Quality Assurance Project Plan

Lake Tapps Monitoring

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June 30, 2004

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Approvals:

Approved by:	June 30, 2004
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Abstract

Lake Tapps is located in Pierce County, Washington, near the town of Bonney Lake. Basic water quality data have been collected by several earlier studies. Except for Secchi depths collected during Ecology's Lake Monitoring Program, earlier studies generally collected samples on only one or two dates at one or two locations. This monitoring project, proposed by Ecology's Southwest Regional Office, is intended to document current conditions in the lake at four stations over the course of a year (eight samples). Results will be compiled, evaluated for quality, and documented. Data analysis, however, is not included in this project.

Organization and Schedule

Staff organization and responsibilities are listed in Table 1.

Table 1. Project personnel and areas of responsibility.

Personnel	Responsibility	Phone
Dave Hallock	Project lead; project planning, implementation, QC review, data management, and documentation	407-6681
Maggie Bell-McKinnon	Field assistance	407-6124
Greg Zentner	Project originator; planning guidance, review, field assistance	407-6680
George Onwumere	Unit lead	407-6730
Stuart Magoon	Laboratory supervisor	360 871-8801

This project will be conducted from May 2004 through March 2006. Sampling will be conducted from July 2004 through June 2005 (Table 2).

Table 2. Project Schedule.

Date	Task	Lake Stations	Tributary Stations
Jun 30, 2004	Complete QAPP		
Jul 2004	Sample	X	X
Aug 2004	Sample	X	
Sep 2004	Sample	X	
Oct 2004	Sample	X	X
Jan 2005	Sample	X	X
Mar 2005	Sample	X	X
May 2005	Sample	X	
Jun 2005	Sample	X	
Sep 2005	Complete data entry		
Dec 2005	Complete QC review; load data to EIM		
Mar 2006	Complete Report		

Background and Problem Statement

Lake Tapps is located in Pierce County, Washington, near the town of Bonney Lake. The lake was created in 1911 when an impoundment on the White River diverted some of the river to the southwest, where a second impoundment for power generation joined together four smaller lakes (Figure 1). At the time of the original diversion and impoundment, the region around the lake was sparsley populated and hydroelectric power generation was the sole use of diverted water. Today, the lake shoreline is densely developed with residential homes; the lake is used intensively for recreation, and Ecology has approved applications for water rights for future muncipal use of Lake Tapps water.

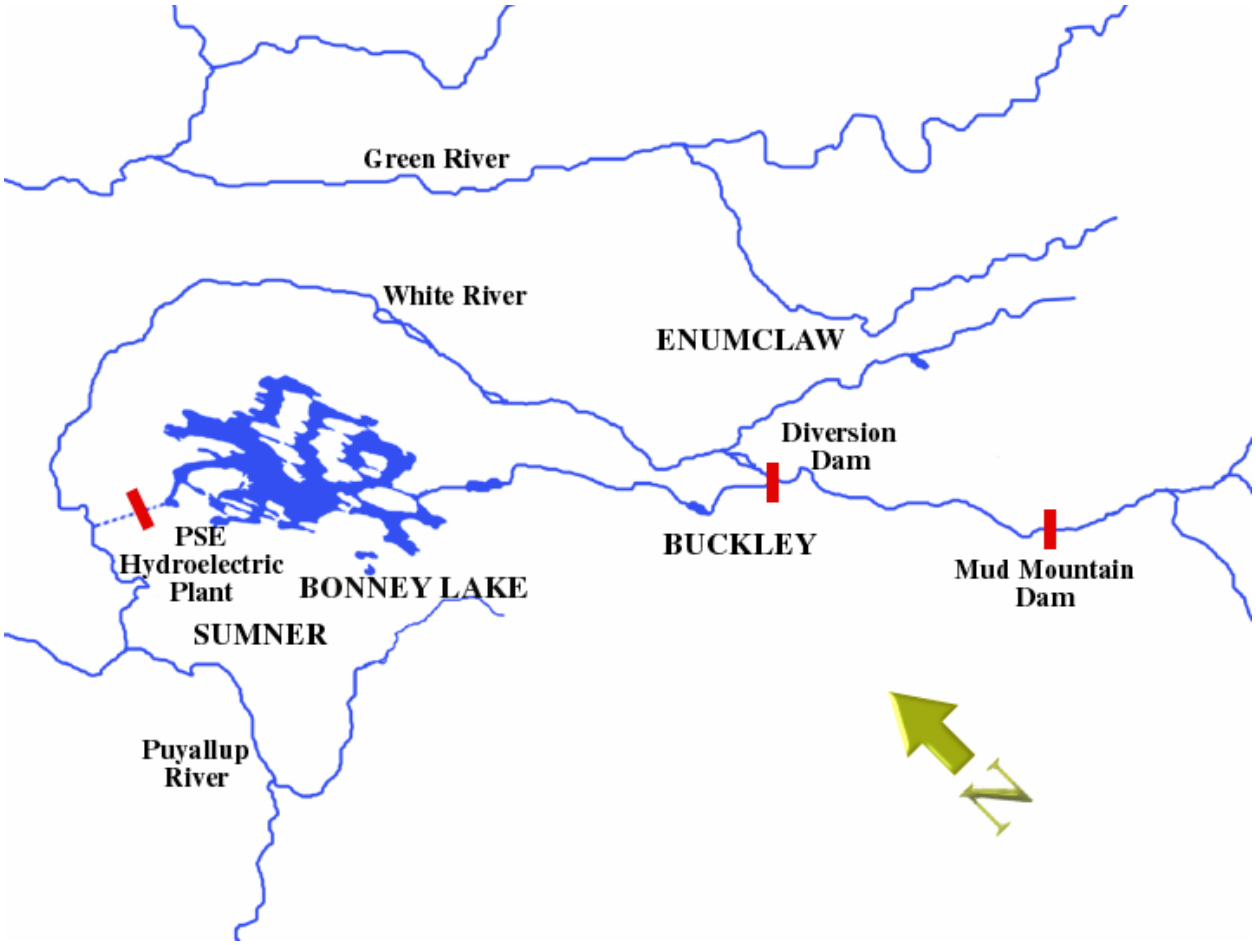

Figure 1. Map of Tapps Lake and the surrounding region (source: http://www.savelaketapps.com).

Lake Tapps has a maximum depth of 27 m and a mean depth of 7.6 m. Its surface area is 10.9 km^2, which, with a shoreline length of 67.6 km, yields a very high shoreline development index of 5.8. The shoreline development index is the ratio of the lake's shoreline length to that of a circle with the same area. On average, lakes with higher indexes are more susceptible to eutrophication.

Lake Tapps is not listed on Ecology's 1998 303(d) list. It is included in the 2002 proposed listing as being impaired by a non-pollutant (Eurasian milfoil; listing #4693). This project is not intended to address that listing but the data collected here may guide future studies of that impairment.

Basic water quality data have been collected by several earlier studies. Samples were collected in September 1974 (Dion, et. al, 1976) and in 1981 (Sumioka and Dion, 1985). In addition, Ecology's Lake Monitoring Program sampled Lake Tapps in 1997 through 2000. Except for Secchi depths collected during the Lake Monitoring Program, however, these studies generally collected samples on only one or two dates at one or two locations.

This monitoring project, proposed by Ecology's Southwest Regional Office, is intended to document current conditions in the lake.

Project Description

The goal of this project is to document baseline water quality conditions in Lake Tapps. Objectives are as follows:

- Determine vertical profiles at up to four open-water stations during the course of a year.
- Determine nutrient concentrations (epilimnion and hypolimnion composites) and other constituents (epilimnion composites only) at up to four open-water stations during the course of a year.
- Determine nutrient concentrations at the major inflow, the head of the diversion channel, and at the outflow during the course of a year.
- Compile, evaluate, and document results.

Quality Objectives

Specific quality objectives for this project are discussed, below.

Bias

Sampling bias will be minimized by strictly adhering to the protocols discussed and referenced herein. Our River and Stream Monitoring Program uses similar field collection and processing procedures; no bias (at least, no bias greater than reporting limits) is present in that program's data, based on a long history of blank samples. This QAPP provides procedures for collecting representative and valid samples, but, as is true for all sampling, some bias due to sampling, even if not measurable or knowable, is likely present in the results. Assessment and management of bias will mostly occur at the laboratory. We expect that bias in the chemical analyses will be corrected so that long-term bias will not occur within a single method.

Precision

The expected levels of precision are given in Table 3. These criteria may be applied to the standard deviation of individual QC split pairs if individual results will be used (for example, compared to a water quality criterion). However, results will primarily be pooled, for example, to estimate a mean concentration, and in this case the standard deviation of QC split pairs may be pooled.

At concentrations near the lowest concentration of interest, it will not be possible to meet the percentage MQOs in Table 3 because errors expressed as a percentage increase at lower concentrations. However, at lower concentrations, the acceptable error is generally greater. The precision criterion is in line with MEL's historic performance for most constituents. Chlorophyll and sediment measures, which are inherently more variable, have less stringent criteria.

Table 3 is intended to indicate the quality of the result from a particular sample (or pooled set of samples) and therefore to apply to lab or field *splits*. Field duplicate samples (i.e., sequentially collected), which include some environmental variability, are not required to meet the criteria in Table 3.

Table 3. Measurement Quality Objectives.

Analyte	Accuracy (deviation or % deviation from true value)	Precision (% RSD)	Bias (% deviation from true value)	Lowest Concentration of Interest
Field Constituents				
Conductivity	± 10 µs/cm at 100 µs/cm	NA	NA	NA
Oxygen	± 0.2 mg/L	NA	NA	NA
pH	± 0.15 std. units	NA	NA	NA
Temperature	± 0.2 ºC	NA	NA	NA
Secchi Depth	NA	± 0.5 m	NA	NA
Lab Constituents				
Ammonia-N	25%	10 %RSD	5%	0.01 mg L^{-1}
Chlorophyll	NA	20 % RSD	NA	1.0 mg L^{-1}
Nitrate+Nitrite-N	25%	10 %RSD	5%	0.01 mg L^{-1}
Solids, total non-volatile	45%	20 %RSD	5%	1 mg L^{-1}
Solids, total	45%	20 %RSD	5%	1 mg L^{-1}
Soluble Reactive Phosphorus	25%	10 %RSD	5%	0.003 mg L^{-1}
Total Nitrogen	25%	10 %RSD	5%	0.025 mg L^{-1}
Total Phosphorus	25%	10 %RSD	5%	0.003 mg L^{-1}
Turbidity	25%	10 %RSD	5%	0.5 NTU

Sampling Design

Samples will be collected from up to four open-water stations: the central lake, and each of the three eastern basins (Table 4 and Figure 2). (If there is insufficient time to sample all four stations, the southern-most basin station will be dropped.) Stations were chosen based on a review of lake bathymetry, shoreline maps, and aerial photos. The lake appears to be divided into a main basin on the west, through which most of the water may flow directly from the inlet to the outlet; and three side-basins that are northeast, east, and south-east of the main basin. The side basins appear to be outside of the main circulatory path. See "Representativeness."

Table 4. Sample stations.

Station	MEL Identifier	Lake Code [a]	Lat.	Long.	Samples	Narrative
#1, epilimnion	6030	TAPPI111E	47.2228	122.1750	Nutrients, TS, TVS, Chl, turbidity, profile	90 ft deep spot in center of main lake. Epilimnion composite.
#1, hypolimnion	6031	TAPPI111H	47.2228	122.1750	Nutrients	90 ft deep spot in center of main lake. Hypolimnion composite.
#4[b], epilimnion	6032	TAPPI141E	47.2348	122.1591	Nutrients, TS, TVS, Chl, turbidity, profile	50 ft deep spot in NE basin. Epilimnion composite.
#4, hypolimnion	6033	TAPPI141H	47.2348	122.1591	Nutrients	50 ft deep spot in NE basin. Hypolimnion composite.
#5, epilimnion	6034	TAPPI151E	47.2243	122.1579	Nutrients, TS, TVS, Chl, turbidity, profile	40 ft deep spot in eastern center basin. Epilimnion composite.
#5, hypolimnion	6035	TAPPI161H	47.2243	122.1579	Nutrients	40 ft deep spot in eastern center basin. Hypolimnion composite.
#6, epilimnion	6036	TAPPI161E	47.2066	122.1518	Nutrients, TS, TVS, Chl, turbidity, profile	20 ft deep spot in SE basin. Epilimnion composite.
#6, hypolimnion	6037	TAPPI161H	47.2066	122.1518	Nutrients	20 ft deep spot in SE basin. Hypolimnion composite.
#7, Inlet	6038	TAPPI171	47.1968	122.1392	Nutrients, turbidity	Inlet, from 218th Street Bridge
#8, Diversion	6039	TAPPI181	47.1717	122.0192	Nutrients, turbidity	Inlet (at diversion), end of River Road.
#9, Outlet	6040	TAPPI191	47.2383	122.2237	Nutrients, turbidity	Outlet, from East Valley Highway Bridge

[a] The lake code follows the convention used in our earlier lake monitoring program: The lake is identified by the first three letters of the lake name, the first two letters of the county, and a digit for cases where these five letters are not unique. The station number follows, then a digit indicating a primary sample (1), duplicate (2), or split (3), followed by a depth indicator (e.g., “E” indicates an epilimnion composite sample).

[b] Station numbers 2 and 3 were sampled by Ecology’s Lake Monitoring Program. The numbers are not being re-used to avoid confusion.

The inlet, also known as the diversion canal or flume, will be sampled from the 218th Street Bridge just before it enters the lake, and just below the diversion from the White River at the end of River Road in Buckley. The outlet, also know as the tailrace discharge, will be sampled from the East Valley Highway Bridge.

Specific constituents to be sampled are listed in Table 3. Vertical profiles (temperature, oxygen, pH, and conductivity) will be recorded at the four lake stations. Nutrients will be analyzed in epilimnion and hypolimnion composite samples and in inlet and outlet grab samples. All remaining constituents will be analyzed in epilimnion composite samples only.

Representativeness

Lake Tapps is highly complex and four sampling stations are not expected to represent the entire waterbody. Some of the lake's embayments exhibit different water quality than the main lake (Figure 3), particularly the northwest arm and the southern-most basin at the inlet. Our stations should represent the majority of the lake, but the southern-most basin, in particular, as well as isolated areas, will likely exhibit water quality different than what we report.

Vertically, composites should ensure that epilimnion lake samples are adequately representative. Bell-McKinnon (2002) reported a very shallow epilimnion (1-2 m), in which case epilimnion composites may not be necessary. The hypolimnion is not typically as well-mixed as the epilimnion; composite samples are a compromise and will indicate whether significant internal nutrient release is occurring, but may not be adequate for internal nutrient load calculations. The inlet and outlet are presumed to be sufficiently well mixed so that a single grab sample will be representative of both the horizontal and vertical distribution of material.

Comparability

All measurement and analytical procedures are documented so that the data will be comparable with samples collected and analyzed in a like manner.

Figure 2. Morphometric map of Lake Tapps showing sampling locations.

Figure 3. Landsat® satellite imagery of Lake Tapps taken 7 July 2000.

Field Procedures

This project will follow field procedures as described in Bell-McKinnon (2002) and Hallock (1995).

Field meters will be maintained and calibrated according to manufacturer's instructions. Profiles will be collected with a Hydrolab© datasonde or similar instrument. Turbidity measurements will use a Hach 2100P portable turbidimeter. For turbidity measurements, to eliminate air bubbles, a syringe will be used to create a vacuum prior to taking measurements.

Laboratory Procedures

MEL conducts laboratory analyses following Standard Operating Procedures (based on methods referenced in Table 5) and other guidance documents (e.g., Ecology, 2001 and Ecology 2003). Methods for constituents are listed in Table 5.

Table 5. Laboratory analytical methods and reporting limits.

Analyte	Sample Fraction	Sample Container (mL)	Method	Reference [a]	Lower Reporting Limit	Holding Time (days)
Ammonia-N	total	125 clear	Automated phenate	SM4500NH3H	0.01 mg L^{-1}	28
Chlorophyll *a*	filterable	1000 brown	Fluorometric	SM10200H3M	0.05 mg L^{-1}	1 to filtration, 28 after filtration
Nitrate+Nitrite-N	total	125 clear	Automated cadmium reduction	SM4500NO3I	0.01 mg L^{-1}	28
Solids, total	filtered	1000 clear	Gravimetric	SM2540D	1 mg L^{-1}	7
Solids, total non-volatile	filtered	1000 clear	Gravimetric	SM2540E	1 mg L^{-1}	7
Soluble Reactive Phosphorus	dissolved	125 brown	Automated Ascorbic acid	SM4500PG	0.003 mg L^{-1}	2
Total Nitrogen	total	125 clear	Persulfate digestion, cadmium reduction	SM4500NB	0.025 mg L^{-1}	28
Total Phosphorus	total	60 clear	ICPMS	EPA 200.8M	0.001 mg L^{-1}	28

[a] SM=Standard Methods (APHA, 2000); EPA=Environmental Protection Agency (EPA, 1983)

Quality Control

Laboratory QC

Laboratory QC will follow MEL's internal procedures. We request that lab sample splits be performed on field QC samples. Using field QC samples will allow us to better partition sources of error between lab and field.

Field QC

In the field, one of the seven epilimnion/inlet/outlet sample locations listed in Table 4 will be sampled in duplicate during each sampling visit. Hypolimnion samples are excluded because the lake may not be stratified. The station to be sampled in duplicate will be randomly chosen except that four QC stations must be lake stations. Measurements (including profiles) and samples will be repeated for all constituents scheduled for collection at the selected QC station.

The results from an original sample and its duplicate (sequentially collected) sample are used to calculate the expected variance that is due to short-term environmental factors, field collection and processing, and laboratory analyses.

Contamination will be assessed by the submission of field blanks. Once during the course of the project, fresh distilled water will be submitted rather than the usual field duplicate sample. These will be “transport blanks” for constituents where there is no field processing of the sample (e.g., total nutrients), and “rinsate blanks” for filtered constituents. Blank results are expected to be below reporting limits.

Instrumentation

Profile data will be collected using a Hydrolab© datasonde or equivalent, calibrated according to manufacturer’s instructions and Bell-McKinnon (2002). The turbidimeter will be checked against the “gelex” standard before each sampling day. The “gelex” standard will be calibrated against a formazin standard quarterly according to the manufacturer’s instructions. If the meter measurement is more than 5 percent different than the “gelex” standard, the instrument will be recalibrated and values re-assigned to the "gelex" standards.

Data Management Procedures

Data will be entered into our lake monitoring data Access® database and provided in spreadsheet form to the client.

Data Review, Verification, and Validation

The laboratory verifies its measurement results. In addition, the following procedures will be followed:

- Standard lab and field QC procedures will be adhered to.
- The data will be checked for data entry errors and completeness.
- Results will be checked for reasonableness.
- Lab and Field QC results will be evaluated to ensure that the measurement quality objectives (MQOs) were met. Data failing to meet MQOs will be either coded as estimates or discarded.

These steps are the responsibility of the project lead.

Data Quality Assessment

QA assessments for precision will be made by comparing calculated standard deviations of split sample pairs to the larger of the percent relative standard deviation times the mean of the sample pair or the maximum standard deviation tabulated in the MQOs (Table 3). Standard deviation for paired samples may be calculated according to Equation 1:

$$s = \sqrt{(r_1 - r_2)^2 / 2} \qquad 1)$$

Where s is the standard deviation and r_1 and r_2 are paired results.

Where results are to be combined then QC pairs may be pooled using Equation 2:

$$s_p = \sqrt{\sum (r_1 - r_2)^2 / 2m} \qquad 2)$$

Where s_p is the pooled standard deviation and m is the number of pairs. The value s_p may then be compared to the MQOs in Table 3.

Data will be compiled and presented with little analysis and interpretation beyond calculating Carlson's Trophic State Index (Carlson, 1977).

References

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