CCAL), phytoplankton species identification are done by Jim Sweet of Aquatic Analysts, and zooplankton species identification are done by Allan Vogel of ZP's Taxonomic Services. Team members and their tasks are shown in Table 1.

**Table 1: Responsible Team Members**

Team Member	Task
Deigh Bates	U.S. Forest Service supervision of tasks
Mark Sytsma	Center for Lakes and Reservoirs supervision of tasks
Roy Koch	Hydrology
Richard Petersen	Project Development
John Rueter	Phytoplankton Efficiency
Scott Wells	Lake Modeling
John Salinas	Water Quality data collection
Allan Vogel	Zooplankton analysis
Jim Sweet	Phytoplankton analysis
CCAL	Chemical analysis

### 3. Personal Contact Information

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### 4. Data quality objectives for measurement data

The ionic strength is very low and nutrient concentrations are close to the detectable limits at Waldo Lake; therefore, strict calibration and use of protocols for sampling devices are required. Additionally, regular measurement repetition is necessary to assure data quality and control. Data quality objectives are required to ensure a consistent and known quality of data collection upon which management decisions are made. An evaluation of results and report on quality of data collected will be associated with each parameter measured. This will be the responsibility of the individual collecting the data. Failure to meet these data quality objectives will require recalibration and repetition of measurements. Calibration techniques are explained in Section 11: Instrument /Equipment Calibration and Frequency.

These procedures may be revised in the future based on the improvement of data collection methods. Any new equipment should be added to this document prior to use. An overlap period of using both new and old equipment side-by-side is advised in order to assess any variations due to instrumentation.

#### *Accuracy*

Accuracy represents the ability to measure the exact value for the parameter being measured. Accuracy for all equipment used is shown in Tables 2 through 4 below. Accuracy of measurements of DO, pH and conductivity will be assured through proper calibration and maintenance (See Sections 10 and 11 below) and will be evaluated by comparison with grab samples.

**Table 2: Data Quality Objectives for Multi-Parameter Probe: Hydrolab® Sonde 4a and Hydrolab® Sonde 111**

Parameter	Expected Range	Precision	Accuracy
Temperature	0 to 30°C	± 0.01°C (a)	±0.15 °C (c) ± 0.1°C (d) (b)
Dissolved oxygen	0 to 14 mg O <sub>2</sub> /L	± 0.3 mg/L (a)	± 0.2 mg/L (b)
pH	4 to 10 units	± 0.3 unit (a)	± 0.2 units (b)
Turbidity	0 to 10 NTU	± 1 NTU (a)	±5% (b)
Redox Potential	-999 to 999 mV	± 10 mV (a)	±20 mV (b)
Conductivity	0to 100 µS/cm @ 25 °C	± 0.3 µS/cm (a)	±1% (b)

Depth	0 to 120 m		±.45 m (c) ± .3 m (d)
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- a) Based on the observed range of differences in duplicate measures during previous Hydrolab® deployments.
- b) Based on manufacturer specifications.
- c) HydroLab III specifications
- d) Hydrolab 4a specifications

**Table 3: Data Quality Objectives for other equipment**

Parameter	General Method	Expected Range	Precision	Accuracy
Transparency	Secchi disk depth	0 to 40 m	0.2 m	±0.2 m
Photosynthetically Active Radiation	LI-COR Spherical radiation sensor.	0 to 2000 $\mu\text{E}/\text{m}^2\cdot\text{s}$	N/A (a)	± 5% of reading (b)
Penetration of Solar Radiation	Kahl® Photometer and Lake Lite Photometer	400-700 nm, with Red, Green, Blue and PAR bands	±1% of surface incident light	± 2% of reading
Absorbed light at 660 nm	Seatech® 25-cm pathlength transmissometer	100-1 %	±1% of surface incident light	± 2% of reading

- a) Based on the observed range of differences in duplicate measures during previous Hydrolab® deployments.
- b) Based on manufacturer specifications

**Table 4: Data Quality Objectives for weather station sensors**

Campbell Scientific Weather Station Parameters	Sensor type	Range	Accuracy
Air Temperature	Vaisala® Temperature and Relative Humidity Probe	-39.2 - 60° C	+/- 0.5° C at extremes +/- 0.2° C at 20 C
Relative Humidity	Vaisala® Temperature and Relative Humidity Probe	0.8-100%	+/- 2% (0-90%) +/- 3% (90-100%)
Precipitation	8 inch diameter Tipping bucket rain gage	Tips at 0.01" increments	Up to 1"/hour: +/- 1% accuracy 1-2"/hour: 0 to -2.5% 2-3"/hour: +0 to -3.5%
Barometric Pressure	Vaisala® Barometric Pressure Sensor	-40-60° C operating temperature, 600-1060 mb	+/- 0.5mb @ 20°C to +/- 2.0 @-20 to 45° C
Wind Speed and Direction	Wind Monitor 05103	0-134 mph 0-360°	+/-0.6mph +/- 3°
Solar Radiation	Kipp-Zohn® CM3 Pyranometer Campbell Scientific Weather Station sensor	305-2800 nm -40-80 °C	+/-10% accuracy

### **Precision**

Precision is the ability of a measurement to be consistently reproduced. Multi-parameter robe precision will be monitored by repeating 10% of all measurements of the water column. Duplicate measurements for temperature, pH, conductivity, dissolved oxygen and secchi disk must not exceed the range specified by the grading scales in Table 9 below. These grading scales are deliberately set higher than the manufacturer's specifications, so they will be feasible to the monitoring staff for conditions encountered at Waldo Lake. For all other parameters, duplicate measurements must not exceed data quality objectives. Calibration techniques, explained in Section 11:

Instrument/Equipment Calibration and Frequency, will help to ensure precision goals are met.

### ***Representativeness***

Representativeness is the extent to which measurements actually represent the true environmental conditions. This includes spatial and temporal variations in samples collected. For this project, relevant time scales include annual, seasonal, daily and hourly variations. To be representative, the sampling procedures must accurately capture variation in measured parameters at various scales.

The fluctuation of recent sampling results indicates a more stringent sampling strategy is needed to more accurately portray lake conditions. Sampling timing and frequency need to be defined and improved to more accurately represent the true environmental conditions. For example, Salinas and Larson (2000) state, daily vertical migration of dinoflagelletes might cause unrepresentative primary productivity assessments, if the depth and timing of sampling do not reflect the location of phytoplankton in the water column.

Representativeness of data collected needs to be considered in sampling design when developing future long-term studies. Since no one has ever studied Waldo Lake on a short-term time scale, the assessment of daily and weekly variations is required. After short-term variability has been assessed, the degree of sampling required for a representative long-term monitoring plan should be determined.

### ***Comparability***

Comparability is the degree to which data can be compared directly to similar studies. Using standardized sampling, analytical methods and units to studies with comparable sensitivity will ensure comparable results. Such studies include research on Lake Tahoe and Crater Lake.

### ***Completeness***

Completeness is the comparison between the amount of useable data collected versus the amount of data dictated by the sampling plan. This is a percentage of the total sample collected and analyzed compared to the goals set out by the project design. Table 5 shows realistic goals of completeness for parameters monitored over the entire field season. If these goals for completeness are not met, additional sampling is required.

**Table 5: Goals for completeness for each sampling season.**

<b>Parameter</b>	<b>Goal</b>
Multi-parameter data collection	100%
Water Quality Chemistry	90%
In situ C14 Phytoplankton Primary Productivity	90%
Light data	75%
Phytoplankton and Zooplankton sample collection	90%
Weather Station Data	90%

## **5. Documentation and Records**

All field data collected will be recorded in a field notebook; this includes all information collected by staff. Information recorded in field notebooks will be legible and well organized. Researchers will report calibration protocol, field procedures

completed, equipment used, any problems occurring, daily conditions and quality assurance procedures completed. This information will be recorded as a part of long-term data storage. Field notebooks and notes will be kept for the duration of the project and for future reference.

Data will be entered into electronic format for distribution and preserved on a computer's hard drive and in CD format. Data will be preserved with a quality code associated with it for future reference, including an assessment of the weather conditions encountered. Quality objective will be used in the analysis of data collected. The data will be archived in MS ACCESS database to allow easy access to the data.

Rare and newly identified plant, and zooplankton samples will be archived for future taxonomic comparison. Permanent mounts of phytoplankton samples will be made. Representatives from Portland State University and the U.S. Forest Service will determine responsibility for maintenance, upkeep and organization of long-term storage of the specimens.

## **6. Uses and Distribution of Data and Reports**

Members of the research team will be responsible for communicating with other members of the team and sharing data collected. Yearly, data collected will be organized and compiled on a CD and kept in permanent storage with the Center for Lakes and Reservoirs and with the U.S. Forest Service. Data reports will be generated for the purpose of public education, knowledgeable management decisions and the development of future research goals and scientific questions.

## **DATA MEASUREMENT / DATA MANAGEMENT**

### **7. Sampling Process Design**

#### ***Sampling timing and frequency***

Historically, sampling contracted by the Forest Service, has occurred monthly from May through October. Road accessibility and weather determine the start and finish of the summer sampling season.

The lake has been visited a minimum of four times per sampling season. In order to ensure sampling is representative, this sampling frequency needs to be reassessed to determine how often and when to sample to best capture daily and seasonal variations in conditions. Data collected from continuous temperature monitoring and generated by computer modeling will aide in this decision.

#### ***Sampling locations***

Current efforts have focused on a primary location at the West Bay location located at the north west side of the lake in a deep area of about 120 meters. Samples have also been collected at the North Waldo Campground boat ramp. Table 6 lists GPS coordinates for these long-term monitoring locations, and Figure 2 shows their locations. The weather station is located at the Islet Campground boat ramp on a jetty. It was installed in 2003 and collects data continuously. Its location is also shown on Figure 2. Data collected from continuous temperature monitoring and generated by computer

modeling will provide information if additional sampling locations would be advantageous.

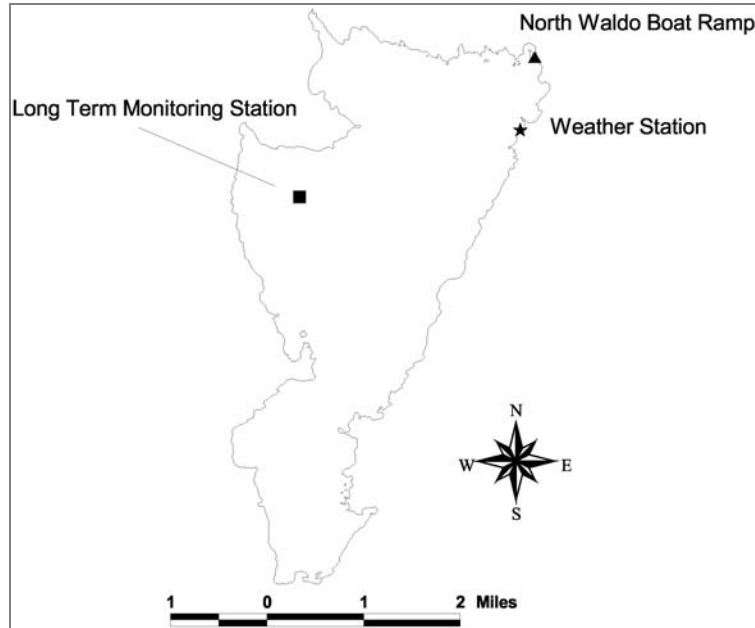


Figure 2: Locations of long-term study sites

Table 6: Long-Term study-site locations

Location	Latitude	Longitude
West Bay Long-Term Station	43.73911 N	122.05589 W
North Waldo Boat Ramp	43.7597 N	122.0068 W
Weather Station	43.74889 N	122.01 W

## 8. Sampling Methods and Requirements

### *Weather Station*

Weather station data loggers will be downloaded once a month to bimonthly. During regular downloading, the pyranometer probe will be cleaned according to manufacturer’s specifications. This data will be analyzed immediately to determine if all probes are functioning properly. Failures and problems will be immediately corrected and faulty probes repaired or replaced.

### *Multi-parameter probe measurement*

Vertical profiles will be collected during regular sampling at the long term monitoring station during the field season. The multi-parameter probe will record parameter values in 1 m intervals from 0-20 meters and 5-meter intervals from 25 meters to the bottom. The probe will be held at each interval until the pH and dissolved oxygen values stabilize. Readings are considered stable when dissolved oxygen concentration readings fluctuate less than 0.2 mg/L. The length of time for stabilization depends of the measurement probe, and will be determined by the researcher, prior to use, usually ranging between 1-4 minutes at each depth. Temperature readings will be validated using

a NIST standardized thermometer on the lake's surface; this reading will be compared with the probe measurement. In order to measure the precision of the vertical profile measurements, values will be recorded again at a minimum of 10% of the sampling depths as the probe is raised to the lake surface. These values will be assessed onsite and repeated if they do not reach data quality objectives as shown in Table 9. Large differences between ascending and descending measurements may indicate that either the probe for that parameter was not working properly or the multi-parameter probe was not held at depth for a sufficient period of time.

Grab samples will be collected at 0,24,60,100, and 120-meter depths for chemical analysis and will be used as an accuracy check for measurements of pH. Conductivity and pH grab samples from 0 and 120 meters will be analyzed in the field using calibrated pH and conductivity meters. Grab samples for dissolved oxygen will be collected at 0,60 and 120-meters. Dissolved oxygen samples will be fixed upon collection and analyzed by Winkler titration as soon as possible after collection.

### ***Transparency measurement***

A 20-cm secchi disk will be lowered into the water column on the shady side of the boat until the disk disappears from view. The disk will be raised until it reappears into view. The depth the disk disappearance and reappearance will be recorded in a field notebook. This procedure will be repeated to find an average value. The time of secchi disk measurement, cloud cover, wind speed, and lake conditions will be noted. The optimum time for secchi disk measurements is between 10 AM and 2 PM. The use of an Aquascope does not allow for comparison of secchi disk readings between years, and will not be used.

### ***Light penetration***

Measurement of light penetration will be taken during periods of consistent cloud cover, on clear, calm days between 10 AM and 2PM in conjunction with secchi disk readings. Time of day, cloud cover, wind speed and lake conditions will be noted in conjunction with light penetration measurement. If very cloudy or inconsistent conditions are encountered the instrument will not be used.

The instrument will be lowered into the water column on the sunny side of the boat. The instrument records solar energy on the lake's surface at the time of deployment. The instrument is placed in the lake to cover the opal glass filter with lake water. It is lifted out of the lake and held above the lake's surface for the first, 100% solar radiation reading. Descending the water column measurements are collected every 5 meters from the surface to 75 m (or to maximum depth for the instrument). The computer collects readings for each bandwidth (red, green, blue, and PAR). A final reading is taken at the surface, is taken with a black cap over the sensor, this represents 0% radiation (Salinas 1999). The same profile will be repeated during each sampling event to assess variations and accuracy.

### ***Transmissometer***

A Seatech® 25-cm pathlength transmissometer has been used to quantify the changes in water transparency of the lake with depth. This instrument uses red light directed straight into a detector. The signal recorded is proportional to the clarity of the

water and inversely proportional to the suspended and dissolved materials in the water. Readings are recorded every meter descending the water column, and then repeated on the way back up, producing a descending and ascending transparency profiles. Measurements are taken to 90 meters (or to maximum depth for the instrument).

### ***Water Sample Collection***

Van Dorn samplers are used to collect water samples at the long term monitoring site. These are collected for water chemistry, phytoplankton primary production, chlorophyll analysis, phytoplankton species analysis and Winkler’s titration at discrete depths. A series of five Van Dorn bottles are attached to a winch cable, lowered to the desired depths (summarized in Table 7) and closed with a messenger activated from the water’s surface. Sample collection bottles are collected and decanted from the Van Dorn sampler through plastic tubing into bottles labeled with time, date, location and depth. Bottling will occur under a shaded canopy immediately following collection.

**Table 7: Summary of water quality sample collection procedures and depths from the long term monitoring station**

<b>Procedure</b>	<b>Depth (m)</b>
D.O. – Field Winklers	0,60,120
Chemistry- including D.O. and pH	0,24,60,100,120, and 0 at North Waldo Swim Area
Chlorophyll	0,12,24,40,60,80,100,120
Phytoplankton	0,12,24,40,60,80,100,120
Carbon -14 Productivity	0,4,8,12,16,24,30,40,60,80,100,110,120
Zooplankton	20-0, 39-20, 60-39, 82-60, 101-82, 120-101

### ***Decontamination prevention***

One-Liter plastic Nalgene® bottles for nutrient and chemical analysis will be provided by the laboratory responsible for chemical analysis. Bottles will be treated in an acid bath, then rinsed with deionized water and dried. Glass bottles for carbon-14 phytoplankton productivity analysis are stored with 0.1 M reagent grade HCl and rinsed 4 times with lake water before they are used. Collection bottles are rinsed twice with receiving water from the appropriate depth before filling. Filtration and sampling equipment will be rinsed six times with deionized water before arrival to the lake and twice with receiving water between sites and depths of collections

### ***Chemistry***

One-Liter plastic Nalgene® bottles are ordered from the chemical analysis laboratory. One-Liter bottles are filled for each sampling depth for each station at the lake, then labeled and sent for analysis the next day on ice via bus. Bottles are rinsed and filled with receiving water from each depth or location. Water chemistry samples are collected using a Van Dorn sampler at 0, 24, 60, 100, and 120 meter depths and at the North Waldo Campground swim area, shown in Table 7. The bottles used to collect samples at 0 and 120 meters for Winkler’s titration to determine dissolved oxygen are filled three times over with receiving water, using procedures to minimize the intrusion of atmospheric oxygen and bubbles. 10 % of samples will be collected in duplicate, using a separate Van Dorn bottle. An additional 10% of samples sent for analysis will be field blanks.

### ***Filtering***

Filtering is used for extracted chlorophyll a measurements. A 500-ml sample of lake water is collected from depths shown in Table 7. The lake sample is cooled on ice at the time of collection, stored in a cooler full of ice during the day, **and then filtered within 24 hours with filters of decreasing size from 20  $\mu\text{m}$  to 0.2  $\mu\text{m}$ .** The filters are stored in labeled vials, coded based on their, pore size, collection depth and location. The exact volume filtered is recorded on a data sheet. Filters will be frozen and stored in a light proof container until analysis. Notes will be kept on quality of procedures, especially for any unusual occurrences, or if volume of water filtered changes.

Plankton	Plankton Size	Filter Pore Diameter
Picoplankton	0.2-2.0 $\mu\text{m}$ in diameter	0.2 $\mu\text{m}$
Nanoplankton	2-30 $\mu\text{m}$ in diameter or length	2.0 $\mu\text{m}$
Microplankton	30-200 $\mu\text{m}$ in diameter or length	20 $\mu\text{m}$

( Kalff, 2002)

### ***Phytoplankton***

Unfiltered lake water is collected at depths specified in Table 7; the water sample is quickly decanted into labeled, 500-ml amber bottles to avoid the effects of settling. Samples are preserved with Lugol's solution and analyzed within 6 months. 10% of samples will be split and analyzed separately for the purpose of taxonomic and enumeration comparison. 10% of samples will be duplicated, by collecting a separate sample with a separate Van Dorn bottle.

### ***In Situ Primary Productivity***

Procedural details for carbon-14 incubations for analysis of phytoplankton primary production are available in the Waldo Lake: Monitoring Protocol Willamette National Forest 1986-1999 (Salinas 1999). Samples are collected at depths indicated in Table 7 upon arrival to the site, before 10 AM. 250-ml volume, glass bottles, one clear, one dark, are filled for the incubation. Bottles are returned to their depth of origin on a rope attached to a floating buoy. At the end of the day, after a 4-6 hour incubation period, these bottles are retrieved and stored in the dark. The samples are filtered upon return to the dock at the end of the day.

10 % of samples will be duplicated and field blanks will be used to test for contamination. Prior to the start of every field season the stretch of the rope used will be measured on land for accuracy. If stretching is found to be a factor, the rope will be replaced or remarked to insure accurate depth during the incubation procedure. Notes will be kept on quality of procedures, especially for any unusual occurrences, or if volume of water filtered changes.

### ***Zooplankton***

A 75-micron mesh, self-closing net with a 50 cm diameter is used to collect zooplankton samples at discrete depths. Tows will be taken from the depths shown in Table 7. The net is lowered to the desired depth at a steady rate, preventing twisting and tangling of the net. It is then quickly raised through the water column and a messenger is dropped at a calculated time. This time is based on the speed that the net is raised and the distance it will travel, in order to close the net at the desired depth.

The outside of the net will be rinsed once with lake water to collect zooplankton from the net into the collection cup. The samples will be poured into a 500-ml bottle and preserved with formaldehyde and BHT for color preservation.

10% of samples will be split and analyzed separately for the purpose of taxonomic and enumeration comparison. 10% of samples will be duplicated, by collecting a separate sample.

## **9. Quality Control Requirements**

The accuracy and precision of the instruments used and the sample collection procedures have been presented previously. Tables 8 and 10 below summarize methods and goals for quality assurance. All data collected will be accompanied by information regarding its' quality. This requires assessing data collection in the field at the time of collection. If requirements outlined in Table 9 below are not met, then repetition of sampling is required.

Field blanks will be composed of deionized water decanted from a clean, rinsed bottle into the appropriate sample bottles. One field blank will be collected for every ten samples collected, this is to determine if there is any contamination caused by collection techniques, equipment contamination. These will be analyzed to assess bias from field sampling as well as transport.

One duplicate will be collected for every ten samples collected in the field, this will be used to quantify variations encountered in the field as well as assess error. A duplicate sample will be collected from the same depth in the water column using a separate Van Dorn bottle.

Split samples will be sent to a different laboratory for separate analysis to ensure unusual species are identified correctly and to assess variations in enumeration. Split samples are created by collecting and preserving a one-liter sample in the field. Once sampling is complete, the sample can be separated in a sample splitter and sent to separate labs. Splitting of samples is needed at least three times a year for the purposes of statistical comparison.

Quality control standards met by laboratories have been previously explained in full (Salinas, 1999).



<b>Parameter</b>	<b>Completion Goal</b>	<b>QA Method</b>	<b>Calibration Check</b>	<b>Required Resampling</b>	<b>Required Assessment of data collection protocol</b>
<b>Chlorophyll</b>	90%	Accurate Labeling Record volume filtered Keep samples cool and dark		>10 % of samples contaminated or collected with errors, resampling required	Errors or changes in procedures noted
<b>Water Sample Collection</b>	90%	Well cleaned supplies Rinse bottles with receiving water Accurate labeling 10 % of samples field blanks 10 % of duplicate samples		>10% of samples collected with error, such as unfilled bottles or failure to rinse with receiving water, than resampling is required	Errors or changes in procedures noted
<b>Light Transmission</b>	100%	Replication of profile			Conditions about light conditions, and wind during measurement should be noted
<b>Light Penetration</b>	75%	Replication of profile Comparison of photometer with spectroradiometer Manufacturer specified maintenance	Calibration of 100 and 0% penetration at surface and capped Comparison of results to theoretical light attenuation Manufacturer specified calibration	Values for profiles may not coincide because of variances in light penetration. One repetition is sufficient.	Consistency of cloud cover, and wind during measurement should be noted

**Table 9: Grading Scales**

	<b>Temperature</b>	<b>pH</b>	<b>Conductivity</b>	<b>DO</b>	<b>Secchi Disk</b>
A	<1.5	≤ .3 (a)	≤ 10%	≤ 3	< 1 m
B	1.51 to 2.00	.31 to .5	10.1% to 15%	.31 to 1.0	1 to 3 m
C				1.1 to 2.0	3 to 5 m
Failure	>2.0	>.5	>15%	>2.0	> 5 m

(a) A grade of A for pH may not be attainable at Waldo Lake due to low ionic strength; this still needs to be assessed.

**Table 10: Project Quality Control Checks**

<b>QC Check</b>	<b>Information Provided</b>
Split samples	Variation in counting and identification
Blanks Reagent blanks Field Blanks	Contaminated reagents Contaminated sampling equipment or preservation acid
Calibration Check samples Zero check Standard check	Accuracy and instrument drift Accuracy and instrument drift
Replicates Field replicates (10% of samples) Laboratory replicates	Variation present in the field Precision of all steps, collection error Analytical precision

## 10. Instrument / Equipment Inspections and Maintenance

Before each sampling event all equipment will be inspected for visible damage such as cracks, breaks or malfunctions. Any equipment found defective in any way would be repaired or replaced. Repairs and problems occurring will be recorded in a field notebook. All sampling equipment will be clean and in good working order before

use. All equipment will be maintained and stored according to manufacturer specifications in order to assure proper functioning. All equipment will be well rinsed and dried before and after use in Waldo Lake. This includes trailers and boats as well as lines, anchors, waders, lifejackets and boots. Careful use of equipment will prevent the transport and introduction of invasive species into this pristine ecosystem.

## **11. Instrument / Equipment Calibration and Frequency**

*Secchi disk* lines are generally a tape measure or winch cable connected to the Secchi disk. No calibration is necessary.

The *Light meter* is calibrated at each use, with a reading taken for air, just above the lake's surface set at 100 % and a capped reading set at 0%. The *transmissometer* has an air calibration set at 96% and a capped calibration at 0% also.

*Multi-parameter probe* Calibration procedures for parameters collected with the multi-parameter probe, for water quality monitoring will strictly follow manufacturer recommendations. Calibration standards will be of National Institute of Standards and Technology quality. All calibrations will be recorded. Calibration procedure will be as follows to insure the probe reaches manufacturer specified accuracy levels:

- *Depth:* Zero depth at each of the lakes during each sampling event. The probe will be lowered with a distance-marked line to provide a backup measurement of depth.
- *Temperature:* Temperature will be checked using a NIST certified thermometer at the surface of each lake and in the laboratory. Temperature acclimation will be verified in the laboratory. Three water baths with temperatures at the extremes encountered in the water column, will be set up allowing the water bath to circulate for 5 minutes and stabilize before taking the reading. All ice will be melted or removed from the ice bath. Measuring probe response time and accuracy will determine how long the probe needs to be left at each depth. With a maximum error of only  $\pm .1^{\circ}$  C at the 3 points, the system's accuracy can be assured to be  $.1^{\circ}$  C.
- *Dissolved oxygen:* Calibrate percent saturation at the lake using default value barometric pressure measured during each of the sampling events. This will be recalculated at the end of deployment to check for equipment drift. Quality control grab samples will be collected from the surface at the start and end of each profile, at 60 meters and from the deepest measurement depth 120 m. Samples will be analyzed by Winkler titration in the field. A zero check can be performed in the lab using a solution of sodium sulfate with temperatures adjusted to be similar to those in field conditions. Drift in dissolved oxygen measurements can occur due to low batteries and within 24 hours of the installation of a new membrane. Calibration will be postponed for a few hours after a new membrane is installed. Battery levels will be monitored routinely.
- *Conductivity:* A two point standard curve will be used, 0 and  $147\mu\text{S}/\text{cm}$ , calibration will occur before and after each sampling period. To prevent contamination of the conductivity standard due to evaporation and carbon dioxide, fresh standard will be used, and its conductivity checked with a primary source. The zero reading of

conductivity needs to be checked. After cleaning and rinsing the sensor with DI water, it will be dried and then calibrated to zero even if the display reads zero. Periodic cleaning of material buildup in the conductivity block by removing the O-rings on the nickel electrodes will prevent slight increases in conductivity readings. Quality control grab samples will be collected from the surface at the start and end of each profile. Samples will be analyzed with a calibrated conductivity meter in the field.

- *pH*: A two-point standard curve with pH 4 and 7 using low ionic strength standard buffers will be used for calibration. Calibration will occur before each sampling period and will be checked with the standards after each sampling period. Quality control grab samples will be collected at the start and end of each profile. Samples will be analyzed with a calibrated pH meter in the field. Response time will be slower in lower temperatures and low ionic strength solutions. (Like those encountered at Waldo Lake.) Response testing must incorporate variables as they are found in the field into laboratory calibration procedures. pH sensitivity at 4 and 7 units with different temperatures encountered in the field will be assessed in the laboratory. Changes in hydrostatic pressure (depth) will also affect the response time to changes in pH. Pressure sensitivity can be quantified in the field by sealing a sample of low ionic strength field water and the sensor in a plastic bag. If this is lowered, then raised, in the water column this will detect changes in pH due to pressure and temperature alone.
- *Turbidity*: A zero check for the turbidity probe will be tested before and after sampling.
- *Power supply drift*: The sonde will be calibrated with the cable length to be used in the field.
- *Response time*: According to manufacturer specifications, response time should be within 1 minute for all parameters, this would be determined in laboratory simulations for individual probes. The response time for changing variables will be recorded during calibration. The true values and the times required for the system to approach the final readings, such as time to reach 90%, 95% and 97% accuracy will be recorded. In the field, by allowing for adequate time for temperature equilibration, temperature sensitivity will be isolated from response time considerations for other variables such as D.O. and pH. In depths where the temperature is changing more than 1° C more time should be given to allow the sensor temperature to equilibrate with the surrounding water.

## **12. Sample Handling and Custody Requirements**

It will be the responsibility of the researcher to deliver the samples to the corresponding laboratories for analysis in a timely manner. Proper storage and handling of samples requiring laboratory analysis will follow the following chain of custody procedure:

- Samples will be labeled and logged in a field notebook upon collection.
- In the field, samples will be the responsibility of the research staff.

- Chlorophyll and nutrient samples will be kept in a cooler containing ice at all times, except when processing occurs, to minimize exposure to light. Water samples will be delivered the day after collection to the laboratory for analysis.
- The analysis laboratory will record sample information concerning arrival date and analysis date.
- Once samples are delivered to the laboratory staff they become their responsibility until analysis.
- Laboratories will follow handling procedures explained in their analytical methods protocol (Salinas, 1999)

### **13. Analytical Methods Requirements**

Laboratory procedures for phytoplankton and zooplankton identification will be provided, by the responsible investigator, in the future. Standard analytical methods (provided by CCAL) to assure accuracy, precision and comparability are available in Waldo Lake: Monitoring Protocol for the Willamette National Forest 1986-1998 (Salinas 1999).

### **14. Data Management**

All data collected in the field will be recorded in field notebooks. Field notebooks will be photocopied upon return to the office. Downloaded data files will be organized into an Access database and preserved on a CD. Electronic format of data collected will be shared with other members of the team and preserved on CDs. Electronic files will be archived into an MS Access database and comma delimited text file for use in modeling.

## **ASSESSMENT AND OVERSIGHT**

### **15. Assessment and Response Actions**

In order to ensure the data is collected and handled as planned, a process of evaluation is necessary. This section describes the checks necessary to ensure that:

- all elements of this QA/QCPP are correctly implemented as prescribed
- the quantity of data generated is adequate, and
- corrective actions, when needed, are implemented in a timely manner and their effectiveness is confirmed.

This will be accomplished through routine monitoring of project activities. Project leaders will monitor activities within their areas of expertise. Monitoring activities will include monthly meetings with the project leaders and the research staff. Project leaders will ensure project activities:

- were technically adequate

- were completely performed
- were properly documented
- satisfied technical requirements, and
- satisfied established QA requirements

Unsatisfactory results or conditions will be documented and corrective actions will be taken. Continued unsatisfactory results will result in closer scrutiny of project activities.

## **16. Data Review, Validation, and Verification**

All data collected are subject to review by the project leaders and appropriate Forest Service staff to determine if data meet QA/QCPP objectives. Decisions to reject or qualify data are based data quality objectives and will be reported to project leaders.

## **REFERENCES**

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