DEPARTMENT OF
ECOLOGY
State of Washington

Quality Assurance Project Plan

West Medical Lake Verification Monitoring

April 2012
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Publication Information

Each study conducted by the Washington State Department of Ecology (Ecology) must have an approved Quality Assurance Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completing the study, Ecology will post the final report of the study to the Internet.

The plan for this study is available on Ecology's website at www.ecy.wa.gov/biblio/1203103.html.

Data for this project will be available on Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm. Search User Study ID, tist0000.

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Quality Assurance Project Plan

West Medical Lake Verification Monitoring

April 2012

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Signatures are not available on the Internet version.
ERO: Eastern Regional Office
EAP: Environmental Assessment Program
EIM: Environmental Information Management database

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Abstract

Several recent changes in the West Medical Lake area have prompted additional study. Data collected by Ecology in 1992 resulted in West Medical Lake being included on the 303(d) list for ammonia and fecal coliform. Additionally, Ecology observed very high nutrient levels and hypolimnetic anoxia in 1992 and again in 1998. Two wastewater treatment plants (WWTPs) which previously discharged to West Medical Lake stopped discharging in 2000.

This study will focus on the effect of these changes. Data will be collected to (1) determine whether the 303(d) listings for ammonia and fecal coliform are still appropriate and (2) assess changes to nutrient concentrations and dissolved oxygen in West Medical Lake since the removal of WWTP effluent. Parameters monitored will include fecal coliform, ammonia, nitrite-nitrate nitrogen, total persulfate nitrogen, ortho-phosphorus, total phosphorus, pH, dissolved oxygen, conductivity, temperature, and lake clarity.

Background

Study Area Description

West Medical Lake is located approximately 15 miles southwest of Spokane, Washington (Figure 1). The lake is located in Water Resource Inventory Area (WRIA) 43 (Upper Crab/Wilson). The lake has a surface area of 890,000 m^2, a volume of 6,044,000 m^3, a mean depth of 6.7 m, and a maximum depth of 8.5 m (Willms and Pelletier, 1992). The lake drains a relatively small basin of about 4.7 km^2. The land surrounding the lake is mostly state owned with no nearshore residential development. However, there is a picnic area on the east side of the lake and a public access, boat rental, and docks at the south end of the lake. Land use near the lake is a mix of forested/natural and dryland farming.

Historically, Eastern State Hospital and Lakeland Village, two facilities operated by the Washington State Department of Social and Health Services (DSHS), discharged treated wastewater to West Medical Lake. Both of these discharges were rerouted in 2000 and connected to the City of Medical Lake's new wastewater treatment plant, providing tertiary treatment. Currently the City of Medical Lake is authorized under the National Pollutant Discharge Elimination System **(**NPDES) Waste Discharge Permit and Reclaimed Water Permit No. WA-0021148 to discharge reclaimed water to West Medical Lake.

The lake is highly eutrophic and may be one of the most enriched lakes in the state. Nutrient levels are extremely high, with total phosphorus concentrations ranging from 2.0 to 2.8 mg/L in 1992 and from 2.6 to 4.9 mg/L in 1998, and total nitrogen levels ranging from 1.4 to 2.1 mg/L in 1992 and from 0.9 mg/L to 2.9 mg/L in 1998. In addition, hypolimnetic anoxia was observed during the summer months both during 1992 and 1998. (Willms and Pelletier, 1992; Smith et al., 2000). The lake has no natural surface water inflow or outflow. A hydraulic residence time of 29 years has been calculated.

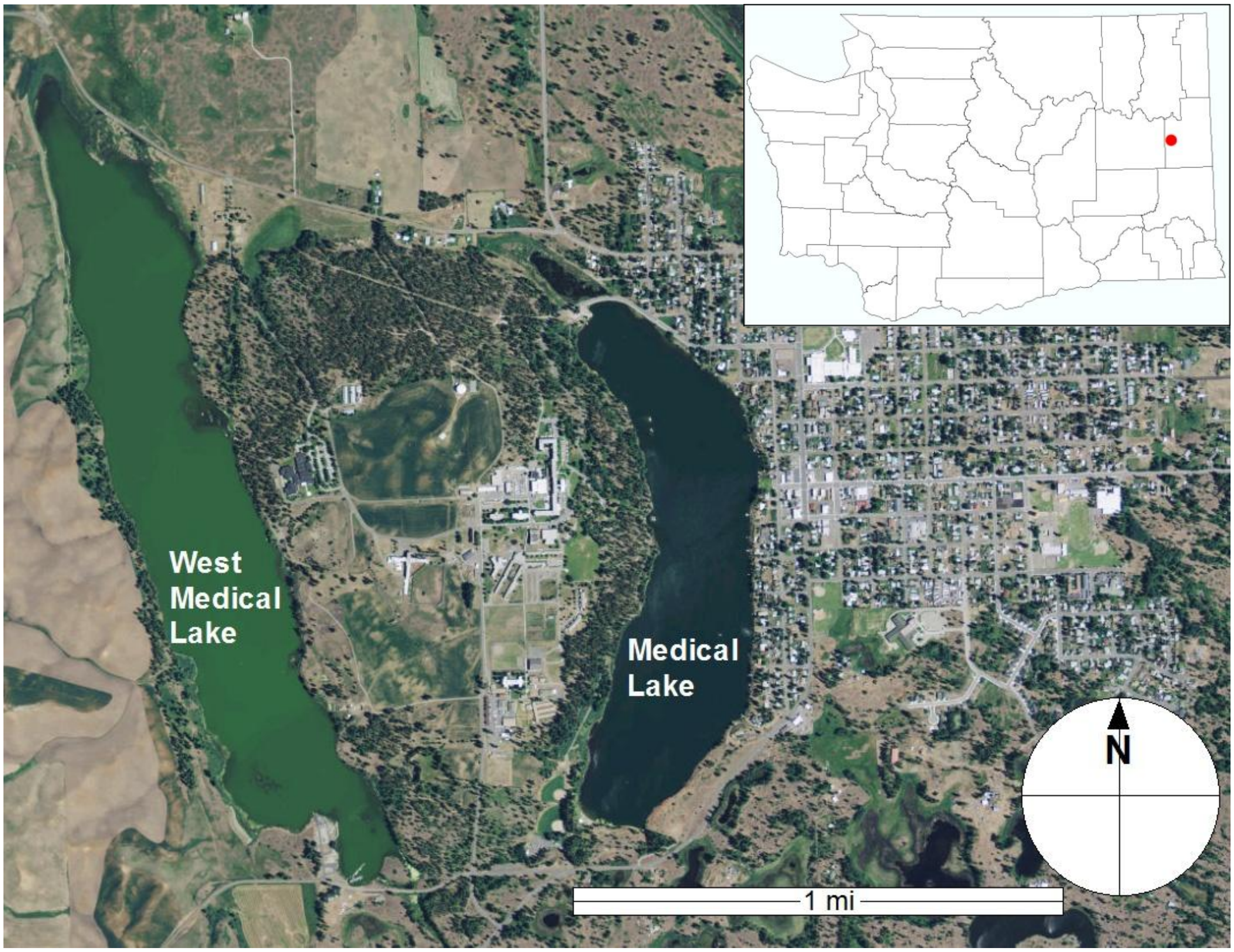

Figure 1. Location of West Medical Lake, also showing Medical Lake and the City of Medical Lake.

Water Quality Impairments

A receiving water study conducted by Ecology (Willms and Pelletier, 1992) led to the listing of West Medical Lake for fecal coliform and ammonia-N on the 303(d) list during the 1998 Water Quality Assessment. Fish tissue sampling by Ecology led to the listings for PCB and 2,3,7,8-TCDD during the 2004 Water Quality Assessment. Table 1 presents all category 5 (impaired waters) 303(d) listings for West Medical Lake. There are no category 2 listings (waters of concern) for West Medical Lake.

Table 1. Category 5 303(d) listings for West Medical Lake.

Water Body	Listing ID	Parameter	Waterbody ID	Township	Range	Section
West Medical Lake	6723	fecal coliform	1177080475730	24N	40E	13
West Medical Lake	8957	ammonia-N	1177080475730	24N	40E	13
West Medical Lake	42173	PCB	1177080475730	24N	40E	13
West Medical Lake	42381	2,3,7,8-TCDD	1177080475730	24N	40E	13

The PCB and 2,3,7,8-TCDD listings are addressed by a study conducted by Ecology's Toxics Studies Unit (Coots and Deligeannis, 2010).

Water Quality Standards and Beneficial Uses

The 2006 Water Quality Standards for Surface Waters of the State of Washington Chapter 173-201A WAC (Ecology, 2006a) designates all lakes for the beneficial use, *Core Summer Salmonid Habitat*. This use protects year round use by salmon or trout including spawning and rearing. Lakes are also given a recreational use, *Extraordinary Primary Contact Recreation*. This use provides extraordinary protection against waterborne disease. Each beneficial use has associated water quality criteria.

Ammonia-N criteria for West Medical Lake are determined by toxicity equations which account for water temperature and pH. The water quality criteria applicable to West Medical Lake are those reflecting the presence of salmonids.

In addition, a total nitrogen criterion of 1.36 mg/L specific to West Medical Lake was recommended during a 1998 study of lakes in Washington State (Smith et al., 2000). Ecology has not officially adopted this criterion. However, comparison of total nitrogen data with this criterion will still be useful for determining whether nutrient concentrations in West Medical Lake have improved, stayed the same, or deteriorated.

Table 2 lists the criteria that are applicable in West Medical Lake.

Table 2. Water quality criteria applicable to West Medical Lake.

Parameter	Criteria
Fecal Coliform	Fecal coliform organism levels must not exceed a geometric mean value of 50 colonies /100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 100 colonies /100 mL.
Dissolved Oxygen	Dissolved oxygen concentrations are not to fall below 9.5 mg/L at a probability frequency of more than once every ten years on average. When a water body's DO is lower than 9.5 mg/L (or within 0.2 mg/L) and that condition is due to natural conditions, then human actions considered cumulatively may not cause the DO of that water body to decrease more than 0.2 mg/L. For lakes, human actions considered cumulatively may not decrease the dissolved oxygen concentration more than 0.2 mg/L below natural conditions.
pH	pH shall be within the range of 6.5 to 8.5 with a human-caused variation within above range of less than 0.2 units.
Temperature	7-day average of the daily maximum temperature (7-DADMax) is not to exceed 16°C at a probability frequency of more than once every ten years on average. When a water body's temperature is warmer than 16°C (or within 0.3°C) and that condition is due to natural conditions, then human actions considered cumulatively may not cause the 7-DADMax temperature of that water body to increase more than 0.3°C. For lakes, human actions considered cumulatively may not increase the 7-DADMax temperature more than 0.3°C above natural conditions
Ammonia	**Acute:** The 1-hour average concentration of total ammonia nitrogen (in mg/L) shall not exceed the numerical value expressed by the following equation more than once every three years on the average: $\frac{0.275}{1+10^{7.204-pH}}+\frac{39.0}{1+10^{pH-7.204}}$ **Chronic:** The 4-day average concentration of unionized ammonia (in mg/L) shall not exceed the numerical concentration expressed by the following equation more than once every three years on the average: $0.80 \div (FT)(FPH)(RATIO)$ where: $RATIO = 13.5; 7.7 \leq pH \leq 9$ $RATIO = \left(20.25 \times 10^{(7.7-pH)}\right) \div \left(1+10^{(7.4-pH)}\right); 6.5 \leq pH \leq 7.7$ $FT = 1.4; 15 \leq T \leq 30$ $FT = 10^{[0.03(20-T)]}; 0 \leq T \leq 15$ $FPH = 1; 8 \leq pH \leq 9$ $FPH = \left(1+10^{(7.4-pH)}\right) \div 1.25; 6.5 \leq pH \leq 8.0$

Project Description

Goals and Objectives

The goals of this project are to:

- Assess the nutrient and fecal coliform status of West Medical Lake after the removal of Eastern State Hospital and Lakeland Village wastewater discharges from the lake.
- Collect enough data to either confirm that ammonia and fecal coliform are still in violation of water quality standards or determine if delisting the lake for these parameters is appropriate.
- Determine whether total nitrogen concentrations are in compliance with the recommended total nitrogen standard for West Medical Lake.

These goals will be served by meeting the following objectives:

- Take field measurements and sample nutrients and fecal coliform at the same locations used by Willms and Pelletier in 1992 to provide comparability between studies.
- Sample fecal coliform twice monthly, and nutrients and field measurements once monthly, from April through September, 2012.

Sampling Design

A field crew consisting of at least two people will collect samples twice monthly from April through October, 2012. Nutrient samples and field measurements will be collected once per month. Fecal coliform samples will be collected twice monthly. Nutrient samples will be collected at two deep sampling sites, one representing the north and the other representing the south half of the lake (WML-1, WML-2). Profiles of pH, conductivity, dissolved oxygen, and temperature as well as secchi disc depths will be measured at the two nutrient sampling sites when nutrient samples are collected. Fecal coliform samples will be collected at four shallow sampling sites, located at the north, west, east, and south edges of the lake (WML-A, WML-B, WML-C, and WML-D). The fecal coliform sites at the west and east edges of the lake are located near the former Lakeland Village and Eastern State Hospital wastewater outfalls. These are the same sampling locations used during Ecology's receiving water study (Willms and Pelletier, 1992). Figure 2 and Table 3 present the sampling locations to be used during this study.

Fecal coliform samples will be taken from approximately 0.5 m below the surface at each fecal sampling location. Measurements of pH, conductivity, dissolved oxygen, and temperature using a Hydrolab will be taken at 1-meter intervals throughout the water column at the nutrient sampling sites. The Hydrolab profile will be used to find the thermocline, which will define the boundary between the epilimnion and the hypolimnion. Composite nutrient samples will be taken from the epilimnion and the hypolimnion at each sampling location. Each composite sample will consist of samples taken at three depths in the appropriate layer. If the lake is not stratified, a single composite sample will be taken. Nutrient parameters collected will include ammonia, nitrite-nitrate, total persulfate nitrogen, orthophosphate, and total phosphorus.

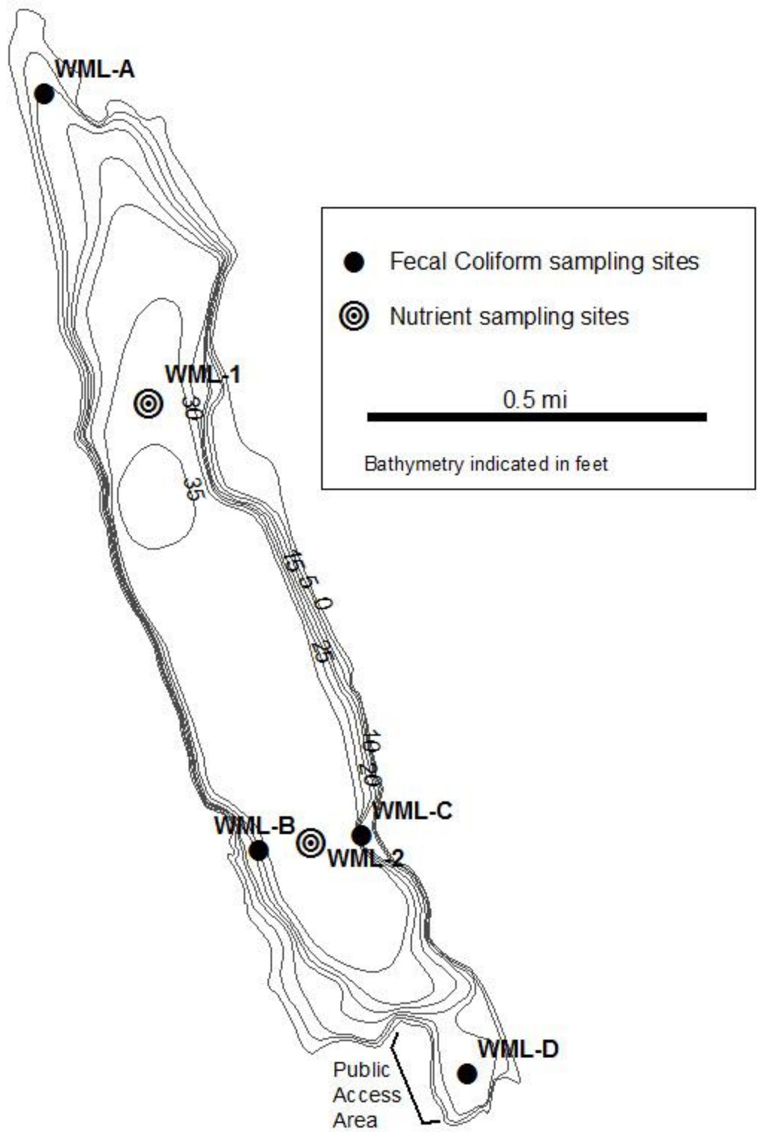

Figure 2. Map showing sampling locations on West Medical Lake.

Table 3. Description of sampling locations.

Station ID	Station Description	Latitude	Longitude	Fecal Coliform	Nutrients	Secchi	Hydrolab profile
WML-1	Deep location in northern half of lake	47.5769	-117.7114		X	X	X
WML-2	Deep location in southern half of lake	47.5677	-117.7069		X	X	X
WML-A	Far north end of lake	47.5834	-117.7143	X			
WML-B	West edge of lake near old Lakeland Village outfall	47.5676	-117.7085	X			
WML-C	East edge of lake near old E. State Hospital outfall	47.5678	-117.7054	X			
WML-D	Far south end of lake near public access and resort	47.5628	-117.7024	X			

Organization and Schedule

Table 4 lists the people involved in this project. All are employees of the Washington State Department of Ecology. Table 5 presents the proposed schedule for this project. Table 6 gives the laboratory costs for this project.

Table 4. Organization of project staff and responsibilities.

Staff (all are EAP except client)	Title	Responsibilities
Elaine Snouwaert Water Quality Program Eastern Regional Office Phone: 509-329-3503	EAP Client	Clarifies scope of the project. Provides internal review of the QAPP and approves the final QAPP. Helps collect field samples and records field information.
Tighe Stuart Eastern Regional Office Phone: 509-329-3476	Project Manager/ Principal Investigator/ EIM Engineer	Writes the QAPP. Oversees field sampling and transportation of samples to the laboratory. Writes the data memo. Conducts QA review of data, analyzes and interprets data, and enters data into EIM.
Administrative Intern Eastern Regional Office Phone: TBD	Field Assistant	Helps collect samples and records field information. May also enter data into EIM.
Gary Arnold Central Regional Office Phone: 509-454-4244	Section Manager	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Dean Momohara Manchester Environmental Laboratory Phone: 360-871-8801	Interim Director	Approves the final QAPP.
William R. Kammin Phone: 360-407-6964	Ecology Quality Assurance Officer	Reviews the draft QAPP and approves the final QAPP.

EAP: Environmental Assessment Program
EIM: Environmental Information Management database
QAPP: Quality Assurance Project Plan

Table 5. Proposed schedule for completing field and laboratory work, data entry into EIM, and reports.

Field and laboratory work	Due date	Lead staff
Field work completed	10/2012	Tighe Stuart
Laboratory analyses completed	11/2012	
Environmental Information System (EIM) database		
EIM user study ID	tist0000	
Product	Due date	Lead staff
EIM data loaded	1/2013	Tighe Stuart or intern
EIM quality assurance	2/2013	TBD
EIM complete	3/2013	Tighe Stuart
Final memo to client		
Author lead	Tighe Stuart	
Due Date	4/2013	

Table 6. Laboratory cost estimate.

Sample Type	Parameter	Sites	QA	Visits	Field Blanks	Analytical cost per sample[1]	Subtotal
Surface Water	Nutrients[2]	2 sites × 2 composite samples	4 during project (2 from each layer)	7	4	$85	$3060
	Fecal Coliform	4	7 during project	14	0	$26	$1638
Total laboratory cost estimate:							$4698

[1]Costs include 50% discount for Manchester Laboratory.
[2]Includes ammonia, nitrite-nitrate, total persulfate nitrogen, orthophosphate, and total phosphorus.

Data Quality Objectives

Field sampling procedures and laboratory analyses inherently have associated uncertainty which results in data variability. Measurement quality objectives state the desired data variability for a project. Precision and bias are data quality criteria used to indicate conformance with measurement quality objectives. The term accuracy refers to the combined effects of precision and bias.

Precision is defined as the measure of variability in the results of replicate measurements due to random error. Random error is imparted by the variation in concentrations of samples from the environment as well as other introduced sources of variation (e.g., field and laboratory procedures). Precision for replicate samples will be expressed as percent relative standard deviation (% RSD).

Bias is defined as the difference between the population mean and true value of the parameter being measured. Bias will be minimized by strictly following sampling and handling protocols. Field equipment will be pre-calibrated and post-checked. Relative percent difference (RPD) will be used as a measure of bias where appropriate.

Field sampling precision and bias will be addressed by submitting field blanks and replicate samples. Manchester Laboratory will assess precision and bias in the laboratory through the use of check standards, duplicates, spikes, and blanks.

Field equipment and laboratory analytical methods, precision and bias objectives, method reporting limits and resolution, and estimated range for field and laboratory measurements are shown in Table 7. The targets for analytical precision of laboratory analyses are based on historical performance by MEL for environmental samples taken around the state by the EA Program (Mathieu, 2006). The laboratory’s measurement quality objectives and quality control procedures are documented in the MEL Lab Users Manual (MEL, 2008).

Table 7. Measurement quality objectives.

Analysis	Equipment Type / Method	Precision (Percent Relative Deviation, %RSD)	Bias (Relative Percent Difference, RPD)	Method Lower Reporting Limit and/or Resolution	Estimated Range
Field Measurements					
Water Temperature[1]	Hydrolab MiniSonde®	+/- 0.2 °C	NA	0.01 °C	0 – 30 °C
Specific Conductivity	Hydrolab MiniSonde®	5%	10%	0.1 umhos/cm	20 – 1000 umhos/cm
pH[1]	Hydrolab MiniSonde®	+/- 0.05 s.u.	NA	0.01 s.u.	1 – 14 s.u.
Dissolved Oxygen[1]	Hydrolab MiniSonde®	+/- 0.2 mg/L	NA	0.1 mg/L	0 – 15 mg/L
Dissolved Oxygen[1]	Winkler Titration	+/- 0.2 mg/L	NA	0.1 mg/L	0 – 15 mg/L
Laboratory Analyses					
Fecal Coliform - MF	SM 9222D	50% of replicate pairs <20% RSD; 90% of replicate pairs < 50% RSD[2]	40%	1 cfu/100 mL	1 - >5000 cfu/100 mL
Ammonia	SM 4500-NH_3-H	10%[3]	If sample is >5 times reporting limit, then 20% RPD	0.01 mg/L	0.01 – 20 mg/L
Nitrate/Nitrite	SM 4500-NO_3 I	10%[3]	See above	0.01 mg/L	0.01 – 10 mg/L
Total Persulfate Nitrogen	SM 4500-N B	10%[3]	See above	0.025 mg/L	0.025 – 20 mg/L
Orthophosphate	SM 4500-P G	10%[3]	See above	0.003 mg/L	0.003 – 1 mg/L
Total Phosphorus	SM 4500-P F	10%[3]	See above	0.005 mg/L	0.005 – 10 mg/L

[1] as units of measurement, not percentages.
[2] replicate results with a mean of less than or equal to 20 cfu/100 mL will be evaluated separately.
[3] replicate results with a mean of less than or equal to 5X the reporting limit will be evaluated separately.
SM: Standard Methods for the Examination of Water and Wastewater, 20th Edition (APHA, 1998).

Representativeness

The study is designed to have enough sampling sites and sufficient sampling frequency to meet study objectives. Some parameter values, especially FC, are known to be highly variable over time and space. Sampling variability can be somewhat controlled by strictly following standard procedures and collecting quality control samples, but natural spatial and temporal variability can contribute greatly to the overall variability in the parameter value. Resources limit the number of samples that can be taken at one site spatially or over various intervals of time.

Completeness

EPA has defined completeness as a measure of the amount of valid data needed to be obtained from a measurement system (Lombard and Kirchmer, 2004). The goal for this project is to correctly collect and analyze 100% of the samples for each of the 2 nutrient and 4 fecal coliform sampling sites. However, problems occasionally arise during sample collection that cannot be controlled; this can interfere with the goal. A lower limit of five samples per site will be required for comparison to Washington State criteria. This should easily be met with the current sampling design. For bacteria, WAC 173-201A states:

"When averaging bacteria sample data for comparison to the geometric mean criteria, it is preferable to average by season and include five or more data collection events within each period….and [the period of averaging] should have sample collection dates well distributed throughout the reporting period."

Sampling and Measurement Procedures

Field sampling and measurement protocols will follow those listed in an Environmental Assessment Program protocols manual (Ecology, 1993). Safety procedures detailed in the Environmental Assessment Program's Safety Manual (Ecology, 2006b) will be followed for all sampling.

Field measurements will follow approved Environmental Assessment Program SOPs (Ecology, 2012):

- EAP013 Determining Global Positioning System Coordinates
- EAP011 Instantaneous Measurement of Temperature in Water
- EAP023 Winkler Determination of Dissolved Oxygen
- EAP033 Hydrolab® DataSonde and MiniSonde Multiprobes.
- EAP015 Manually Obtaining Surface Water Samples
- EAP030 Fecal Coliform Sampling
- EAP071 Minimizing the Spread of Aquatic Invasive Species from areas of Moderate Concern

Sampling sites will be located using a handheld GPS, the boat's depth finder, and easily-recognized landmarks on the lake shore.

Nutrient samples will be taken using a Kemmerer sampler with a graduated rope to ensure that samples are taken from the correct depth. The Kemmerer sampler will be triple-cleaned with deionized water between each station. The process of lowering the open sampler will also provide a local-water rinse prior to sample collection. Individual samples composing the composite sample will be emptied into the composite container. Sample bottles will be filled from the composite container. The composite container will be triple-rinsed with deionized water between each composite sample.

Fecal coliform samples will be taken directly, using a sampling pole. This will allow the sampler to reach far enough away from the boat to ensure that the water being sampled has not been disturbed by the boat. This will also allow the sampler to ensure against collecting water from the surface layer.

Conductivity, temperature, pH, and dissolved oxygen will be profiled using a Hydrolab® multiprobe. The profile will consist of discrete measurements taken at depths of 0.5 m, 1 m, and then at 1-meter intervals to the bottom of the lake.

Secchi disk depths will be recorded at each nutrient sampling site as a measure of lake clarity.

Table 8 lists the sample size, containers, preservation, and holding time for each parameter in this study. Sample containers will be provided by Manchester Laboratory. Sample containers will be filled, tagged, and put on ice.

Table 8. Sample containers, preservation, and holding times.

Parameter	Sample Matrix	Container	Preservative	Holding Time
Ammonia	Surface water	125 mL clear poly	H_2SO_4 to pH<2; Cool to 4ºC	28 days
Nitrate/Nitrite	Surface water	125 mL clear poly	H_2SO_4 to pH<2; Cool to 4ºC	28 days
Total Persulfate Nitrogen	Surface water	125 mL clear poly	H_2SO_4 to pH<2; Cool to 4ºC	28 days
Orthophosphate	Surface water	125 mL amber poly with Whatman Puradisc™ 25PP 0.45um filters	Filter in field with 0.45um pore size filter; Cool to 4°C	48 hours
Total Phosphorous	Surface water	125 mL clear poly	1:1 HCl to pH<2; Cool to 4°C	28 days
Fecal Coliform	Surface water	250 mL autoclaved clear poly	Cool to 4ºC	24 hours

Quality Control Procedures

Hydrolab meter measurements will conform to the quality control parameters in Table 7 and the calibration drift parameters in Table 9. Meter dissolved oxygen measurements will be compared to Winkler samples. At least three Winklers will be taken during each sampling event to assess dissolved oxygen meter accuracy or correct results. Winklers will be taken using the Kemmerer sampler at depths corresponding to particular Hydrolab readings, simultaneously with those readings. Winkler bottles will be filled by attaching a length of surgical tubing to the nozzle of the Kemmerer sampler and flushing the Winkler bottle from the bottom with three times the volume of the bottle, similar to the use of a standard dissolved oxygen funnel.

Conductivity, pH, temperature, and dissolved oxygen data from the Hydrolab will be verified using pre- and post-deployment calibration checks, which will be recorded and kept with field data.

To assess field variability, a duplicate Hydrolab profile will be taken at least twice during the course of the project. A duplicate secchi disk measurement will be taken each time a duplicate Hydrolab profile is taken.

Table 9. Hydrolab® equipment individual probe calibration end drift requirements.

Parameter	Calibration Drift End Check
Dissolved Oxygen	± 4%
Temperature	N/A
Conductivity	± 10%
pH	± 0.2 s.u.

Total variability for laboratory analysis will be assessed by collecting replicate samples. Quality control samples will be taken at intervals summarized in Table 10. This represents a 14% duplication for nutrient samples and 13% duplication for fecal coliform samples. MEL routinely duplicates sample analyses in the laboratory (lab duplicate) to determine laboratory precision. The difference between field variability and lab variability is an estimate of the sample field variability.

Field blanks and filter blanks for nutrient parameters will be submitted four times during the project to assess some areas of bias. Field and filter blanks will be made by sampling deionized water following exactly the same procedures used to take regular stream samples, using the same compositing container and syringe, as applicable.

MEL will inform the project manager or principal investigator as soon as possible if any sample is lost, damaged, has a lost tag, or gives an unusual result.

Table 10. Sample quality control samples and intervals.

Analysis	Field Replicates	Check Standard	Method Blank	Duplicate	Matrix Spikes
Total Nitrogen	Replicate both epilimnion and hypolimnion twice during project (4 replicates total)	1/batch	1/batch	1/20 samples	1/20 samples
Ammonia Nitrogen		1/batch	1/batch	1/20 samples	1/20 samples
Nitrate + Nitrite Nitrogen		1/batch	1/batch	1/20 samples	1/20 samples
Orthophosphate		1/batch	1/batch	1/20 samples	1/20 samples
Total Phosphorus		1/batch	1/batch	1/20 samples	1/20 samples
Fecal Coliform	1/month (every other run)	N/A	1/batch	1/20 samples	N/A

Data Management Procedures

Field measurement data will be entered into a field book with waterproof paper in the field and then entered into EXCEL® spreadsheets as soon as practical after returning from the field. This data will be used for preliminary analysis and to create a table to upload data into Ecology's EIM system.

Sample result data received from MEL by Ecology's Laboratory Information Management System (LIMS) will be added to a spreadsheet for laboratory results. This spreadsheet will be used to informally review and analyze data during the course of the project.

All monitoring data will be available in EIM, via the Internet, once the project data have been validated. The URL address for this geospatial database is www.ecy.wa.gov/eim/index.htm. All data will be uploaded to EIM by the EIM data engineer after the data have been reviewed for quality assurance and finalized.

All spreadsheet files, paper field notes, and Global Information System (GIS) device products created as part of the data analysis will be kept with the project data files.

Audits and Reports

At the conclusion of this study a technical memo will be written from the project lead to the client summarizing the study findings. This memo will include a brief analysis of whether fecal coliform and ammonia are still in violation of water quality standards based on the current listing policy (WQP Policy 1-11). The memo will also discuss whether total nitrogen concentrations are within the recommended total nitrogen criterion for West Medical Lake.

Data Verification

Laboratory-generated data reduction, review, and reporting will follow the procedures outlined in the MEL *Lab Users Manual* (MEL, 2008). Lab results will be checked for missing and improbable data. Variability in lab duplicates also will be quantified using the procedures outlined in the *Lab Users Manual*. Any estimated results will be qualified and their use restricted as appropriate. MEL will send a standard case narrative of laboratory quality assurance/quality control results for each set of samples to the project manager.

Field staff will check field notebooks for missing or improbable measurements before leaving each site. The EXCEL® (Microsoft, 2007) Workbook file containing field data will be labeled DRAFT until data verification is complete. Data entry will be checked against the field notebook data for errors and omissions. Missing or unusual data will be brought to the attention of the project manager for consultation. Valid data will be moved to a separate file labeled FINAL.

The project manager will check data received from LIMS for omissions against the Request for Analysis forms. Field replicate sample results will be compared to quality objectives in Table 7. The project manager will review data requiring additional qualifiers.

After data verification and data entry tasks are completed, all field and laboratory data will be entered into a file labeled FINAL and then into the EIM system. Another field assistant will independently review EIM data for errors at an initial 10% frequency. If significant entry errors are discovered, a more intensive review will be undertaken.

Data Quality (Usability) Assessment

After the project data have been reviewed and verified, the project lead will determine if the data are of sufficient quality to meet the study objectives. The project memo from the project lead to the client will discuss data quality and whether project objectives were met.

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Appendix. Glossary, Acronyms, and Abbreviations

Glossary

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Dissolved oxygen (DO): A measure of the amount of oxygen dissolved in water.

Effluent: An outflowing of water from a natural body of water or from a man-made structure. For example, the treated outflow from a wastewater treatment plant.

Eutrophic: Nutrient- rich and high in productivity resulting from human activities such as fertilizer runoff and leaky septic systems.

Fecal coliform: That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. Fecal coliform are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

Geometric mean: A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10 to 10,000 fold over a given period. The calculation is performed by either: (1) taking the nth root of a product of n factors, or (2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Nutrient: Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

Parameter: A physical chemical or biological property whose values determine environmental characteristics or behavior.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Salmonid: Any fish that belong to the family *Salmonidae*. Basically, any species of salmon, trout, or char. www.fws.gov/le/ImpExp/FactSheetSalmonids.htm

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and water courses within the jurisdiction of Washington State.

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited estuaries, lakes, and streams that fall short of state surface water quality standard, and are not expected to improve within the next two years.

Acronyms and Abbreviations

DSHS	Washington State Department of Social and Health Services
e.g.	For example
Ecology	Washington State Department of Ecology
EAP	Ecology's Environmental Assessment Program
EIM	Environmental Information Management database
et al.	And others
GPS	Global Positioning System
MEL	Manchester Environmental Laboratory
PCB	Polychlorinated biphenyls
QA	Quality assurance
QAPP	Quality assurance project plan
RPD	Relative percent difference
RSD	Relative standard deviation
SOP	Standard operating procedures
TCDD	Tetrachlorodibenzo-p-dioxin
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area
WWTP	Wastewater treatment plant

Units of Measurement

°C	degrees centigrade
cfu	colony forming units
km	kilometer
m	meter
mg/L	milligrams per liter (parts per million)
mL	milliliter
s.u.	standard units