Thurston County
Surface Water Ambient Monitoring Program

Standard Operating Procedures and Analysis Methods
For Water Quality Monitoring

Revised February 2009

Thurston County Public Health and Social Services Department
Environmental Health Division

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Project Organization

The Thurston County surface water ambient monitoring program is coordinated through the Thurston County Department of Water and Waste Management, Storm and Surface Water Utility. The water quality monitoring element of the ambient monitoring program is conducted by staff in the Public Health and Social Services Department, Environmental Health Division. The individuals involved in the water quality monitoring are as follows:

Sue Davis, Project Manager and Field Collection
Cathy Hansen, Data Management and Reporting
Linda Hofstad, Data Management and Reporting
Heather Saunders, Field Collection
Mike Clark, Thurston County Environmental Health Laboratory Manager
Steven Lazoff, Aquatic Research, Inc., Laboratory Manager

Project Background

The Thurston County ambient surface water quality monitoring program is part of the overall, on-going Thurston County monitoring program, which includes surface water quality monitoring, stream discharge gauging, lake level monitoring, and precipitation gauging. Most rivers, streams, and public-access lakes in the county are being monitored. The monitoring network is supported by Thurston County and the Cities of Lacey, Olympia, and Tumwater. The program compliments the marine and fresh water quality monitoring conducted by Washington Departments of Health and Ecology and the US Geological Survey stream discharge measurement program.

The data generated by this project are used by the local jurisdictions' storm and surface water utilities and by the public, professional consultants, tribes, and other environmental agencies such as Washington Department of Ecology and US Environmental Protection Agency.

Project Description and Design

Project Objectives

The objectives of this long-term water quality monitoring program are the following:

- Provide a long-term, consistent water quality baseline of data for streams and lakes;
- Provide data that is used to track water quality and quantity trends over time and identify problems areas where corrective actions should be taken.
- Enable broad analysis of the data with the capacity for comparison between areas;
- Ensure that monitoring equipment is available for routine monitoring and emergency response;
- Provide easy access to information/data by jurisdictions, agencies, and citizens;

- Compliment state Departments of Health and Ecology marine and freshwater monitoring programs.

Project Tasks and Timetable

Table 1. Tasks and Timetable

Activity	Frequency	Completion Date
Field data collection and sampling	Monthly	On-going
QA/QC	Monthly	On-going
Data management	Monthly	On-going
Data posting to County website	Annually	January 31
Report preparation	Every 2 years	June 30

For EPA project # WS-96073601-0, the project began July 1, 2008.

Sampling Locations and Selection Rationale

All monitored rivers and streams have sampling stations near their mouths to evaluate the impacts of activities in the watershed on the receiving water. A few of the rivers and streams have additional up-stream stations to segment sections based upon major land-uses or to isolate known problem areas.

Most lakes in the monitoring program have one sampling station located over the deepest part of the lake. Those lakes that have multiple basins have a monitoring station in two basins. The lakes that are included in the 2009 monitoring program include Long (2 sites), Pattison (2 sites), St Clair (2 sites), Capitol (2 sites), Hicks, Deep, Ward, Black, and Summit.

The number and locations of monitoring stations are periodically adjusted as the program is adapted to new information or changing priorities. Table 2 on the following page lists the streams and rivers in the 2008/2009 water year monitoring program is included below. A map showing the sampling locations for all of the water bodies is included in Appendix B.

Table 2. Stream Sampling Sites

2008/09 Ambient WQ Monitoring Sites					
Monitoring Sites	**Location**	**Site ID**	**Stream Ambient**	**TCEH Macros**	**NH_3**
NISQUALLY					
McAllister	Southbound I-5 on-ramp	NISMC0000	X		
Eaton	at Yelm Hwy	NISEA0000	X		
Yelm @ 103rd	at 103rd and Creek St.	NISYL0030	X		
Yelm mouth	off Mud Run Rd	NISYL0000	X new		
Thompson	At Centralia Power Park	NISTH0000	X new		
HENDERSON					
Woodard	4116 Libby	HENWO0000	X	X	
Tanglewilde	Tanglewilde Outfall	HENWL0800	X		X
Woodland	at Pleasant Glade Rd	HENWL0000	X		
BUDD/DESCHUTES					
Black Lk Ditch	at RW Johnson	BUDBD0000	X		
Chambers	off end of 58th	DESCH0300	X	X	
Deschutes @ Tumwater	at Tumwater Falls Park under bridge	DESDE0000	X		
Deschutes @ Waldrick	off bridge at Waldrick Rd.	DESDE0025	X		
Deschutes @ Vail Lp	under bridge at Vail Lp. Rd.	DESDE0045	X		
Percival	at Footbridge	BUDPE0000	X	X	
Spurgeon	at Boe residence off Rich Road	DESSP0500	X		
Reichel	at Vail Loop Rd	DESRE1100	X		
Indian	at Quince Ave	BUDIN0010	X		
Mission	at East Bay Dr	BUDMI0000	X		
Ellis	at East Bay Dr	BUDEL0000	X		
Moxlie	at Marine Dr	BUDMO0000	X		X
Schneider B	at West Bay Dr	BUDSC0000	X		
ELD					
Green Cove	mouth off Cooper Pt Rd	ELDGC0000	X	X	
McLane	mouth at Delphi Rd bridge	ELDMC0000	X	X	
Perry	off Perry Creek Rd	ELDPE0000	X	X	
TOTTEN					
Kennedy	at Mouth	TOTKE0000	X	X	
Schneider T	Pneumonia Gulch off 101	TOTSC0000	X	X	
Schneider Head	upstream of Steamboat Interchange	TOTSC0040	X		
CHEHALIS					
Beaver	at Littlerock Rd	BLABE0700	X		
Black @ Moon	at Moon Rd	BLABL0010	X		
Black @ 128th	at 128th in Littlerock	BLABL0050	X		
Chehalis	At Independence Rd	CHECH0010	X		
Prairie	Off Old Highway 9	CHEPR0510	X		
Salmon	at Littlerock Rd by Quarry	BLASA1020	X		
Scatter @ James	at James	CHESC0100	X		
Scatter @ Gibson	at Gibson Rd	BLASA1020	X		
Blooms Ditch	off 110th	BLABM0910	X		
Skook	at Highway 507	SKOSK0000	X		

Sampling Frequency and Rationale

The streams and rivers are **sampled monthly** throughout the year. The monthly ambient monitoring program has been in place since December 2003. The major water quality impacts of concern in this region occur during the wet season and are associated with contaminants washing off the land into the streams during storm events. The typical water quality concerns associated with dry season/low flow conditions are high water temperature, low dissolved oxygen, and elevated concentrations of specific contaminants associated with continuous (not storm related) pollution sources. To acquire a sufficient amount of data which reflects both wet and dry season influences, samples are collected monthly.

The emphasis for lake sampling is during the warm weather growing season because it is the period when symptoms of nutrient enrichment are manifested and beneficial uses may be impaired. Lake sampling is conducted **six times per year, monthly from May through October.**

Sampling Parameters

Parameters measured at **stream and river** stations include:

- temperature
- pH
- dissolved oxygen
- specific conductance
- stream discharge
- staff gage level (if present)
- total phosphorus
- nitrate-nitrite
- ammonia
- turbidity
- fecal coliform bacteria
- field observations - including any changes from previous sampling events, water appearance, etc.

Parameters measured at **lake** stations include:

- temperature
- pH
- dissolved oxygen
- specific conductance
- secchi disk visibility
- total phosphorus - at surface and bottom depths
- total nitrogen - at surface and bottom depths
- chlorophyll *a* (phaeophyton *a* adjusted) - epilimnion composite
- algae identification - epilimnion composite
- field observations - including water color and appearance, changes from previous sampling, macrophyte growth, etc.

Measurement Quality Objectives and Quality Control Requirements

Laboratory Quality Control

Quality assurance objectives for measurement data are usually expressed in terms of accuracy, precision, completeness, representativeness, and comparability. The laboratory submits quality control and quality assurance results and calculations to the project manager with the analytical reports. A sample QA/QC reports from Aquatic Research, Inc. is included in Appendix C.

Definitions of these characteristics are as follows:

Accuracy: A sample spike is prepared by adding a known amount of a pure compound to the environmental sample (before extraction for extractable), and the compound is the same or similar (as in isotopically labeled compound) as that being tested for in the environmental sample. These spikes simulate the background and interference found in the actual sample. The percent recovery of the spike is taken as a measure of accuracy and is calculated as follows:

$$\%R = \frac{100\ (O-X)}{T}$$

where: %R = Percent recovery; O = Measured value of analyte concentration after addition of spike; X = Measured value of analyte concentration in the sample before the spike is added; and T = Value of spike.

Tolerance limits for acceptable percent recovery established by the lab in accordance with contract laboratory procedures (CLP) guidelines will be followed for this program. Sample spike recoveries that fall outside the tolerance limits shall be assessed and the problem identified and corrected by the lab.

Surrogate spikes are also a measure of accuracy. When surrogate recoveries are outside the control limits, the corrective action procedures specified in the methods must be followed by the laboratory.

Laboratory blanks are analyzed by the lab to ensure samples are not contaminated during the analytical process of the lab. If there is contamination in the blank, the lab should be contacted immediately and requested to check their QA data. Samples should be re-analyzed if holding times have not been exceeded. If an environmental sample result is greater than ten times the concentration in the blank, then the data is acceptable but always qualified. If the sample result is less than ten times the concentration in the blank, the data must be discarded. If holding times have expired and the data is essential, then re-sample.

Precision: Precision is the degree to which a set of results are repeatable using the same methods and performed under the same conditions. To examine precision the lab performs duplicate analyses. Two aliquots of the same sample are made in the laboratory and each aliquot is treated exactly the same throughout the analytical method. The percent difference between the values of the duplicates, as calculated below, is taken as a measure of the precision of the analytical method.

$$\%D = 2\ \frac{(D1 - D2)}{} \times 100$$

$$(D1 + D2)$$

where: %D = Percent difference; D1 = First sample value; and D2 = Second sample value (duplicate)

The tolerance limit for percent difference between laboratory duplicates will be +/- 25%. If the precision values are outside the limits, the laboratory will recheck the calculations and/or identify the problem. Reanalysis may be required. Sample results associated with the out-of-control precision results may be qualified at the time of validation.

Completeness: Completeness is a measure of analytical effort and will be measured as:

$$\%C = V/T \times 100$$

where: C = Completeness of analytical effort, in percent; V = Number of sample analyses that have been validated (validation is the process of review and approval of sample data); and T = Total number of samples that have been submitted for validation.

The target for completeness by the analytical laboratory is 95 percent.

Table 3 shows the acceptance levels for data generated from this program.

Table 3. Quality Assurance/Quality Control Criteria for Laboratory Analysis

PARAMETER	PRECISION (RPD)	ACCURACY (%)	COMPLETENESS (%)
nutrients	25	>80% <120%	95%
chlorophyll a	25	--	95%

RPD = Relative Percent Difference from duplicate analysis; Control limit is 25 RPD if result is > 5 times the detection limit, and is $\pm$ the detection limit if the result is $\leq$ 5 times detection limit.

The target for completeness of the overall project data is 83%, or 10 of 12 sampling events for streams and 5 of 6 sampling events for lakes.

Representativeness: Representativeness is the degree to which data accurately and precisely represent the true value of a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness is maximized by following standard procedures for sampling and analysis.

Replicate samples are taken every ten samples (10%) for all sampled parameters. The replicates are taken side-by-side to reduce field variability. In the lab, blanks, spikes, and splits are used to evaluate the accuracy and precision of the analysis. Field replicates are used to evaluate overall variability. There are no control limits established for field replicates. Data from field replicates are averaged and entered as one number in the database system.

Comparability: Comparability is maximized through the use of standard analytical methods with demonstrable equivalency in terms of method performance criteria and equivalent reported units. Use of standard methods applies to both the laboratory analysis and field procedures.

Field Instrument Quality Control

Table 4 provides instrument specifications for the field instruments used in the ambient monitoring program.

Table 4 - Instrument Specifications

Parameter	Instrument	Range	Accuracy	Resolution
pH	YSI Multi-Parameter Instrument (650 MDS display - 6920 Sonde Unit)	0-14 units	+/-0.2 units	0.01 units
Temperature	YSI Multi-Parameter Instrument (650 MDS display - 6920 Sonde Unit)	-5 to 45 °C	+/- 0.15 °C	0.01 °C
Conductivity	YSI Multi-Parameter Instrument (650 MDS display - 6920 Sonde Unit)	0 to 100 mS/cm	+/- 5% of reading +0.001mS/cm	0.001 mS/cm - 0.1 mS/cm (range dependent)
Dissolved Oxygen	YSI Multi-Parameter Instrument (650 MDS display - 6920 Sonde Unit)	0 to 50 mg/L	Within 0 to 20 mg/L, +/- 2% of the reading or 0.2 mg/l, whichever is greater	0.01 mg/L
Turbidity	YSI Multi-Parameter Instrument (650 MDS display - 6920 Sonde Unit)	0 to 1000 NTU	+/- 5% of the reading or 2 NTU, (whichever is greater) relative to calibration stds	0.1 NTU
Discharge	Swoffer Model 2100 current meter	0.1 to 25 ft/ sec	± 1%	

All field instruments are pre- and post-calibrated. The results of the calibrations and any deviation from the expected values are recorded. Significant deviations result in a variety of actions, including: using new standards for calibration, changing membranes, cleaning probes, replacing probes. The action(s) taken are recorded, along with the results of the actions. Table 5 shows the tolerances for drift in the field instruments between the pre-and post-calibrations. Drift beyond those levels will result in the data being flagged or discarded. For temperature, the instruments will be checked, annually, using a certified thermometer under ice bath and room temperature conditions. If the instrument is greater than $\pm$ 0.5 degrees C, the instrument will be sent to the manufacturer for re-calibration.

Table 5. Field Instrument Drift Tolerance Limits

Parameter	Post-Calibration Drift Tolerance Limit
pH	±0.2 units
dissolved oxygen	±0.5 mg/l
specific conductance	±10%
turbidity	±10%

Data Quality Control

When, during post-calibration procedures, a field parameter falls outside of the acceptable range, the field data for that sampling date is either flagged or discarded.

Lab data is reviewed against criteria in Table 3 upon receipt. It is also reviewed to identify any data that appears to be an outlier. If any problems are found, project staff contact the lab to discuss the data. Based on the findings, a decision is made to either accept, flag (qualify), or discard the data.

Instrument Calibration and Frequency

Calibration Procedures for YSI Model 6920 sonde with 650 MDS display

The instrument is calibrated prior to sampling each day. The instrument is post-calibrated following a day of sampling to ensure that the instrument performed within the acceptable range of accuracy and precision. The manufacturer's calibration procedures are followed for each parameter in accordance with the instrument manual provided. Calibration for dissolved oxygen is an air calibration. Conductivity is calibrated using a single calibration standard solution. pH and turbidity probes are calibrated using a two point calibration method with certified calibration standards. The two pH calibration standards used for stream sampling are 4 and 7, and for lakes they are 7 and 10. The turbidity calibration standards used are 0 and 100 NTU. Between the calibration of each probe, the instrument is rinsed three times with deionized water and once with the next parameter's standard solution.

As with the other instruments, all calibration information is recorded in a calibration logbook. If, during post-calibration procedures, a parameter falls outside of the acceptable range, staff troubleshoot the problem and take action in accordance with the equipment manual. Actions taken may include cleaning probes, soaking probes in specific solutions, changing a membrane, replacing a probe, or sending to the instrument for service to the manufacturer.

The equipment is routinely cleaned and maintained in accordance with the manufacturer's recommendations contained in the equipment manual.

Calibration Procedures for Swoffer Model 2100 Current Meter

1. Switch to CALIBRATE and read the calibration number. If the displayed number is lower, check the battery. A weak battery will allow the calibration number to "drift" downward and cause erroneous readings. Always keep a fully charged 9 volt battery in the spare compartment.

   Changes in the calibration number are proportional to the measurement error on a percentage basis. If the calibration number is 186 and the meter reads 184 then the velocity error due to calibration error will be about 1%. Record the calibration number in the logbook.

   Swoffer Meter #1 Calibration number is 175.
   Swoffer Meter #2 Calibration number is 186.
   Swoffer Meter #3 Calibration number is 184.

2. Check the propeller for damage, such as cracks or rough edges, which would change the calibration. Rough edges can be repaired with fine sandpaper. Cracks and other major damage require the replacement of the propeller.

3. Spin-test the instrument by laying the wading rod on a table or floor with the propeller perpendicular to the floor. Set the knob to "count". Blow on the propeller, and hit the reset button at the moment you stop blowing on the propeller. The propeller should free-spin to a count of at least 400 or greater. If it does not, the instrument should be cleaned or parts replaced as necessary to obtain that level of free-spin before use.

Sampling Methods

A. Field Instruments

Field parameters (temperature, pH, dissolved oxygen, and turbidity) are measured using a Yellow Springs Instrument (YSI) multi-parameter field instrument, Model 6920 and display unit 650 MDS. For streams, the instrument is placed in the flow with the probes facing upstream. For lakes, field parameters are measured by lower the instrument into the lake by one or two meter increments from the surface to the bottom of the lake, as determined by the depth sensor on the instrument.

The nutrient samples for lakes at the bottom are collected using a Kemmerer sampler. Chlorophyll *a* samples are taken as composite samples from the epilimnion (warm surface layer) or the photic zone (the surface area where sunlight can penetrate) using the Kemmerer sampler. Secchi disk visibility (or water clarity) is measured using a standard black and white quadrant disk. A Swoffer Model 2100 current meter is used to measure stream discharge using the wading technique.

B. Field Procedures

A field log is used to record field measurements and observations, including samples collected, date, time, station, weather, field personnel, field instruments used, and any notes regarding deviation from standard procedures. The following is a step-by-step procedure for taking measurements and samples in the field.

1. Streams

Field Measurements and Observations

- record date, time, weather conditions, field crew, field instruments used, field measurements, visual observations, samples taken, and any changes in procedures at each sampling station. Data will be recorded in a water-proof field book.
- allow instrument to stabilize
- record measurements in field book
- measure stream discharge using the primarily the six-tenth wading method described by US Geological Survey (USGS Water Supply Paper 2175, 1982), or the two-point method where depth is greater than 2.5 feet.

Sample Collection

- Stream samples, where possible, will be collected mid-channel and mid-depth. Usually collection is accomplished by wading. At non-wadable sites, samples will be taken mid-stream off a bridge with a custom sampling device.

- Mark sample bottles with the **station identification, date, time, parameters to be analyzed for, field personnel, source of water, and budget charged**. For fecal coliform bacteria samples, fill out the laboratory form with the above information and wrap the form around the sample bottle.

- Store samples on ice in a cooler until returned to the office. Store all bottles in a refrigerator until shipped (in a cooler on ice) or analyzed. Deliver bacteria samples to the Thurston County Health Lab upon returning from the field.

  Fecal Coliform Bacteria Samples

  Use pre-cleaned and sterilized bottles prepared by the Thurston County Environmental Health Lab. When sampling for bacteria, avoid touch the inside or mouth of the bottle. If there is any question about the sterility of a bottle, use another bottle. This parameter is time sensitive and should be analyzed no more than 24 hours after collection.

  To sample:
  - open the bottle with care (do not touch the mouth or inside of the bottle);
  - do **not** rinse the bottle as the bottle contains a preservative;
  - sample from mid-stream and mid-depth if possible, avoiding the surface micro-layer;
  - face up-stream when collecting the sample to ensure collecting water unimpacted by the presence of the field personnel;
  - fill the bottle to the neck, leaving some air space;
  - cap the bottle and attach the completed lab slip;
  - transport in cooler on ice and deliver to the EH lab same day.

Nutrients

Collect samples in pre-cleaned polyethylene bottles supplied by the laboratory. Nutrient samples may include ammonia, nitrate + nitrite, total nitrogen, soluble reactive phosphorus, and total phosphorus.

To sample:

- rinse the bottle(s) two times with the sample water;
- sample from mid-stream and mid-depth when possible;
- face up-stream when collecting the sample to ensure collecting water unimpacted by the presence of the field personnel;
- fill the bottle to the neck, leaving some air space;
- transport on ice, store refrigerated until shipped, ship on ice in a cooler to the analyzing lab.

2. Lakes

Lake stations will be sampled monthly from May through October. The stations are generally located over the deepest basin in the lake. Field parameters are measured at one-meter depth increments (or 2-meter depth increments for lakes over ten meters deep) to identify stratification. The temperature and dissolved oxygen profiles are used to determine appropriate sampling depths for chlorophyll *a* and algae samples and to determine the depth for bottom sample collection.

Field Measurements and Observations

At the established lake station, first check the depth reading before placing the instrument in the water and zero if necessary. Place the YSI instrument in the water so all the probes are completely covered. Wait for all of the parameters to stabilize before recording. Record depth, temperature, pH, conductivity, and dissolved oxygen in the field book. Also record: date, time, field personnel, equipment used, lake color, weather (including wind conditions). Then lower the instrument one meter at a time using the depth reading on the instrument, and record the field parameters at each depth increment (take measurements every two meters in lakes where depth exceeds ten meters).

Secchi Disk Measurement

- lower disk into the water to the point where it cannot be seen;
- pull it back up to where it is just visible;
- record the depth (in meters to the nearest hundredth) in the field book.

Sample Collection

Chlorophyll a (and Phaeophyton a) and Algae Identification Samples

Samples will be collected using a Kemmerer water sampler and composited from two or three discreet samples to obtain a one-liter composite sample for chlorophyll and a 250-ml sample for algae.

To sample:

- determine sampling depths necessary for the composite sample (Use the temperature profile data to determine extent of the epilimnion in the summer. The epilimnion is the warm upper layer of water having a fairly uniform temperature. If sampling in the winter when most local lakes are not stratified, use 1.5 times the secchi disk depth as the surface layer to sample);
- record the composite sampling depths in the field book;
- lower the Kemmerer column sampler to the determined depth;
- rinse the bottle with water in the epilimnion (surface is OK);
- fill the sample bottle from the Kemmerer sampler with the appropriate volume of water to have an equal volumes from each depth, i.e. fill bottle one-third volume from each depth if three depths will be sampled to comprise the composite.
- repeat steps above the appropriate number of times to fill the composite samples;
- add the 1 mg/L $MgCO_3$ preservative to the chlorophyll samples and shake;
- transport in cooler on ice, store refrigerated until shipped or analyzed
- preserve the algae identification samples with 4 drops of the preservative Lugols solution

Nutrients

Samples are taken at approximately 0.5 meters below the surface and 0.5 meters above the lake bottom with a Kemmerer sampler. Procedure is as follows:

- label the sample bottles. The sample identification is "station identification" followed by an "A" for surface sample or a "B" for bottom sample;
- determine the lake depth with the YSI instrument;
- for the near-surface sample, rinse the bottle with lake surface water two times;
- collect the near-surface sample by submerging the bottle mouth down in the water, when at 1.5 feet depth tilt the bottle side-wise and move forward in a scooping motion until filled. Empty enough liquid to bring the water level to the shoulder of the bottle.
- For the near-bottom sample, lower the Kemmerer to the appropriate depth, using caution to avoid hitting the bottom and disturbing the bottom sediment;
- rinse the sample bottle twice with the sample water from the Kemmerer;
- discard the bottom sample if suspended sediment is present; sample again as necessary;
- record the sampling depths in the field book;
- transport in cooler on ice, store refrigerated, Shipped in a cooler on ice to the analyzing lab via Greyhound bus

Sample Handling and Custody Procedures

Samples to be analyzed at the Thurston County Environmental Health lab are delivered directly to the lab by field staff on the same day as collection. Attached to every sample is a sample slip completed by the field staff. Samples are analyzed within 30 hours of collection.

Samples to be analyzed by Aquatic Research, Inc. are stored in the Environmental Health sample refrigerator immediately upon returning from the field. The morning after completion of the sampling event, a chain of custody form is completed and enclosed in a cooler with the samples and blue ice. The

cooler is shipped via Greyhound bus to the Aquatic Research lab in Seattle. The samples arrive in Seattle and are picked up by lab staff on the same day as shipped.

Analytical Methods

Pre-cleaned water sampling bottles are supplied by the analyzing laboratory with the exception of algae identification bottles which are prepared by Environmental Health ambient program staff.

Analyzing entities used for this project have the appropriate certification from Washington Department of Ecology or Washington Department of Health for the parameters tested. The Quality Assurance Plan for the Thurston County Environmental Health Laboratory is in Appendix A. The analytical methods are listed in the table below.

Table 6. Analysis of Surface Water Samples

Chemical Analysis	Reporting Units	Recommended Holding Times	Analytical Method	Detection Limit
Ammonia-Nitrogen (NH_3)	mg/L as N (ppm)	7 days	EPA350.1	0.010 mg/l
Chlorophyll *a* (with Phaeophyton *a*)	ug/l	30 days	SM18 10200H.1 & 2	0.1 ug/l
Fecal Coliform (FC) most probable number membrane filter	cfu/100 mL	30 hours	APHA-9221C APHA-9222D	1 cfu/100ml
Nitrate + Nitrite (NO_3+NO_2)	mg/L as N	48 hours OR 28 days if preserved	EPA353.2	0.010 mg/l
Total Nitrogen (TN)	mg/L as N	28 days	SM 20 4500N-C	0.100 mg/l
Total Phosphorous (TP)	mg/L as P	28 days	SM18 4500PF	0.002 mg/l

Nutrient samples analyzed by Aquatic Research for this project are analyzed within 5 days of collection and are not acid preserved. The rationale for this is as follows: 1) This ambient monitoring program requires low level detection limits due to the nature of the waters being sampled. Acid preserving would require samples to be neutralized before analysis and then diluted, which would raise the detection limits above the desired limits. 2) For the nutrient parameters being analyzed, there is expected to be very little measurable loss or conversion between time of collection and time of analysis when analyzed within 5 days of collection .

Data Analysis and Reporting

At the end of each water year (September 30), the data is compiled and compared against the data objectives. Laboratory reports, QA worksheets, chain-of-custody records, and field notes are retained in the ambient monitoring program records. Upon completion of the data analysis, the project will be evaluated against the stated project goals and objectives.

Specific QA information that is evaluated is as follows:

- changes in the monitoring / QA project plan
- results of performance and/or systems audits
- significant QA problems and recommended solutions
- data quality assessment in terms of precision, accuracy, representativeness, completeness, comparability, and detection limits
- data qualifiers and rejections
- examination of whether the QA objectives were met, and the resulting impact on decision-making limitations on use of the measurement data

Data generated from this project are annually posted to the County website for accessibility by the public. Every two-year water resources monitoring report is prepared, and the document is posted to the website. In addition to being a compilation of two-years of data, the data is compared to the state water quality standards established in Chapter 173-201A WAC and shown in Table 7 below. Streams with several years of data are graphed to examine trends.

Water Quality Standards

The Washington State water quality standards for all surface water bodies are established in Chapter 173-201A of the Washington Administrative Code (WAC) which was amended July 1, 2003. Water quality standards for surface waters were established consistent with public health and public enjoyment of the waters and the propagation and protection of fish, shellfish, and wildlife. The standards for the parameters that are monitored by Thurston County are shown in Table 6. Refer to WAC 173-201A for a complete description of the water quality standards.

Table 7. Water Quality Standards for Surface Waters

Water Contact Recreation Criteria				
Parameter	Extraordinary Primary Contact Recreation (includes lakes)	Primary Contact Recreation	Secondary Contact Recreation	
Fecal Coliform (colonies/100 mL) Freshwater – geometric mean and not more than 10% of the samples >XXX	50; 100	100; 200	200; 400	
Freshwater Aquatic Life Uses Criteria				
	Char	Salmon & Trout Spawning, **Core** Rearing, and Migration	Salmon & Trout Spawning, **Non-core** Rearing, and Migration	Salmon & Trout Rearing and Migration **Only**
Dissolved Oxygen (mg/l) Lowest 1-Day Minimum	9.5	9.5	8.0	6.5
Temperature (degrees C) Highest 7-DAD* Maximum	12°C (53.6°F)	16°C (60.8°F)	17.5°C (63.5°F)	17.5°C (63.5°F)

pH Within range shown with human-caused variation within the range of less than XX units.	6.5 – 8.5; 0.2	6.5 – 8.5; 0.2	6.5 – 8.5; 0.5	6.5 – 8.5; 0.5
Turbidity (NTUs) Not exceed X over background when background is 50 NTU or less; or a XX% increase in turbidity when background is > 50 NTU.	5; 10%	5; 10%	5; 10%	10; 20%

*7 day average of the daily maximum temperatures

The "General Water Quality" condition stated in the descriptive summary for each stream and lake in the water resources report is made on the basis of the guidelines below.

Stream Water Quality Categories

"Excellent" - No water quality standard violations, and very low fecal coliform and nutrient concentrations.

"Good" - Usually meets water quality standards; OR violates only one part of the two part fecal coliform standard; OR the violation is most likely the result of natural conditions rather than pollution.

"Fair" - Frequently fails one or more water quality standards and other parameters such as nutrients indicate water quality is being impacted by pollution.

"Poor" - Routinely fails water quality standards by a large margin; other parameters such as nutrients are at elevated concentrations.

Lake Water Quality Categories

"Excellent" - Very low nutrient and chlorophyll *a* concentrations, and very high water clarity; Classified as Oligotrophic; Uses not impaired.

"Good" - Low to moderate nutrient and chlorophyll *a* concentrations, and moderate to high water clarity; Classified as Mesotrophic; Uses not impaired.

"Fair" - Moderate to high nutrient and chlorophyll *a* concentrations, and low to moderate water clarity; Classified as Eutrophic; Uses sometimes impaired.

"Poor" - High nutrient and chlorophyll *a* concentrations, and low water clarity; Classified as Eutrophic; Uses impaired during most of the summer season by excess algae and/or aquatic macrophyte (plant) growth.

Data Management Procedures

The lab data for fecal coliform bacteria results is received as hard copies of individual sample sheets. The lab data from Aquatic Research Inc is received as hard copies of lab reports for each sampling event. The field data is kept in field notebooks. These records are stored in ambient monitoring program files by water year.

The field and lab data is entered into the Thurston County's surface water Access database, from which it is easily accessible and can be transferred electronically upon request. The data entry is check by the data entry staff and ten percent of the data entry is reviewed for errors by a second project staff. At the end of each water-year after the data management activities are complete, the data is posted on the County ambient monitoring website for easy public access.

Audits and Reports

The Thurston County Environmental Health laboratory is certified by Ecology to perform the fecal coliform bacteria analyses and participate in audits by Ecology. These performance and system audits have verified the adequacy of the laboratory standard operating procedures, which include preventive maintenance and data reduction procedures.

The Thurston County Environmental Health Department laboratory schedule for auditing methodology and quality control is every two years by Department of Ecology. All quality control reports as required for certification are maintained on-site in the lab. The responsible person is Thurston County microbiologist, Mike Clark, at (360) 786-5465. The Ecology staff who conducts the audits is Aimee Bennett from the Laboratory Accreditation Program.

Aquatic Research, Inc is certified by Ecology to perform the nutrient and chlorophyll analysis. The responsible person is Steve Lazoff, at (206) 632-2715. The Ecology staff who conducts the audits is Aimee Bennett from the Laboratory Accreditation Program. A copy of the Scope of Accreditation can be found in Appendix D.

Data Validation and Verification

Field and laboratory data will be verified and validated throughout the project and at the completion of the data collection period. The staff will verify in the field the measurement collected and upon completion of the instrument post-calibration process. The lab staff will verify all lab-generated data following standard protocol.

The project manager will validate the data according the data objective in this QA Project Plan.

APPENDIX A

THURSTON COUNTY

ENVIRONMENTAL HEALTH

QUALITY ASSURANCE PLAN

FOR

SURFACE WATER ANALYSIS

INTRODUCTION

To assure that routinely generated analytical data in the Thurston County Environmental Health Laboratory is scientifically valid and defensible, a regime of quality assurance procedures are in place. The following is a description of these procedures. Where appropriate reference is made to Standard Method for the Examination of Water and Wastewater, 16th Edition.

I. Sampling Procedures:

Upon receipt of a sample in our laboratory the date and time of receipt as well as the initials of the person receiving the sample is written on the accompanying sample information form. The sample is then either immediately placed in the laboratory refrigerator to await analysis or analysis is begun at once. Every attempt is made to begin analysis the same day that a sample is taken and in all cases within 24 hours.

To begin analysis, each sample is unwrapped and placed on it's accompanying form. The form is then examined for information completeness and accuracy and a decision is made whether to subject the sample to membrane filtration (MF) or multiple tube fermentation (MTF). Generally, sewage effluent and very turbid surface water samples are subjected to the MTF technique; all other samples are run MF. Each sample bottle and it's accompanying form are given a number and the 'date of analysis" is stamped on the form. The bottle and form are then separated and analysis is begun. The information on each form is computerized and printed out on a laboratory log sheet (See Dilution Log Book). Each test's data is then entered in the appropriate space on the log sheets next to the respective sample information.

After analysis, each sample bottle is autoclaved, emptied, washed, and sterilized according to Standard Methods Section 9040.

II. Measurements and Calibrations:

All instruments, reagents, and media are monitored regularly to assure their accuracy and performance. The following table summarizes the type of measurements or calibrations and their frequency:

INSTRUMENT OR MEDIA	TYPE OF MEASUREMENTS OR CALIBRATIONS	FREQUENCY
Autoclave	Sterilizing of spore strips. Maximum reg. thermometer timer accuracy	Monthly Quarterly Quarterly
Automatic Pipettor	Accuracy at 10ml.	Quarterly
pH Meter	To pH 4 and 7	Weekly
Conductivity Meter	To 10 Micromhos	Monthly
Thermometers	To incubator temperature with NBS thermometer	Annual
Balance	1mg. to 100gm	Quarterly
MF Funnels	To 100ml, 50ml, 20ml, 10ml	Annual
Air Incubator	To 35 $\pm$ .5 C	Twice Daily
Water Bath Incubator	To 44.5 $\pm$ .2 C	Twice Daily
Refrigerator	TO $\leq$ 5 C	Daily

Pure Water System	Conductivity Plate Count pH Chlorine Residual Biological Suitability Trace Metals Analysis	Monthly Annual Annual
Oven	Thermometer - 175 C Timer: 2 Hours	Annual Annual
UV Sterilizer	Effectiveness on Control Cultures as measured by plate count.	Biannual
Media	pH Control Cultures	Each Batch
Sample Bottles	Sterility	Each Batch
Buffer	pH Sterility	Each Batch

III. Data Reduction, Validation, and Reporting:

Data Reduction: MF fecal coliform analyses are performed on a variety of sample volumes in an attempt to produce a culture plate with twenty (20) to sixty (60) CFU's. Once the appropriate plate is counted, the colony number is converted to colony forming unites per 100ml. using the following formula.

$$\#\text{ colonies per 100ml} = \frac{\text{colonies counted X 100}}{\text{ML sample filtered}}$$

MTF serial dilutions are reported directly as fecal coliforms per 100ml. No data conversion is necessary.

Data Validation: Water bacteriological report forms are filled out and the data is rechecked against the log book data.

Reporting: All analytical data is reported directly to the individual who submitted the sample. A copy is kept on file by Thurston County Environmental Health. All data is also kept on computer disk.

IV. External Quality Control Checks:

Annual EPA proficiency samples are analyzed for total and fecal coliform bacteria by Membrane Filtration and Multiple Tube Fermentation.

V. Preventive Maintenance Procedures and Schedules:

Autoclave: Under contract with MDT Corporation - inspected and serviced four times per year:

MDT Corporation
177 E. Henrietta Road
Rochester, NY 14623

Mettler Balance: Serviced and calibrated annually by:

Quality Control Services
516 SE Morrison, Suite 213
Portland, Oregon 97214

Pure Water System: Maintained and serviced biannually by:

Continental Water Systems NW
PO Box 1084
Kent, Washington 98035

Other laboratory equipment is cleaned and serviced as necessary by laboratory personnel.

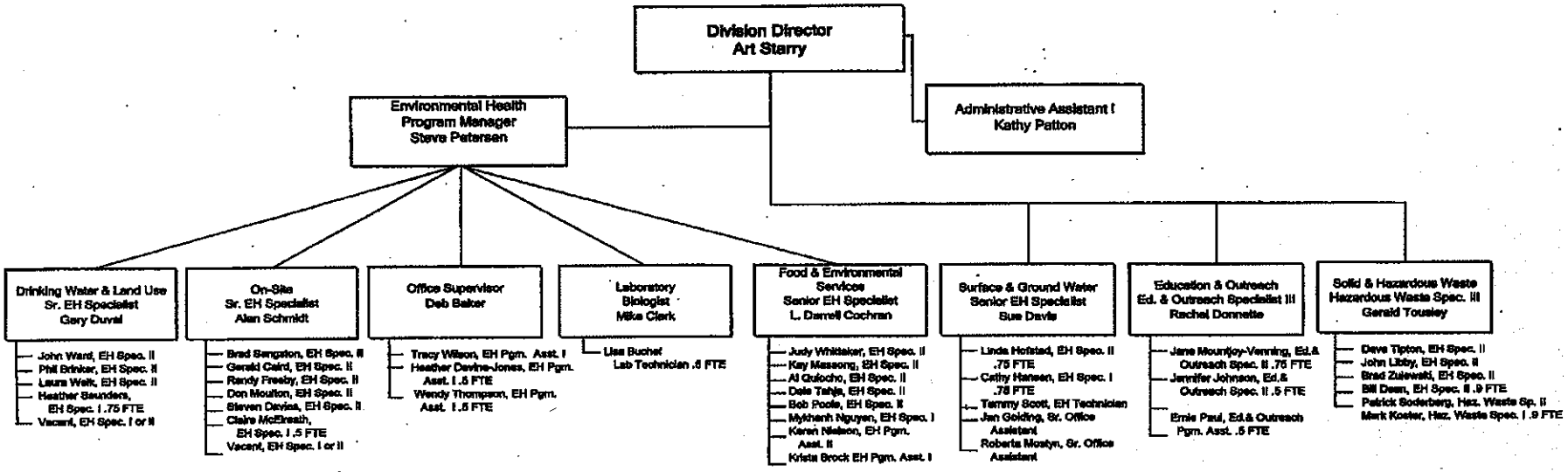
VI. Data Quality Control:

Ten percent (10%) of all growth positive countable MF plates are subcultured to verify up to ten colonies per plate and up to ten colony forming units per plate subcultured to EC broth. If there is a disparity between initial counts and verified counts, the final count is amended accordingly.

"Begin Run" and "End Run" controls are performed on each Membrane Filtration Series. If controls show any growth, the data from that MF series is deemed invalid and requests for new samples are made.

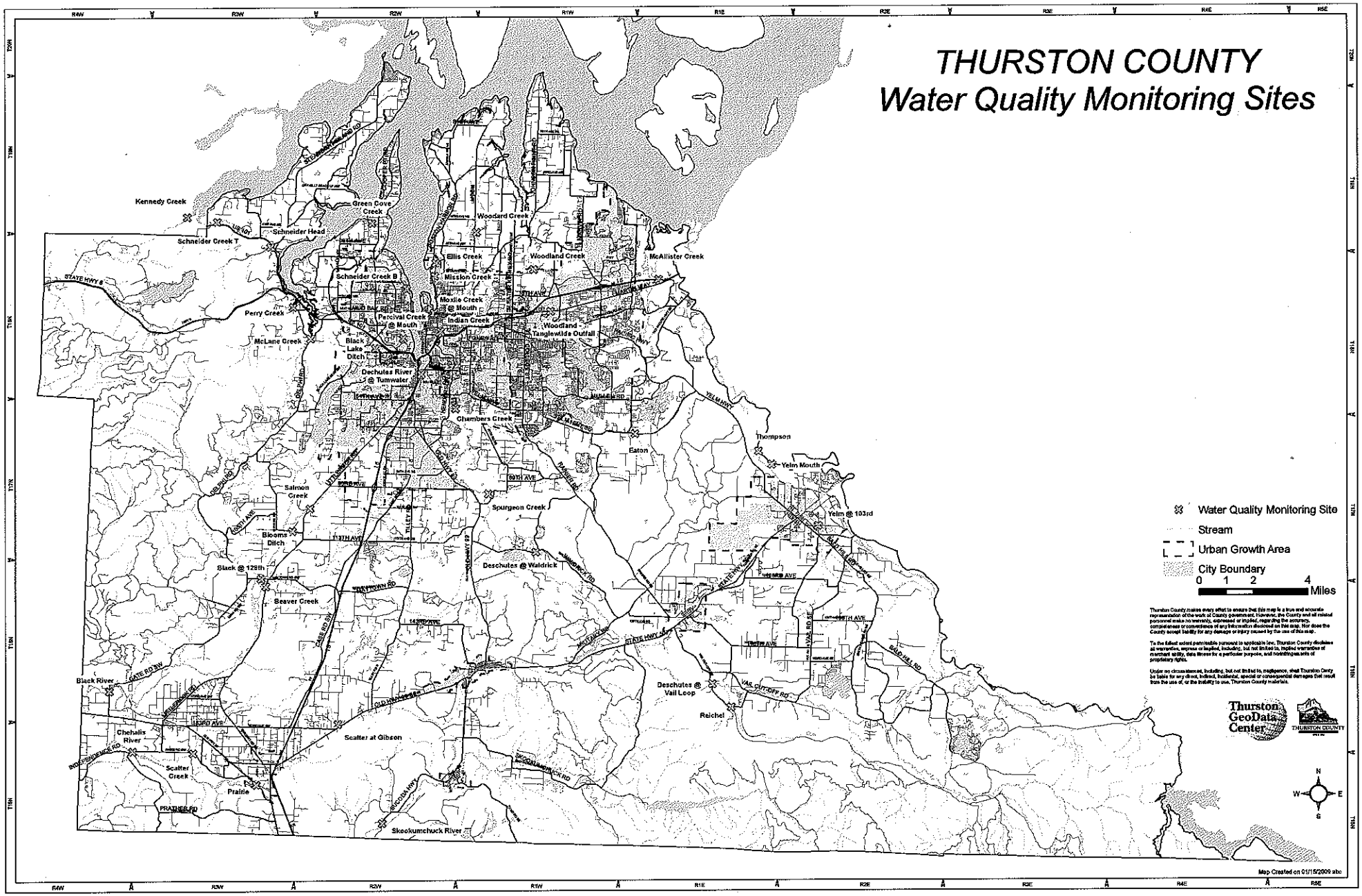
With MTF cultures (A-1 Broth), growth and gas positive tubes do not require further verification.

Environmental Health Division
Organization Chart



9/14/2005

APPENDIX B


THURSTON COUNTY
Water Quality Monitoring Sites
Kennedy Creek
Green Cove Creek
Schneider Creek T
Schneider Head
Woodard Creek
Ellis Creek
Woodland Creek
McAllister Creek
Schneider Creek B
Mission Creek
Moxlie Creek @ Mouth
Perry Creek
Percival Creek @ Mouth
Indian Creek
Woodland - Tanglewilde Outfall
McLane Creek
Black Lake Ditch
Deschutes River @ Tumwater
Chambers Creek
Thompson
Eaton
Yelm Mouth
Salmon Creek
Spurgeon Creek
Yelm @ 103rd
Blooms Ditch
Black @ 128th
Deschutes @ Waldrick
Beaver Creek
Black River
Deschutes @ Vail Loop
Reichel
Chehalis River
Scatter at Gibson
Scatter Creek
Prairie
Skookumchuck River
Water Quality Monitoring Site
Stream
Urban Growth Area
City Boundary
0 1 2 4
Miles
Thurston GeoData Center
THURSTON COUNTY
N
W
E
S
Map Created on 01/15/2009 abc

APPENDIX C

AQUATIC RESEARCH INCORPORATED

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: TCH031-74 **PAGE 3**

REPORT DATE: 05/30/08

DATE SAMPLED: 05/19-21/08 **DATE RECEIVED:** 05/22/08

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM THURSTON COUNTY HEALTH / LAKES PROGRAM

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/l)	TOTAL-N (mg/l)	AMMONIA (mg/l)	NO3+NO2 (mg/l)
METHOD	SM18 4500PF	SM20 4500N-C	EPA 350.1	EPA 353.2
DATE ANALYZED	05/28/08	05/27/08	05/23/08	05/23/08
DETECTION LIMIT	0.002	0.100	0.010	0.010
DUPLICATE				
SAMPLE ID	CA2	CA2	BATCH	BATCH
ORIGINAL	0.022	0.558	0.020	0.330
DUPLICATE	0.022	0.558	0.021	0.331
RPD	0.55%	0.05%	6.32%	0.36%
SPIKE SAMPLE				
SAMPLE ID	CA2	CA2	BATCH	BATCH
ORIGINAL	0.022	0.558	0.020	0.330
SPIKED SAMPLE	0.078	1.63	0.208	0.531
SPIKE ADDED	0.050	1.00	0.200	0.200
% RECOVERY	112.67%	107.05%	94.15%	100.36%
QC CHECK				
FOUND	0.091	0.435	0.304	0.416
TRUE	0.090	0.435	0.324	0.408
% RECOVERY	100.88%	100.02%	93.75%	101.91%
BLANK	<0.002	<0.100	<0.010	<0.010

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

APPENDIX D

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
Post Office Box 488 • Manchester, Washington 98353-0488 • (360) 895-6144

August 5, 2008

Mr. Steven Lazoff
Aquatic Research, Inc.
3927 Aurora Ave N
Seattle, WA 98103

Dear Mr Lazoff:

Thank you for submitting the information we requested in support of your accreditation for metals by ICP-MS. Here is a revised Scope of Accreditation showing full accreditation for all of the metals for which we have received satisfactory proficiency testing (PT) sample results. Accreditation will granted for silver and vanadium upon receipt of the necessary PT sample results.

If you have any questions concerning the accreditation of your lab, please contact me at (360) 895-6148, fax (360) 895-6180, or by e-mail at slom461@ecy.wa.gov.

Sincerely,

Stewart M. Lombard
Lab Accreditation Unit Supervisor

SML:sml
Enclosures

Scope of Accreditation

Aquatic Research, Inc.

Seattle, WA

is accredited by the State of Washington Department of Ecology to perform analyses for the parameters listed below using the analytical methods indicated. This Scope of Accreditation may apply to any of the following matrix types: non-potable water, drinking water, solid and chemical materials, and air and emissions. Accreditation for all parameters is final unless indicated otherwise in a note. Accreditation is for the latest version of a method unless otherwise specified in a note. EPA refers to the U.S. Environmental Protection Agency. SM refers to American Public Health Association's publication, Standard Methods for the Examination of Water and Wastewater, 18th, 19th or 20th Edition, unless otherwise noted. ASTM stands for the American Society for Testing and Materials. PSEP stands for Puget Sound Estuary Program. Other references are detailed in the notes section.

Matrix Type/Parameter Name	Reference	Method Number	Notes
Drinking Water			
Alkalinity, Total	SM	2320 B(4a)	
Color	SM	2120 B	
Cyanide, Total	SM	4500-CN E	
Fluoride	SM	4500-F C	
Hardness, Total (as CaCO3)	SM	2340 C	
Nitrate	SM	4500-NO3 F	
Nitrate + Nitrite	EPA	353.2	
Nitrite	SM	4500-NO3 F	
Orthophosphate	EPA	365.1	
Orthophosphate	SM	4500-P F	
Solids, Total Dissolved	SM	2540 C	
Specific Conductance	SM	2510 B	
Sulfate	SM	4500-SO4 E	
Sulfate	ASTM	D516-02	
Total Organic Carbon	SM	5310 B	
Turbidity	EPA	180.1	1
Aluminum	EPA	200.8	
Aluminum	SM 18/19	3113 B	
Aluminum	EPA	200.7	

Matrix Type/Parameter Name	Reference	Method Number	Notes
Antimony	EPA	200.8	
Antimony	SM 18/19	3113 B	
Arsenic	SM 18/19	3113 B	1
Arsenic	EPA	200.8	
Barium	EPA	200.7	
Barium	EPA	200.8	
Beryllium	EPA	200.8	
Beryllium	SM 18/19	3113 B	
Cadmium	EPA	200.8	
Cadmium	EPA	200.7	
Calcium	EPA	200.7	1
Chromium	EPA	200.7	
Chromium	EPA	200.8	
Copper	EPA	200.8	
Copper	EPA	200.7	
Copper	SM 18/19	3113 B	
Iron	EPA	200.7	
Iron	EPA	200.8	
Lead	EPA	200.8	
Lead	SM 18/19	3113 B	
Magnesium	EPA	200.7	
Manganese	EPA	200.8	
Manganese	EPA	200.7	
Mercury	EPA	245.1	
Mercury	EPA	200.8	
Nickel	EPA	200.7	
Nickel	EPA	200.8	
Selenium	EPA	200.8	
Selenium	SM 18/19	3113 B	
Silver	EPA	200.7	

Matrix Type/Parameter Name	Reference	Method Number	Notes
Sodium	EPA	200.7	
Thallium	EPA	200.8	
Zinc	EPA	200.8	
Zinc	EPA	200.7	
Chlorinated Pesticides	EPA	508.1	1
PCBs	EPA	508.1	1
Organic Compounds	EPA	525.2	1
Purgeable Organic Compounds	EPA	524.2	
Trihalomethanes	EPA	524.2	
Vinyl Chloride	EPA	524.2	1

Non-potable Water

Acidity	SM	2310 B(4b)
Alkalinity, Total	SM	2320 B(4b)
Ammonia	EPA	350.1
Ammonia	SM 18	4500-NH3 H
Anionic Surfactants	SM	5540 C
Biochemical Oxygen Demand, BOD/CBOD	SM	5210 B
Chemical Oxygen Demand (COD)	SM	5220 D
Chloride	SM	4500-Cl- C
Color	SM	2120 B
Cyanide, Total	SM	4500-CN E
Fluoride	SM	4500-F C
Hardness, Total (as CaCO3)	SM	2340 C
Hexane Extractable Material	EPA	1664
Nitrate	EPA	353.2
Nitrate	SM	4500-NO3 F
Nitrate + Nitrite	EPA	353.2
Nitrogen, Total	SM 20	4500-N C
Nitrogen, Total Kjeldahl	SM	4500-Norg C
Nitrogen, Total Kjeldahl	EPA	351.1

Matrix Type/Parameter Name	Reference	Method Number	Notes
Orthophosphate	SM	4500-P F	
Orthophosphate	EPA	365.1	
Phosphorus, Total	EPA	365.1	
Phosphorus, Total Persulfate	SM	4500-P F	
Solids, Total Dissolved	SM	2540 C	
Solids, Total Suspended	SM	2540 D	
Solids, Total Volatile	SM	2540 E	
Specific Conductance	SM	2510 B	
Sulfate	SM	4500-SO4 E	
Sulfate	ASTM	D516-02	
Sulfide	SM	4500-S2 D	
Sulfide	SM	4500-S2 F	
Total Organic Carbon	SM	5310 B	
Turbidity	SM	2130 B	
Aluminum	SM 18/19	3113 B	
Aluminum	EPA	200.7	
Aluminum	EPA	200.8	
Antimony	SM 18/19	3113 B	
Antimony	EPA	200.8	
Arsenic	EPA	200.8	
Arsenic	SM 18/19	3113 B	1
Barium	EPA	200.8	
Barium	EPA	200.7	
Beryllium	EPA	200.8	
Beryllium	SM 18/19	3113 B	
Boron	EPA	200.8	
Cadmium	EPA	200.7	
Cadmium	EPA	200.8	
Cadmium	SM 18/19	3113 B	
Calcium	EPA	200.7	

Matrix Type/Parameter Name	Reference	Method Number	Notes
Chromium	EPA	200.8	
Chromium	EPA	200.7	
Chromium	SM 18/19	3113 B	1
Copper	EPA	200.8	
Copper	SM 18/19	3113 B	
Copper	EPA	200.7	
Hardness, Total (as CaCO3)	EPA	200.7	1
Iron	EPA	200.7	
Iron	EPA	200.8	
Lead	EPA	200.7	1
Lead	SM 18/19	3113 B	
Lead	EPA	200.8	
Magnesium	EPA	200.7	
Manganese	EPA	200.7	
Manganese	EPA	200.8	
Mercury	EPA	1631	
Mercury	EPA	200.8	
Molybdenum	SM	3113 B	
Molybdenum	EPA	200.8	
Nickel	EPA	200.7	
Nickel	EPA	200.8	
Potassium	EPA	200.7	1
Selenium	SM 18/19	3113 B	
Selenium	EPA	200.8	
Silica	EPA	200.7	
Silver	SM 18/18	3113 B	1
Silver	EPA	200.7	
Sodium	EPA	200.7	
Thallium	EPA	200.8	
Vanadium	EPA	200.7	1

Matrix Type/Parameter Name	Reference	Method Number	Notes
Zinc	EPA	200.7	
Zinc	EPA	200.8	
BNA Extr (Semivolatile) Organics	EPA	8270	
Volatile Organic Compounds	EPA	8260	
Fecal Coliform - count	SM	9222 D	2
Total & Fecal Coli - count	SM	9221 B1,2,C&E1	

Solid and Chemical Materials

Aluminum	EPA	6010	1
Barium	EPA	6010	1
Beryllium	EPA	6010	1
Cadmium	EPA	6010	1
Calcium	EPA	6010	1
Chromium	EPA	6010	1
Cobalt	EPA	6010	1
Copper	EPA	6010	1
Iron	EPA	6010	1
Lead	EPA	6010	1
Manganese	EPA	6010	1
Molybdenum	EPA	6010	1
Nickel	EPA	6010	1
Silver	EPA	6010	1
Sodium	EPA	6010	1
Strontium	EPA	6010	1
Titanium	EPA	6010	1
Vanadium	EPA	6010	1
Zinc	EPA	6010	1
Glycols	EPA	8015	
Total Pet Hydrocarbons - Diesel	WDOE	NWTPH-Dx	1
BNA Extr (Semivolatile) Organics	EPA	8270	1

Matrix Type/Parameter Name	Reference	Method Number	Notes

Accredited Parameter Note Detail

(1) Provisional pending acceptable proficiency testing (PT) results (WAC 173-50-110). (2) Provisional pending receipt of eveidence that requirements in the microbiology audit report have been met.

S M Lombard
Authentication Signature

August 5, 2008
Date

Stewart M. Lombard, Lab Accreditation Unit Supervisor