Water Quality Assessments of Selected Lakes Within Washington State

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Water Quality Assessments of Selected Lakes Within Washington State

1999

by
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Acknowledgments

The Lake Water Quality Assessment Program continued its new approach to lake assessments in 1999 for the second, and final, year. This would not have been possible without the support of management and the Washington State Department of Ecology (Ecology) 319 grant process. Funding for the program was supplied through an Environmental Protection Agency (EPA) 319 grant of $184,727. Unfortunately, this will be the final year of the program due to a lack of continued funding.

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Abstract

Beginning in 1998, the Washington State Department of Ecology began a new approach to assessing lake water quality. Traditionally, lake monitoring focused on long-term trends in water clarity and general lake assessments. Although trend data are crucial in documenting declining or improving water quality, they provide very little information as to whether or not beneficial uses of a lake are impaired. The original intent of the Clean Water Act was to protect the beneficial uses (e.g., swimmable, drinkable, fishable) of our waters. This new approach is an attempt to evaluate the condition of the beneficial uses on certain lakes throughout the state and to recommend lake-specific nutrient criteria for those lakes in order to protect or restore their uses.

New methods were developed to evaluate variables on some of our monitored lakes. Monitoring concentrated on assessing fish and wildlife habitat, zooplankton, aquatic plants, watershed condition, water chemistry, and user perception. Beneficial uses were determined by evaluating the user perception surveys and talking with conservation district representatives and the Washington State Department of Fish & Wildlife biologists. A lake-specific criterion was then recommended to protect or improve conditions on the lake. Lake-specific criteria were determined using procedures outlined in general in Washington's Water Quality Standards (WAC 173-201A) and in more detail herein. If proposed criteria are codified into the WAC, then, should a criterion ever be exceeded in a particular lake, measures could be taken either to reduce nutrient concentrations or to conduct a more detailed study in order to refine the criterion.

Introduction

In 1989, the Washington State Department of Ecology (Ecology) began a grant funded statewide lake monitoring program. Volunteers collected bi-monthly Secchi data (see Glossary, Appendix A) and Ecology staff collected water quality data in the spring and late summer. This program is described in Smith, et al., 2000. Our primary technical goal was to assess the trophic state (see Glossary, Appendix A) of as many lakes in Washington as possible.

We expanded the lake monitoring program in 1998 in response to the establishment of new water quality standards allowing the designation of lake-specific criteria and the availability of additional funds. The lake monitoring program in 1998 and 1999 included a lake-specific studies portion that expanded on the traditional basic assessment approach. (Our funding was reduced in 2000 to minimum levels needed to maintain the volunteer portion of the program. Our current primary technical objective is to assess long-term transparency trends in 40 to 50 lakes statewide.)

The purpose of this report is to present the findings from the portion of the Lake Water Quality Assessment Program (LWQA) that deals with lake-specific studies. In 1999, we studied 20 lakes. Lakes are reported and assessed on an individual basis (Appendix B); a comparative analysis of statewide lake water quality is not within the scope of this report.

Program Objectives

The objectives of the lake-specific studies portion of the program are as follows:

- ◊ Refine protocols for lake-specific studies established in 1998.
- ◊ Recommend nutrient criteria, if possible, for each studied lake as per WAC 173-201A-030(6) "Establishing lake nutrient criteria".
- ◊ Pursue an integrated approach to lake assessment with Washington State Department of Fish & Wildlife (WDFW) officials, local government officials, and citizen volunteers.

The specific goal for 1999 was to select and sample 20 lakes according to requests from within Ecology, WDFW, and local governments.

Methods

Methods for lake selection, data collection, sample analysis, and data analysis are described below. Methods for quality assurance and quality control (QA/QC) of data collected for the program are discussed in the “QA/QC Evaluation and Results” section.

Lake Selection

Lakes were selected based on Water Quality Management Area needs assessment reports (e.g., Jacobson, 1996) and personal communications with Ecology regional office representatives, WDFW biologists, and, in some cases, local governments. Various criteria were used in selecting lakes, such as a perception of water quality problems, other complementary on-going technical activities in the watershed, or simply a paucity of knowledge about a particular popular or high-value lake.

Field Methods

Many of the field methods implemented in 1999 were adopted from methods used or developed outside of Washington State, which were then customized for the Program’s needs.

Sample Collection

Ecology staff visited lakes selected for special studies monthly from June through September. The purposes of these visits were to (1) collect Hydrolab® profile data (see Glossary, Appendix A) and sample for chemical parameters from the deep site of lakes once each month; (2) conduct habitat assessments once during the season; (3) conduct watershed assessments in September; (4) collect zooplankton samples in June and August; (5) distribute user perception surveys; and (6) do Secchi depth quality assurance evaluations with volunteer monitors on selected lakes.

During each field visit, the volunteer (on lakes with volunteers) escorted Ecology personnel to their monitoring site. The boat was anchored if possible. The volunteer and Ecology staff each measured Secchi depth. Temperature, pH, dissolved oxygen, and conductivity profiles were completed using a Hydrolab® Surveyor III and Reporter (see Glossary, Appendix A). Temperature profile data were used to determine whether the lakes were stratified, and if so, to determine depths within the epilimnion and hypolimnion (see Glossary, Appendix A) for collecting water samples. Weather conditions, water color, and general observations about the lake were recorded. If an obvious algal bloom was occurring at the surface or at depth (as indicated by a large change in dissolved oxygen with no concurrent decrease in temperature), a sample was collected for later identification. Macrophyte samples were either identified onsite or collected for later identification. Algae and macrophyte samples were collected for qualitative purposes only, and results may not include all species in the community. Complete aquatic plant surveys were conducted independently, and results of those surveys are also included (see Parsons, 1999).

During each visit, water samples for total phosphorous (TP), total persulfate nitrogen (TN), turbidity, and chlorophyll *a* were collected using a Kemmerer water sampler, and were composited from two to three equidistant depths within the strata (epilimnion or hypolimnion) sampled (Table 1).

Table 1. Analytical methods used for samples collected for the LWQA Program.

Parameter	Strata Sampled[1]	Sample Preservation[2]	Analytical Method[3]	Method Detection Limit	Holding Time	Lab[4]
Total Phosphorus	epilimnion, hypolimnion	H_2SO_4 to pH < 2	SM 4500-P D	3 µg/L	28 days	MEL
Total Nitrogen	epilimnion, hypolimnion	H_2SO_4 to pH < 2	EPA 353.2	10 µg/L	28 days	MEL
Chlorophyll a[5]	epilimnion	$MgCO_3$[6]	SM 10100H (2,B)	0.5 µg/L	28 days	MEL
Turbidity	epilimnion		SM 2540D, E	1 NTU	7 days	MEL
Fecal Coliform Bacteria	nearshore grab samples (2 sites)		SM 9222D	1 colony/ 100 mL	30 hours	MEL

1 All samples except fecal coliform bacteria were composited.
2 All samples kept on ice or stored at 4°C until delivery to the lab, or until filtered.
3 Huntamer and Hyre, 1991
4 Manchester Environmental Laboratory (MEL)
5 Corrected for phaeophytin.
6 Approximately 2 mL saturated $MgCO_3$ added with last of filtrate onto filter. Filters were iced, or frozen, until delivered to lab.

Fecal coliform samples were collected approximately 20-35 feet from shore in areas that were suspected to have some potential source of bacteria. Fecal coliform bacteria sample bottles were filled by "scooping" water from about eight inches below the water surface to avoid surface films.

All samples, except those for chlorophyll *a*, were transported on ice to the lab and stored at 4°C. Chlorophyll *a* samples were filtered through Whatman 4.7 cm GF/C filters as soon as possible after collection. For most samples, 500 mL aliquots were filtered. About 2 mL of saturated $MgCO_3$ was added to the last of the filtrate to preserve the sample on the filter. Filters were placed in 10 ml of 90% acetone, then stored in the dark and on ice or refrigerated until transported to the lab for analysis.

Sampling Protocols for Zooplankton

A measure of uses on a given lake should include an evaluation of the health of a fishery. In a study of 18 natural lakes in upstate New York, Mills and Schavone (1982) demonstrated a strong correlation between mean length of cladocerans and planktivore weight ($r^2 = .70$; $P<0.05$). In other words, the presence of large zooplankton indicate predator fish are keeping prey species in balance. Dominance of smaller zooplankton suggests too few piscivores to suppress planktivore density (see Glossary, Appendix A). Their research resulted in an index to determine the predator/prey balance in the fish communities within a given lake. This index has been widely used on the east coast of the United States to measure zooplankton as a cost effective surrogate to collecting and measuring fish.

No index has yet been developed for Washington State and we therefore assessed the zooplankton data qualitatively. For example, a large decline in mean zooplankton size between June and August may suggest an over abundance of planktivores relative to piscivores.

A standard approach to sampling zooplankton in the field was followed. Methods for collecting, storage, and enumeration are patterned after the “Zooplankton Workshop Reference Guide” prepared by BSA Environmental Services, Inc. (Beaver, 1997) and are described in detail in Smith, et al., 2000.

Habitat Characterization

In order to do a whole lake assessment, an evaluation of the riparian and littoral zones (see Glossary, Appendix A) is important. The habitat survey included an evaluation of physical structure, aquatic and riparian vegetation, and human impacts in these zones, all of which may contribute to the protection or degradation of lake water quality. The methodology in the EPA publication entitled *Surface Waters, Field Operations Manual for Lakes*, Section 5 (Kaufmann and Whittier, 1997) provides an excellent approach to evaluating these zones. Specific protocols for our habitat survey methodology are included in Smith et al., 2000.

Ten transects were surveyed on each lake, with numerous measures collected at each transect. Each measure in the survey typically results in an integer value score. Results are summarized in each lake-specific report (Appendix B) by averaging the scores of the ten transects. For example, if station A has vegetation covering 20-30% of the substrate, that station would be assigned a 2 for “vegetated substrate,” according to protocols. The reported (summarized) value for “vegetated substrate” is the average score for the 10 transects. A score of 2.6 would indicate that the average transect’s “vegetated substrate” score was about midway between 2 (which indicates 20-30% vegetation) and 3 (which indicates 40-75% vegetation). (The interpretation of the integer scores is provided in the summarized report.)

Watershed Survey

A standard "windshield" survey of the watershed was implemented as part of the new approach to assessing lakes because knowledge of the watershed may contribute to understanding attributes of the water quality in the lake. For instance, if agriculture is predominant in the watershed, livestock or fertilizers may be impacting the lake's tributaries. Also, many poor management practices can be seen from the windshield of a vehicle. This survey consisted of a thorough driving tour of the watershed. Observations were recorded regarding land uses, management practices (good and bad), waterfowl, and beneficial uses of the lake. Protocols and a copy of the survey form used in the field are included in Smith et al. (2000).

User Perception Questionnaire

The idea of implementing user perception surveys originated after reviewing research conducted by University of Maine's Water Research Institute. Maine's research demonstrated relationships between water clarity, property values, and other socio-economic factors within the lake community (Boyle et al., 1997). WAC 173-201A-030(6) calls for public input before setting a nutrient criterion in a lake. The surveys conducted in Maine were modified and edited for Washington State then distributed to most of the lake communities studied in 1999.

The questionnaires were designed primarily to help investigators of lake water quality determine the following:

1) Primary recreational uses and their relative importance.
2) Lake user's perception of the quality of those uses.
3) Socio-economic value of the resource.

In 1999, however, efforts were focused primarily on objective #1 while objectives #2 and #3 were considered experimental.

The return of the questionnaires was voluntary, of course, and we did not follow up on non-respondents. Although an effort was made to widely distribute the questionnaires, often only a small fraction was returned. Returns were greatest where volunteers were available to distribute questionnaires by hand. For these reasons, we cannot apply confidence intervals to the results. Therefore, questionnaire data are, essentially, considered "qualified" and results have been interpreted with caution. Nevertheless, questionnaire results complemented very nicely our own observations and often provided insights that would otherwise have been missed.

Two types of questionnaires were developed, one for visitors and one for residents, though most questions were common to both. The resident questionnaire, followed by a brief synopsis of why each question was asked, is included in Smith et al. (2000).

Sample Analysis Methods

Methods used for sample analyses are listed in Table 1. Sample preservation and analytical methods used by Manchester Environmental Laboratory (MEL) are described in Huntamer and Hyre (1991).

Keys used for algal identifications were Smith (1950), Edmondson (1959), Prescott (1962; 1978), and VanLandingham (1982). Keys used for macrophyte identifications were Tarver *et al*. (1978), Prescott (1980), and others (see Parsons, 1999).

Methods Used for Estimating Trophic Status

Carlson's (1977) trophic state indices (TSI) for Secchi depth (TSI_{SD}), total phosphorus (TSI_{TP}), and chlorophyll *a* (TSI_{CHL}), tempered with professional judgment, were used to estimate the trophic status of the monitored lakes. In general, TSIs of 40 or less indicate oligotrophy, TSIs between 40 and 50 indicate mesotrophy, and TSIs greater than 50 indicate eutrophy (Carlson, 1979). To describe lakes that appeared to be between trophic states, the terms "oligo-mesotrophic" and "meso-eutrophic" were used. Refer to the Glossary in Appendix A for more detailed definitions of trophic state terms.

TSI_{SD} values were calculated from a time-weighted mean Secchi depth calculated from all Secchi data collected between mid-May and mid-October 1999. A minimum of five Secchi depth measurements separated by at least two weeks were required to calculate an unqualified TSI_{SD} for each lake. TSI_{SD} values failing the five measurement minimum are qualified with the letter 'N.' TSI_{TP} and TSI_{CHL} values were similarly calculated from time-weighted mean total phosphorous and chlorophyll values, respectively.

It is not valid to average TSI values from different trophic state parameters, and to use that average to summarize a lake's trophic status. According to Carlson (1977), "the best indicator of trophic status may vary from lake to lake and also seasonally, so the best index to use should be chosen on pragmatic grounds." A subjective assessment of all data collected during the monitoring season was used to determine an appropriate index for assigning trophic states. Other data collected during this study, data from other sources (short term lake surveys conducted by Ecology or universities, consultant reports from Ecology-funded lake restoration activities, etc.), and information from the volunteers (e.g. on aquatic herbicide use) were used to temper the trophic state assessment for most lakes. As a result, the final trophic state estimations were not based on TSI alone, and were not necessarily based on the same parameters for all lakes. The basis for each trophic state assessment is discussed in the "Summary" section of the individual lake assessments in Appendix B.

Overall Lake Assessments and Setting Criteria

Water Quality Standards (WAC 173-201A (6)) suggest total phosphorus criteria for lakes (also referred to as "action values," see Glossary, Appendix A) based on ecoregion and trophic state. If measured concentrations are below the action value, a criterion may be proposed at or below the action value, or a lake-specific study may be conducted. Measured concentrations above the action value or where no action value is provided require a lake-specific study. The characteristics monitored in the LWQA Program are similar to examples included in the Water Quality Standards for lake-specific studies.

An evaluation of the primary beneficial uses on each lake is one of the purposes of the lake-specific study. These were determined from the user perception surveys, observations during sampling, and discussions with volunteer monitors. Determining whether or not the water quality in the lake supports the beneficial uses required best professional judgment. The types of uses were considered and water quality was subsequently determined sufficient or insufficient to support those uses. The results of the questionnaires were reviewed to determine how the users perceive water quality. Additionally, local governments, fish and wildlife officials, and other lake studies were consulted. Aquatic plant surveys as well as results from the habitat survey provided information on aquatic vegetation, which may impact the quality of swimming, fishing, and boating, as well as fish reproduction and wildlife habitat suitability.

If beneficial uses were supported, then the nutrient criterion recommended for the lake was generally the mean total phosphorus concentration plus an adjustment for interannual variation (described below), or the action value. In general, the more protective of either the action value or the mean total phosphorous value was recommended as a criterion. The final recommendation also depended on best professional judgment as to whether current nutrient concentrations were elevated due to anthropogenic sources.

If beneficial uses were not supported and were adversely impacted by artificially high nutrient concentrations, then further study may be necessary to determine what nutrient concentrations will support the beneficial uses. Alternatively, if uses were not supported because of habitat modifications, or other non-nutrient related attributes, then recommendations are made on how to improve conditions in order to support those uses. Recommendations can be based on the results from water quality, habitat, watershed, user perception, zooplankton, and Hydrolab® surveys. One benefit of this new approach to lake assessment is the potential to integrate information for management purposes.

The lake-specific nutrient criteria proposed in this report were selected using information compiled through the seasonal sampling. As previously discussed, a criterion was usually recommended as either the action value listed in the Water Quality Standards, or the mean total phosphorus concentration plus an adjustment to allow for natural interannual variation. This adjustment was calculated as the median interannual standard deviation of all lakes monitored by the LWQA program for more than two years with similar phosphorus concentrations to the lake being evaluated (Table 2). For example, if the seasonal mean value for phosphorus in a given lake is 18.3 ug/L, a recommendation of a nutrient criterion of 18.3 + 4.1 = 22.4 ug/L total phosphorus was made. However, if that lake was in the Puget Lowlands and was assessed as lower mesotrophic, the action value of 20 ug/L may be recommended because the action value is more protective yet is still above the mean measured concentration.

Table 2. Median inter-annual standard deviations based on historical data as a function of mean total phosphorus concentrations.

Mean Phosphorus Concentration (μg/L)	Median Inter-annual Standard Deviation	Number of Lakes
Less than or equal to 10	3.0	19
>10 through 20	4.1	43
>20 through 30	5.1	17
>30 through 40	8.0	16
>40 through 60	15.0	7
>60 through 80	27.8	2
Greater than 100	70.6	8

The intent of recommended criteria is to be protective but not overly sensitive. The ideal criterion should be sensitive enough to have a reasonable probability of identifying lakes that may be degraded or degrading; yet not so sensitive as to falsely identify lakes as degrading that are merely undergoing inter-annual variation. Too insensitive a criterion would fail to identify degrading lakes; too sensitive a criterion would falsely report too many lakes as degrading and would be meaningless as a management tool. These criteria should be considered preliminary. Once a lake has exceeded a criterion, a more detailed study should be conducted, including in particular a nutrient loading analysis, the first objective of which should be an evaluation and refinement of the criterion.

Quality Assurance and Quality Control Evaluation

All data collected for the LWQA Program were evaluated to determine whether data quality objectives for the program (Table 3) were met. Methods used for data quality evaluations are described in *Lake Water Quality Assessment Program Quality Assurance Project Plan* (Hallock, 1995-draft). QA/QC analysis for all parameters is listed in Appendix C.

Table 3. Summary of data quality objectives for the LWQA Program.

Parameter	Detection Limit	Precision	Accuracy (Bias)
Secchi Depth	--	< 10% CV[a] (daily pairs) < 5% CV (all pairs/lake)	< 10% CV[b] (volunteer/ Ecology)
Total Phosphorus	5 µg/L	< 7.5% CV (10 lab splits)	< 2.5% relative bias (lab check standards)
Total Persulfate Nitrogen	0.050 mg/L	< 5% CV (lab splits)	< 5% relative bias (lab check standards)
Chlorophyll *a*	0.5 µg/L	< 10% CV (field dups) < 45% CV (May/August)	< 2.5% relative bias (lab check standards)
Profile parameters			
Temp.	--	--	± 1.0°C
pH	--	--	± 0.2 SU
D.O.	--	--	± 0.50 mg/L
spec. cond.	--	--	± 5 µmho/cm
Fecal Coliforms	1 colony/100 mL	< 35% CV (lab splits)	--

[a] Coefficient of Variation

[b] In the case of Secchi depth, this isn't truly "accuracy" but rather a comparison between volunteer and Ecology staff collected readings. QC requirements for Secchi depth were only applied to volunteer-collected data.

Profile Data

The Hydrolabs® were pre- and post-calibrated daily for pH and dissolved oxygen. The manufacturer's instructions were followed for pH calibration, using pH 7 (low ionic strength) and pH 10 (either low or standard ionic strength) standard buffer solutions. Post-calibration readings within 0.2 pH units of the buffer values were considered acceptable. One post-calibration reading out of 90 taken did not meet quality assurance requirements. All measurements failing quality assurance requirements are qualified accordingly, as denoted by the qualifier "J," indicating an estimate.

The dissolved oxygen sensor was calibrated against theoretical water-saturated air, in accordance with manufacturer's instructions. Daily field samples were collected for Winkler titrations and check standards. Post-calibration results within 0.5 mg/L were considered acceptable. Eight post-calibration readings out of 45 taken failed quality assurance requirements. Seven field checks of 15 taken failed quality assurance requirements. (We have consistently had difficulties with oxygen check standards. Air calibration may be insufficiently accurate for our data quality objectives.) All measurements failing quality assurance requirements are qualified accordingly, as denoted by the qualifier "J," indicating an estimate.

Specific conductance, a more stable parameter on the Hydrolab®, was checked periodically using the manufacturer's instructions. Potassium chloride standards used for conductivity calibration ranged from 101 to 147 μmhos/cm at 25°C (the molarity varied between individual solutions used). Post-calibration values within 5 μmhos/cm of the standard value were considered acceptable. One post-calibration reading out of three calibration checks taken did not meet quality assurance requirements. All measurements failing quality assurance requirements are qualified accordingly, as denoted by the qualifier "J," indicating an estimate.

Temperature was also checked periodically against a National Bureau of Standards (NBS) mercury thermometer. Values within 1.0°C were considered acceptable. All four post-calibration results met quality assurance requirements. Post-calibration results are listed in Appendix D.

Additionally, two duplicate Hydrolab® profiles were collected on each survey. "Nonsequential" duplicates were collected from the same station as the nutrient duplicate sample. "Sequential" duplicates were collected by retrieving the Hydrolab® and immediately repeating the measurements at the same station and depths as previously measured. The precision of duplicate readings was calculated as the median of percent coefficient of variation (CV%s) of data pairs from the same depths. Although no specific quality assurance standards were set for duplicate Hydrolab® data, all median CV%s were under 4%, indicating good precision. Surprisingly, in general, nonsequential duplicates did not have greater variability than sequential duplicates indicating that one site adequately represents whole lake conditions, at least for profile data. Median CV%s are listed below in Table 4. Additionally, profile quality assurance results are listed in Appendix D.

Table 4. Summary of Quality Assurance/Quality Control data for Hydrolab® profiles.

DISSOLVED OXYGEN				**PH**			
Nonsequential Duplicates		**Sequential Duplicates**		**Nonsequential Duplicates**		**Sequential Duplicates**	
Date	Median CV%	Date	Median CV%	Date	Median CV%	Date	Median CV%
June	2.89	June	2.16	June	0.79	June	0.62
July	1.53	July	2.53	July	0.16	July	0.65
August	2.37	August	3.76	August	0.62	August	0.47
September	2.24	September	3.09	September	1.17	September	1.01

TEMPERATURE				**CONDUCTIVITY**			
Nonsequential Duplicates		**Sequential Duplicates**		**Nonsequential Duplicates**		**Sequential Duplicates**	
Date	Median CV%	Date	Median CV%	Date	Median CV%	Date	Median CV%
June	0.32	June	1.13	June	0.14	June	0.51
July	0.19	July	0.89	July	0.19	July	0.87
August	0.30	August	0.55	August	0.69	August	1.45
September	0.09	September	0.64	September	0.20	September	0.57

Laboratory Quality Assurance

Laboratory QC requirements include the use of check standards, reference materials, matrix spikes, blanks, and lab split samples (duplicates). Lab splits are discussed below. For the most part, data quality for this project met all lab quality assurance and quality control criteria as determined and evaluated by the Manchester Environmental Laboratory. Exceptions that caused results to be qualified as estimates include the following: five turbidity samples exceeded holding times due to a shipping problem and subsequent late arrival at the lab; one total persulfate nitrogen sample was qualified due to improper storage in transit; two fecal coliform samples were qualified due to a colony count greater than 150, indicating that results may be equal to or greater than the reported value; and one fecal coliform sample was qualified due to the presence of motile, non-fecal spreader colonies which interfered with sample processing. Additionally, thirteen fecal coliform, four turbidity, three total phosphorous, and one total persulfate nitrogen results were qualified as containing the analyte below the method's limit of detection. These qualifiers were noted and taken into consideration when assessing lake water quality and setting nutrient criteria.

Field Quality Assurance

Total Phosphorous Data

Lab precision was calculated by pooling the coefficients for all pairs of lab splits. Results (Appendix C) were all under the acceptable median CV% of 7.5 percent (Table 5). Total phosphorous samples were collected at a second site from ten lakes during the course of the survey. These duplicate samples were collected to evaluate the representativeness of collecting epilimnetic data from a single lake station. The Quality Assurance Project Plan (QAPP) for the LWQA Program (Hallock, 1995) states that the total precision of these nonsequential duplicates should be evaluated by pooling the CV%s for each pair and, if the median CV% exceeds 21 percent, then collecting from a single lake station is generally not representative of lakewide epilimnetic phosphorous. Results (Appendix C) show that the median CV% did not exceed 21 percent; therefore, sampling at one site is generally representative (Table 5).

In addition to nonsequential duplicates, sequential duplicates were collected by immediately repeating the sample collection at the original sampling site. Although no specific quality assurance standards were set for sequential duplicate total phosphorous data, all median CV%s indicate little variance (Table 5).

Other Water Chemistry Data

QA/QC evaluations for total nitrogen, chlorophyll *a*, solids, and fecal coliform bacteria followed the methods described in Hallock (1995). All available lab QC data results are listed in Appendix C and summarized below in Table 6.

Total Nitrogen

All median CV%s for total nitrogen lab splits fell below the QAPP standard of 5 percent. Similarly, the nonsequential duplicate CV% in July (the only month measured) was well under the QAPP standard of 30 percent.

Chlorophyll a

All median CV%s for chlorophyll a lab splits fell below the QAPP standard of 10 percent. Likewise, sequential duplicate results also fall at or below the QAPP standard of 10%.

Fecal Coliform Bacteria

We did not conduct quality assurance calculations on fecal coliform data due to the wide variability in fecal concentrations expected in the field. A single fecal bacteria sample is not considered to be representative lakewide. These samples were generally used to assess high risk or potential source areas such as swimming beaches, heavily developed embayments, etc.

Turbidity

All paired turbidity readings were within 0.5 NTUs, the acceptable range set forth by the QAPP.

Table 5. Summary of Quality Assurance/Quality Control Data for 1999.

TOTAL PHOSPHOROUS					
Lab Splits (QAPP standard ≤7.5%)		**Nonsequential Duplicates (standard ≤21%)**		**Sequential Duplicates (no standard)**	
Date	Median CV%	Date	Median CV%	Date	Median CV%
June	0.5	June	6.0	June	3.9
July	5.6	July	8.7	July	7.8
August	6.3	August	3.3	August	7.7
September	2.0	September	2.2	September	14.4

TOTAL NITROGEN					
Lab Splits (QAPP standard ≤5%)		**Nonsequential Duplicates (standard ≤30%)**		**Sequential Duplicates (no standard)**	
Date	Median CV%	Date	Median CV%	Date	Median CV%
June	0.8	June	None	June	5.6
July	1.7	July	5.1	July	3.1
August	0.6	August	None	August	3.1
September	0.9	September	None	September	7.3

CHLOROPHYLL A					
Lab Splits (QAPP standard ≤10%)		**Nonsequential Duplicates (no standard)**		**Sequential Duplicates (standard ≤10%)**	
Date	Median CV%	Date	Median CV%	Date	Median CV%
June	0.8	June	0.3	June	0.9
July	1.2	July	3.5	July	10.0
August	None	August	4.9	August	9.9
September	2.1	September	0.0	September	4.7

TURBIDITY				
Lab Splits (QAPP standard within 0.5NTU)		**Nonsequential Duplicates (no standard)**		**No turbidity sequential duplicates**
Date	Max. Difference	Date	Median CV%	
June	0.1	June	16.3	
July	0.2	July	49.9	
August	0.1	August	35.4	
September	0.1	September	43.0	

Summary

Data collected for each lake, individual lake assessments, and proposed criteria are tabulated or discussed in Appendix B. We have recommended a phosphorus criterion for all of the 20 lakes monitored by this study (Table 6). Only one lake had TP concentrations in 1999 that were greater than the proposed criterion (Deer Lake). If our proposed criteria are approved, Deer Lake should become eligible for Total Maximum Daily Load studies. The other 19 lakes would not be in violation of water quality standards unless future phosphorus concentrations exceeded criteria.

Table 6. Summary of individual lake assessments.

Lake Name	County	Assessed Trophic State	Mean TP Concentration (ug/L)	Proposed TP criteria (ug/L)
Big	Skagit	Mesotrophic	18.7	20.0
Browns	Pend Oreille	Oligo-mesotrophic	15.2	18.8
Campbell	Skagit	Eutrophic	27.8	32.6
Curlew	Ferry	Mesotrophic	19.3	20.0
Deer	Stevens	Oligo-mesotrophic	21.4	20.0
Desire	King	Meso-eutrophic	24.3	29.8
Duck	Grays Harbor	Eutrophic	39.3	47.2
Erie	Skagit	Eutrophic	28.8	33.7
Gillette	Stevens	Mesotrophic	23.4	27.8
Harts	Pierce	Eutrophic	67.3	87.0
Long	Spokane	Mesotrophic	18.8	25.0[1]
Loomis	Pacific	Eutrophic	40.6	48.6
Martha	Snohomish	Mesotrophic	12.5	15.8
McMurray	Skagit	Mesotrophic	21.5	25.8
North Skookum	Pend Oreille	Eutrophic	23.2	35.9
Potholes	Grant	Eutrophic	31.6	44.0
Rowland	Klickitat	Eutrophic	39.9	51.4
Sacajawea	Cowlitz	Eutrophic	76.6	101.2
Starvation	Stevens	Eutrophic	68.4	90.0
Terrel	Whatcom	Eutrophic	34.5	41.0

[1] A criterion of 25ug/L total phosphorus from June 1 to October 31 in the eutrophic zone is already listed in the Water Quality Standards (Chapter 173-201-080 (106) WAC).

Recommendations

◊ 1999 marks the final year of the LWQA Program due to a loss of EPA 319 grant funding. While technical monitoring and lake assessments have been eliminated, we have some funding to continue volunteer monitoring of Secchi depth for another season. These data will be used to assess transparency trends. Lakes are a vital ecosystem, providing critical habitat as well as recreation. This lake monitoring program was the only statewide program that assessed the health of these ecosystems, and the only program that developed protective water quality criteria for lakes. Funding for lake monitoring should be restored.

◊ If the LWQA Program should obtain funding or be revived, several procedures need to be evaluated (see recommendations in Smith et al. 2000). Also, the accuracy of air calibrating the profiling instrument oxygen sensor should be investigated.

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Appendix A

Glossary of Terms

Glossary

Action Value – a total phosphorus (TP) value established at the upper limit of the trophic states in each ecoregion. Exceedance of an action value indicates that a problem is suspected. A lake-specific study may be needed to confirm if a nutrient problem exists.

Algae Bloom – abundant growth of algae that results in mats, scums, or otherwise dense growths forming in or on the water. Not all types of algae form blooms.

Ambient Water Quality Monitoring – monitoring to collect baseline information on a water resource, which can therefore be used to determine if a water quality problem exists and how water quality is changing.

Bathymetric Map – a contour map of a lake's depth.

Blue-Green Algae – a type of algae that, when found in bloom concentrations, is usually associated with polluted or eutrophic water bodies. Most blue-green algae are considered to be nuisance species, because they may develop unpleasant scums and odors.

Chlorophyll *a* – a pigment found in the cells of photosynthetic plants. The quantity of chlorophyll *a* in a water sample indicates the amount of photosynthesizing algae per volume of water. In this report, chlorophyll *a* concentrations are reported in µg/L.

Clean Water Act (Federal Clean Water Act) – this law requires water quality to be kept at an acceptable level to support both swimming and fishing in all surface waters. The authority to enforce this law is with the EPA, but this authority can be delegated to individual states; it has been delegated to Washington.

Color – a test used to measure the color of water from which suspended matter has been removed. Color in water may result from natural metals, humus and peat materials, algae, and aquatic plants.

Conductivity – a measure of the ability of a solution to conduct electrical current. As ion content of water increases, conductivity will increase. The unit for expressing conductivity is µmhos/cm.

Cultural Eutrophication – eutrophication caused or accelerated by human activities.

CV – Coefficient of variation; calculated by dividing the standard deviation by the mean. It expresses variability relative to the mean of the sample.

Dissolved Oxygen – oxygen content in water that comes from being in contact with the atmosphere, from agitation (as in streams), or from being released by photosynthesizing aquatic plants. Oxygen is depleted by bacteria that decompose vegetation or other organic material, and from respiration by plants and animals. The unit for expressing dissolved oxygen is mg/L.

Epilimnion – the "top" (closest to the surface), warmer layer of water in a thermally stratified lake. See metalimnion, hypolimnion.

Eutrophic – describes a lake that has high nutrient concentrations, abundant plant and algae growth, and low water clarity. Eutrophication can occur naturally over time, or can be accelerated by human activities (see Cultural Eutrophication).

Fecal Coliform Bacteria – bacteria that are associated with mammal and bird feces. Fecal coliform bacteria results determine whether feces have entered and contaminated a water body. Fecal coliform bacteria results are reported in this report in colonies/100 mL.

Hydrolab® - the brand name of an instrument used to measure temperature, pH, dissolved oxygen and conductivity at various depths in water.

Hypereutrophic – describes a lake in advanced eutrophication which has very high nutrient concentrations, and very abundant plant and algae growth. In this report, hypereutrophic lakes will have a trophic state index value greater than 70.

Hypolimnion – when a lake is thermally stratified, the hypolimnion is the cooler layer of water at the bottom of the lake. See Epilimnion.

Lake Height – volunteers for this program measured the distance from a fixed point (usually on a stationary dock or piling) to the water surface. For most lakes the fixed point was above the water surface, so the greater the lake height value, the lower the water level.

Limnology – the science of lakes and streams, including the factors that influence the biology and chemistry of inland waters. (From the Greek *Limne,* which means "lake").

Littoral zone – The shallow area that extends from shore to the lakeward limit of rooted aquatic plants.

Macrophyte – any aquatic plant larger than algae that grows on, or in, water.

Meso-eutrophic – a trophic state that is borderline between mesotrophic and eutrophic.

Mesotrophic – describes a lake that has moderate concentrations of nutrients, a moderate amount of plant and algae growth, and moderate water clarity (generally 7 to 13 feet, as measured with a Secchi disk).

Metalimnion – the middle layer of water between the epilimnion and hypolimnion of a thermally stratified lake. The metalimnion is located at the thermocline.

mg/L – milligrams per liter. A unit used to describe the concentration of a substance in solution. One mg/L is equivalent to one part per million (ppm).

Nitrogen – an essential plant nutrient that can be present in water in various forms. Common forms are nitrate, nitrite, ammonia, and dissolved nitrogen gas. Nitrogen concentrations are reported in mg/L.

Nutrients – substances, especially nitrogen and phosphorus compounds, that fertilize the growth of aquatic plants and algae. The amount of nutrients in water will affect the amount of plants and algae that can grow.

Oligotrophic – describes a lake that has low nutrient concentrations, little plant or algae growth, and very clear water.

Oligo-mesotrophic – a trophic state that is borderline between oligotrophic and mesotrophic.

Oxidation-Reduction Potential – "Redox" **–** the oxidizing or reducing intensity in water, measured in volts. In chemical reactions, electrons flow between constituents in a solution until equilibrium is reached; constituents which have gained electrons are reduced, and constituents which have lost electrons are oxidized.

pH – represents on a scale of 0 to 14 the acidity of a solution. A pH of 7 is neutral; acid solutions such as vinegar have a pH of less than 7, and basic solutions have a pH greater than 7.

Phase I Study – lake water quality monitoring (called a diagnostic/feasibility study) funded through the Centennial Clean Water Fund Program. Phase I must be completed before Phase II (implementation of the lake restoration plan) can begin. For Phase I, twelve months of water quality data are collected and interpreted, and available restoration approaches are evaluated to determine the feasibility of implementing each approach.

Phosphorus – an important, often critical, plant nutrient that can be present in water in various forms. Phosphorus can be dissolved in water (orthophosphorus), adsorbed onto particles, or taken up by plants. Phosphorus concentrations are reported in μg/L.

Phytoplankton – Microscopic plant plankton that live unattached in water.

Piscivore – an organism that habitually feeds on fish; in lakes, piscivores generally include predator fish, birds, and freshwater mammals.

Planktivore – an organism that habitually feeds on plankton; in lakes, planktivores generally include fish, waterfowl, and plankton.

Plankton – the assemblage of suspended minute plants and animals that have relatively limited powers of locomotion, or that drift in the water subject to the action of waves and currents. Plankton forms the lowest level of the food chain, and includes zooplankton and phytoplankton.

Productivity – the amount of algae, aquatic plants, fish, and wildlife a waterbody can produce and sustain.

Profile Data – data collected at various depths of a lake to characterize a sampling site from surface to bottom. In this report, profiled parameters are temperature, pH, dissolved oxygen, and conductivity.

Riparian – Pertaining to the banks of streams, lakes, or tidewater

Runoff – water that washes over a ground surface or within the soil column as groundwater. Runoff can pick up suspended and dissolved substances from areas it has washed, and carry the substances to streams and lakes.

Secchi Disk – a black and white, 20 cm diameter disk that is attached to a rope. The disk is used to measure water transparency in open water. See Transparency.

Stratification (Thermal Stratification) – the state in which a lake forms distinct layers (the epilimnion and hypolimnion), usually because of the temperature differences between the surface and bottom of the lake. These layers do not mix while the lake is completely stratified.

Thermocline – when measuring temperature from the surface to bottom of a lake, the thermocline is characterized by a considerable change in temperature with little change in depth. It is the transition area between the epilimnion and hypolimnion.

Total Suspended Solids – measures the amount of suspended matter that is filtered out of a sample of water, and dried at a specified temperature. Nonvolatile solids are the residue remaining after the sample is ignited at a specified temperature. The units for expressing solids results are mg/L. Suspended solids do not include dissolved solids (such as salts).

Transparency – generally, water clarity of open water measured by a Secchi disk is called Secchi disk transparency. Secchi disk transparency is a measurement of the depth that sunlight can penetrate water and then reflect back up to the surface.

Trophic State – characterizes a lake according to the amount of plants that grow in a lake. Trophic state also characterizes the water clarity and the amount of nutrients in the water. See Oligotrophic, Mesotrophic, and Eutrophic.

Trophic State Index – a number that rates a lake according to the extent of eutrophication. In this report, oligotrophic lakes have lower trophic state values, and eutrophic lakes have a higher trophic state index value.

Turbidity – a measurement of the effects of light-absorbing and light-scattering substances that are suspended in water. Turbidity is determined by passing a light through a sample and measuring the amount of light that is scattered by the suspended particles. Turbidity is not the same as transparency.

Turnover (Lake Turnover) – the seasonal mixing of water layers that occurs when temperature differences lessen between the top and bottom layers of water. Turnover occurs during fall in most lakes. Lakes that freeze over during winter will also turnover after spring thaw.

Water Clarity – another term for Transparency.

Water Quality Standards – criteria established by Washington State for surface waters, cited in Chapter 173-201A WAC (Washington Administrative Code). Water quality standards (for dissolved oxygen, pH, fecal coliform bacteria, temperature, and other parameters) are established for classes of rivers, streams, and marine waters (Class A, AA, etc., depending on their characteristic uses), and lakes (Lake Class).

Watershed – all the area that collects water and drains to a lake via streams, surface runoff, or groundwater.

Winterkill – fish dill in lakes generally caused by the depletion of oxygen in water while the lake is frozen over.

Zooplankton – microscopic animals in water that eat algae and are eaten by fish.

µg/Kg – micrograms per kilogram. A unit of concentration used to describe how many micrograms of a chemical or contaminant are present in one kilogram of the analyzed substance (such as sediment or fish tissue). One µg/Kg is equal to one ppb (parts per billion).

µg/L – micrograms per liter. A unit of concentration used to describe how many micrograms of a substance are in one liter of solution. One µg/L is equal to one milligram per cubic meter (mg/m^3), and to one part per billion (ppb). One thousand μg/L is equal to one mg/L.

μmhos/cm – micromhos per centimeter. A unit used to describe conductivity measured by two electrodes 1 cm^2 in area and 1 cm apart.

Appendix B

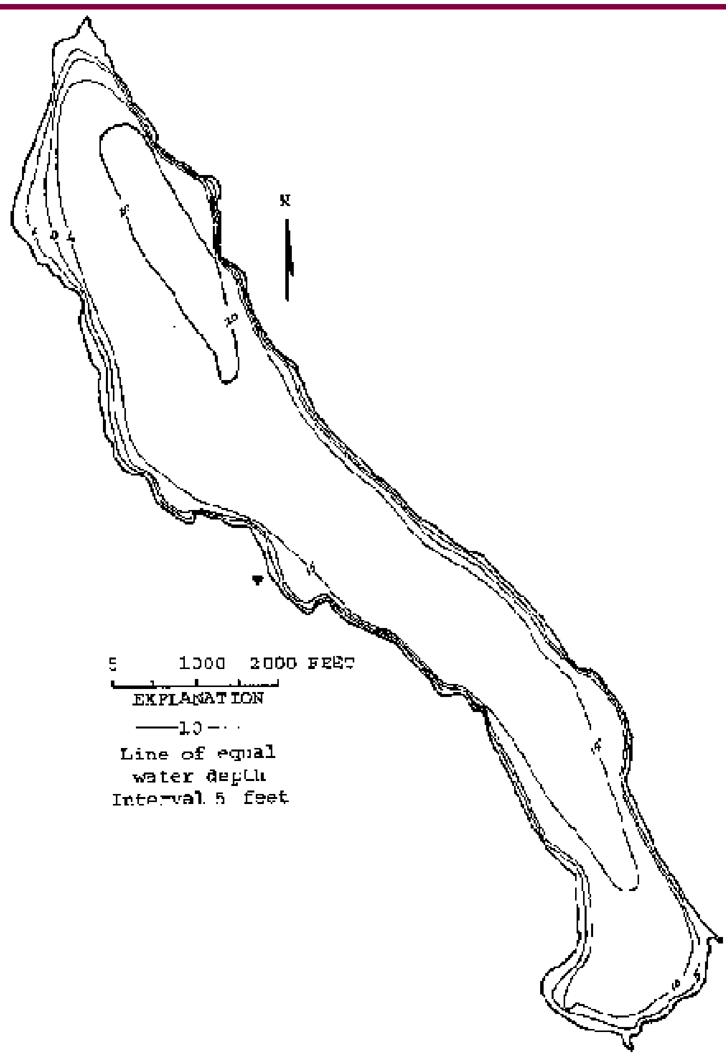
Individual Lake Assessments

BIG SKAGIT County *Lake ID:* BIGSK1

Ecoregion: 2

Big Lake is located five miles southeast from Mount Vernon and about twenty five miles south from Bellingham. It is fed by several inflows, the largest, Lake Creek, comes from McMurray Lake. Six additional unnamed tributaries are located along the western shore. It drains to the Skagit River via Nookachamps Creek. The lake is shallow with abundant plant and algal growth and is a popular water body for personal watercraft.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
520	23	14	22	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
7470	6.21	81	48 23 52.	122 14 24.



Station Information

BIGSK1

Primary Station   Station # 1   latitude: 48 23 15.9   longitude: 122 14 04.9

Description: Deep part of lake. Directly north of boat launch, about 500 feet west of shore.

Trophic State Assessment for 1999

BIG

Analyst: Sarah O'Neal

TSI_Secchi: [a]	44
TSI_Phos:	46
TSI_Chl:	50
Narrative TSI: [b]	M

Big Lake is shallow, with abundant plant and algal growth. Despite its productivity, plants grew less densely than expected, and algal blooms were subtle enough to prevent detracting from the aesthetic value of the lake. The lake underwent Sonar treatment in the summer of 1998 to combat the invasive, non-native aquatic plants, Brazilian elodea (Egeria densa) and Eurasian watermilfoil (Myriophyllum spicatum). The treatment drastically reduced, if not eliminated, the milfoil and affected the Brazilian elodea, though not as significantly as hoped. A second sonar treatment was being considered for the summer of 2000. The lake experienced a steady decline in transparency through the summer, as indicated by Secchi readings. Shallow depths in the lake prevented thermal stratification, however, dissolved oxygen levels dropped off sharply near the bottom. We recorded one high fecal count in August near the public boat launch. The source of contamination is unknown. Possible sources include agriculture, stormwater runoff, goose and animal access, and swimmers. Popular activities on the lake included skiing and the use of personal watercraft. Most questionnaire respondents, however, were primarily interested in fishing. Survey respondents indicated a strong desire for restrictions on popular motorized activities. Visitors enjoyed warmwater fishing, particularly for largemouth bass. According to Washington Department of Fish and Wildlife (WDFW), yellow perch, largescale suckers, and brown bullhead were also abundant in the lake. Coldwater fish species declined dramatically since the last evaluation in 1978, although cutthroat trout and coho salmon utilized the lake at very low densities. A considerably lower percentage of large zooplankton in September than in June indicated heavy predation by planktivores. This suggests that population of piscivores may be too small to suppress planktivore density.

Shallow depths, dense residential development, and a location in a relatively large watershed may render Big Lake particularly susceptible to (and may have already caused) human-caused eutrophication. In 1999, however, the water quality was supporting the lake's primary uses, fishing and primary contact recreation. The mean measured total phosphorous concentration for Big Lake was 18.7. Pending a more thorough study, we recommend a tentative total phosphorus criterion of 20 ug/L, the action value for Puget Lowlands lower mesotrophic lakes. Future studies will likely recommend lowering this criterion.

Time-weighted means: Secchi = 3.1 m; TP = 18.7 ug/L; Chl = 7.6 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

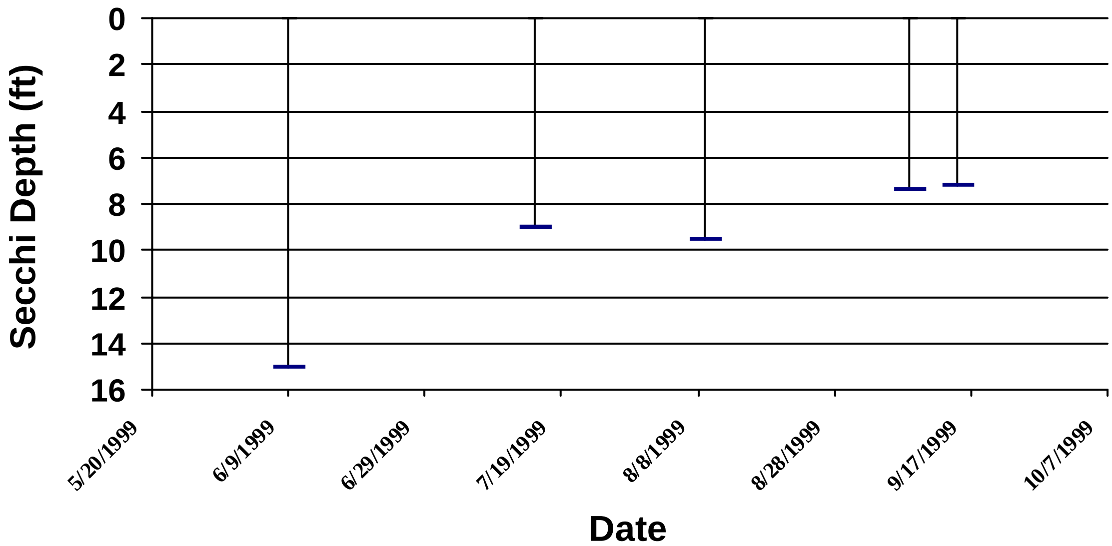
Chemistry Data

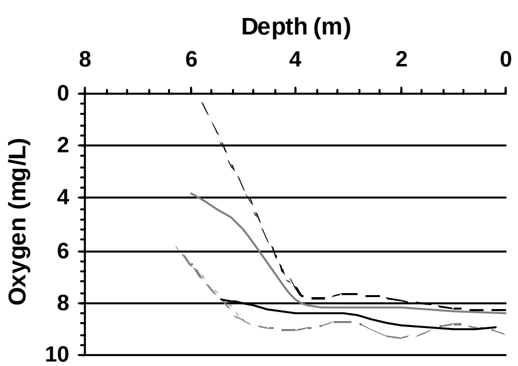
BIG

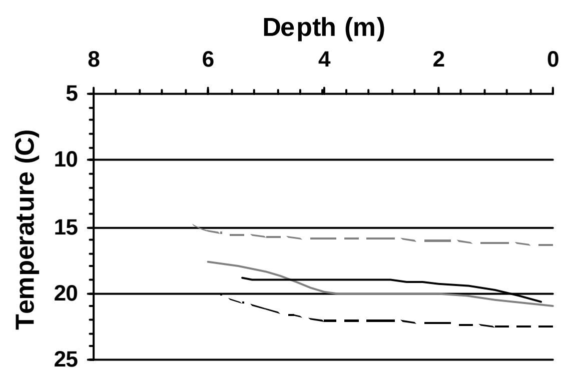
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
6/9/1999		L					6			
		L					24			
8/9/1999		L					45			
		L					270 J			
9/8/1999		L					3			
		L					1 U			
Station 1										
6/9/1999		E	16.1	.363	23	5		28.7	5850	.8
7/15/1999		E	14.1	.305	22	7.24				1.2
		H	20.1	.342	17					
8/9/1999		E	17.4	.289	17	4.1				1.6
9/8/1999		E	24.2	.303	13	11.7				2.3

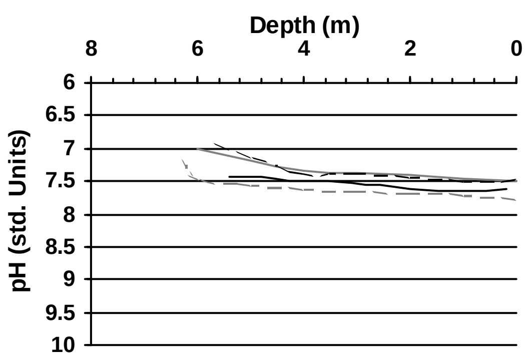
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

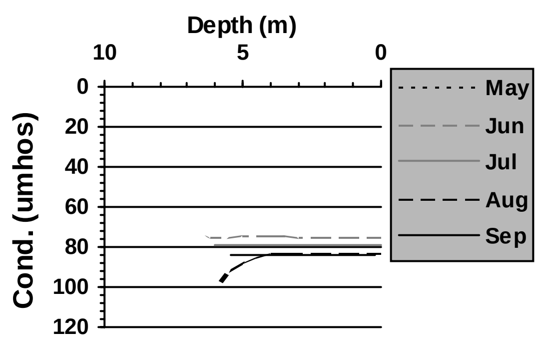
Secchi Depth and Profile Graphics **Station:** 1 BIGSK1











Secchi Data and Field Observations

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/9/1999			15.09	2	50	1		5	4	0	0	1	
	Sampler: SMITH			Remarks: Slight algae bloom. Water very calm. Lots of large daphnia. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.									
7/15/1999			9.02	6	50	3		4	4	27	19	1	1
	Sampler: SMITH			Remarks: Sample site is directly east of white condo just 150 meters off east shore. Small algal bloom (blue-green). Water unusually clear for July.									
8/9/1999			9.51	6	20	1	1	4	4	0	27	1	1
	Sampler: SMITH			Remarks: Fec #1 at Big Lake Resort; Fec #2 at Public boat launch.									
9/8/1999			7.4	2	0	1	1	3	3	0	2	1	2
	Sampler: SMITH			Remarks: Sample site right off Big Lake Resort. A considerable blue-green bloom. Fec #1 near north end of lake on west side near a new dock approx. 300 yds from outlet.									
9/15/1999			7.22										
	Sampler: Parsons			Remarks:									

BROWNS

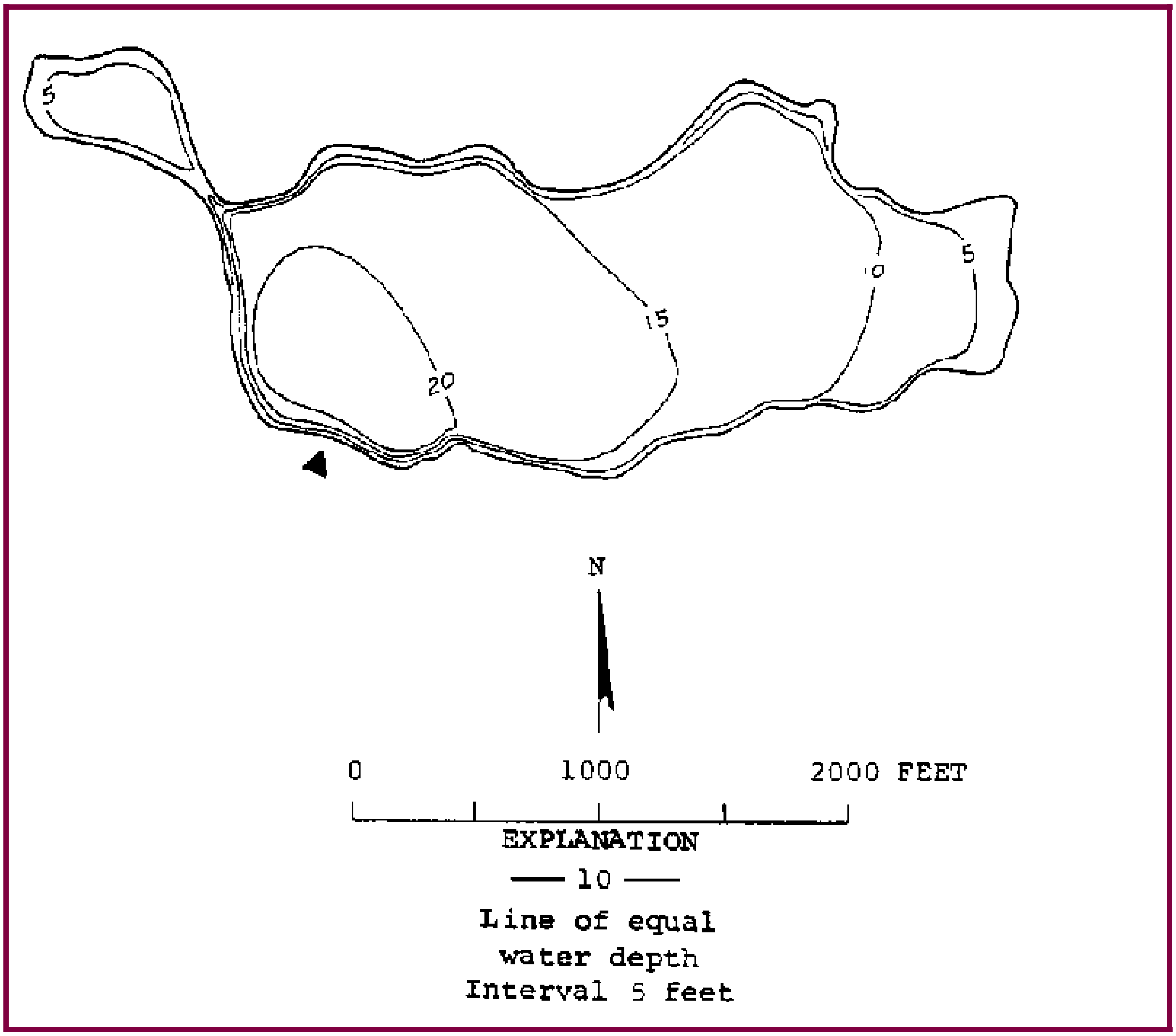
PEND OREILLE County

Lake ID: BROPE1

Ecoregion: 8

Browns Lake is located twenty miles north of the Washington-Idaho border town of Newport. It sits in the Colville National Forest. It is fed by a small tributary in the Pend Oreille River drainage.

Area (acres)	Maximum Depth (ft)	Mean Depth (ft)	Drainage (sq mi)	
84	23	13	5	
Volume (ac-ft)	**Shoreline (miles)**	**Altitude (ft abv msl)**	**Latitude**	**Longitude**
1085	2.06	3450	48 26 12.	117 11 25.



Station Information

BROPE1

Primary Station	Station # 1	latitude: 48 26 17.0	longitude: 117 11 46.0
	Description: Deep part of lake, mid lake out from USFS campground access.		

Trophic State Assessment for 1999

BROWNS

Analyst: Sarah O'Neal

TSI_Secchi: [a]	33	B
TSI_Phos:	43	
TSI_Chl:	33	
Narrative TSI: [b]	OM	

Browns Lake was likely near its natural trophic state. Anthropogenic disturbance in the lake was limited to a US Forest Service campground and some logging in the watershed. No private development had occurred around the lake, and all motors were prohibited. Questionnaires indicated fly-fishing as the primary use. Questionnaire responses also indicated a desire to maintain the current motor restriction. WDFW stocked Browns Lake annually with approximately 20,000 cutthroat trout fry. The relatively cold and mostly oxygenated hypolimnion likely supported the trout. The lake's oligo-mesotrophic state clearly supported fly-fishing and other uses, including canoeing, kayaking, and relaxing. Average phosphorus concentrations were higher than would be expected given transparency and chlorophyll averages. A possible cause was the widely fluctuating water level in the lake which may have increased the proportion of sediment-associated phosphorus that was not biologically available. There was no evidence of internal phosphorus loading.

Because uses were supported and the trophic state of the lake was natural, a total phosphorus criterion may be set at the seasonal mean established during 1999 sampling, adjusted for interannual variability. Therefore, we recommend a total phosphorus criterion for the lake of 18.8 ug/L total (mean 15.2 ug/L plus standard deviation of 3.6 ug/L). However, nitrogen concentrations were very low and TN:TP ratios indicate nitrogen limitation. Because the lake may be nitrogen limited, if the application of nitrogen-based fertilizers is to be part of silviculture operations in the watershed, extreme care should be taken to stay well back from the lake, tributaries, and nearshore areas and timing and buffer requirements should be strictly followed. Other nitrogen sources should similarly be kept away from the lake.

Mean Secchi = 6.4m; Mean TP = 15.2 ug/L; Mean Chl = 1.3 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

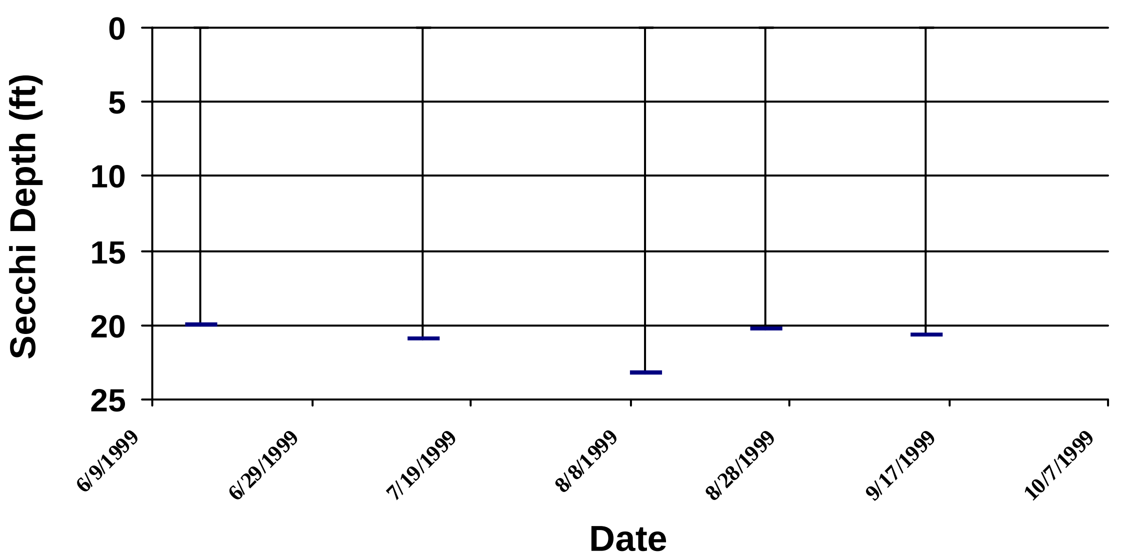
Chemistry Data

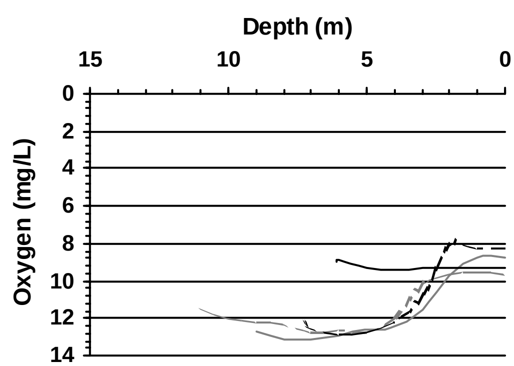
BROWNS

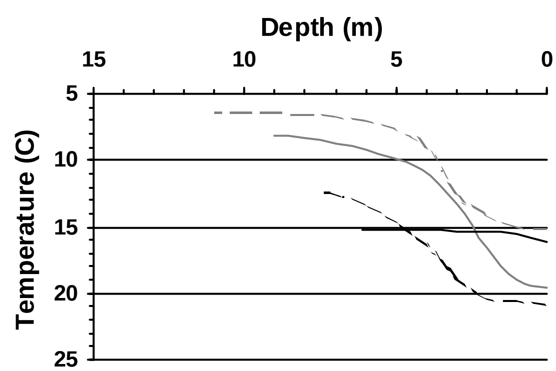
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 1										
6/15/1999	1130	E	17.7	.083	5	.65		7.44	2020	.7
		H	17.2	.083	5					
7/13/1999	1130	E	5.8	.095	16	.54				.6
		H	8.91	.103	12					
8/10/1999	1100	E	17.5	.073	4	.8				.5 U
		H	15.9	.107	7					
9/14/1999	1040	E	16.8	.112	7	2.6				.5 U

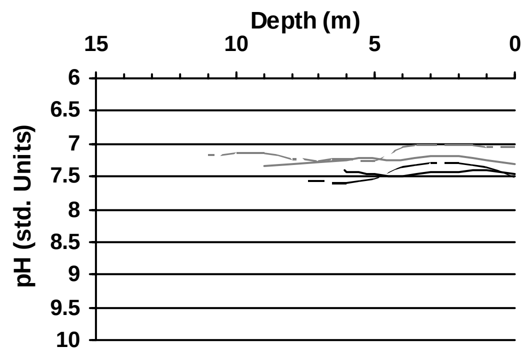
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

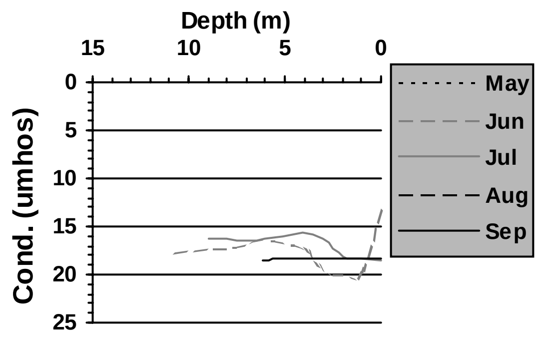
Secchi Depth and Profile Graphics **Station:** 1 BROPE1











Secchi Data and Field Observations

BROWNS

Date	Time	Temperature (F)	Secchi (ft)	Color (1-greens, 11-browns	Brightness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/15/1999			20	2	0	3	1	5	5	0	0	4	0
	Sampler: HALLOCK			Remarks:	Bottom 11.0M. Water is clear and clean with some possible Volvox. Level is very high (5ft above base of a cottonwood near launch). No motors permitted. USFS campground only development. Two fishermen said they usually get RBT but cutthroat this year. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.								
7/13/1999			21	3	0	2	1	5	5	0	0	4	0
	Sampler: HALLOCK			Remarks:	Sounds of logging in watershed. Water still high. Signs of crayfish. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.								
8/10/1999			23.3	4	0	1	1	4	4	0	0	10	0
	Sampler: HALLOCK			Remarks:	Bottom 7.4M. Small Gloeotrichia-like specks. Lake level down several feet from last month. Plant fragments floating throughout lake (Elodea and Ranunculus). Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.								
8/25/1999			20.34										
	Sampler: Parsons			Remarks:									
9/14/1999			20.7 B	2	0	2	1	4	4	0	6	1	0
	Sampler: HALLOCK			Remarks:	Bottom 6.1M. Secchi disk hit bottom. Elodea and Nitella came up on anchor. Water level ~15ft below high water mark on trees. Lots of small (1.5cm) brown/black frogs. Gloeotrichia present. Not stratified.								

CAMPBELL

SKAGIT County

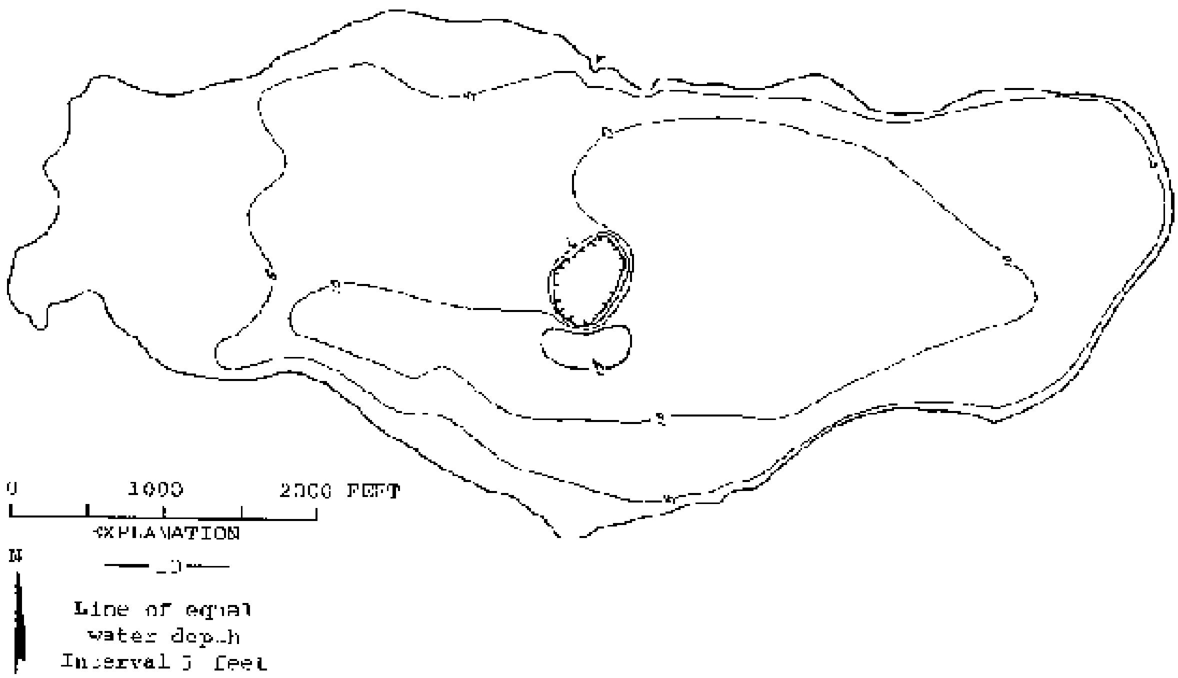
Lake ID: CAMSK1

Ecoregion: 2

Campbell Lake is located four miles south from Anacortes, and approximately fifteen miles west from Mount Vernon. It is 1.5 miles long. It is fed by Lake Erie via a small stream and drains to Simlik Bay. Its macrophytes are mechanically harvested and it serves as a popular sport fishing lake.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*
367	16	8	6

Volume (ac-ft)	*Shoreline (miles)*	*Altitude (ft abv msl)*	*Latitude*	*Longitude*
2770	3.69	43	48 26 05.	122 36 53.



Station Information

CAMSK1

Primary Station Station # 1 latitude: 48 26 15.0 longitude: 122 37 00.0

Description: About 50 meters off of the south side of the Island

Trophic State Assessment for 1999

CAMPBELL

Analyst: Sarah O'Neal

TSI_Secchi: [a]	53
TSI_Phos:	52
TSI_Chl:	68
Narrative TSI: [b]	E

Campbell Lake is probably naturally eutrophic. The lake is shallow, and had abundant plant and algal growth. High productivity prompted a restoration project for the lake in 1986, which included alum treatment. WDFW and Entranco Engineering documented a subsequent improvement in trophic state. However, two of three survey respondents indicated a decline in water quality (the remaining respondent did not know about water quality trends). This may have been due to both frequent--and occasionally foul smelling--algal blooms, as well as the introduction and proliferation of the invasive, non-native aquatic plant, Eurasian watermilfoil. The milfoil dominated the plant community in the lake and formed surface mats by mid-summer. The lake exhibited exceptionally high chlorophyll-a levels, which peaked in June with a concentration of 113 ug/L. This indicates an extraordinary level of photosynthetic activity. The lake shoreline was mainly vegetated, though it was significantly influenced by residential development. Residences dominated the watershed, but agriculture was also prominent, and cows were seen in the lake. How these potential sources of nutrients affected trophic state is unknown. Fortunately, fecal coliform levels remained insignificant throughout the summer, at least at designated sample sites.

Uses supported by the lake included swimming, fishing, and relaxing. Motorized activities included waterskiing and jetskiing, and questionnaire respondents consistently indicated a desire to restrict watercraft in order to reduce noise levels. A large littoral zone provided extensive warmwater fish habitat. The healthy zooplankton community decreased drastically in average size by August, indicating predation by planktivores and possible scarcity of piscivorous species. According to a WDFW survey, also conducted in 1999, largemouth bass and bluegill were the most abundant fish in the lake, followed closely by yellow perch. Brown bullhead, pumpkinseed, black crappie, and sculpin were also present at lower densities in Campbell Lake. No coldwater fish were found, however, likely due to warm temperatures and low oxygen levels at deeper depths.

Despite some indicators of poor water quality, uses of the lake appeared to be supported, including fishing, primary contact recreation, and relaxing. Because uses were supported, and the lake is probably naturally eutrophic, a total phosphorus criterion may be set at the seasonal mean that was established during 1999 sampling, adjusted for interannual variability. Therefore, pending a more thorough study, including a nutrient budget analysis, we recommend a tentative total phosphorus criterion for the lake of 32.6 ug/L (mean 27.8 ug/L plus standard deviation of 4.8 ug/L).

Mean Secchi = 1.6m; Mean TP = 27.8 ug/L; Mean Chl = 44.0 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

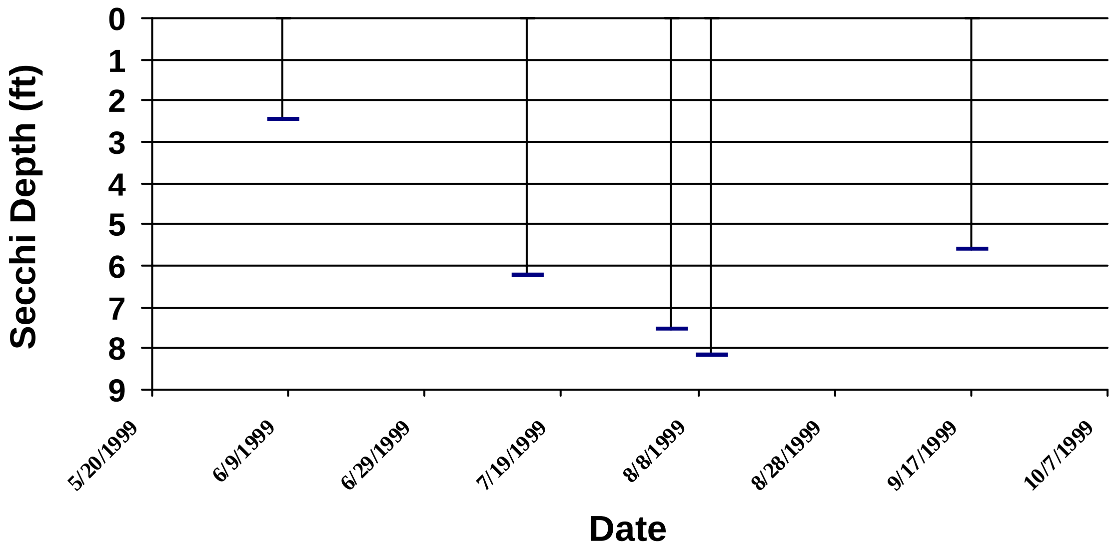
CAMPBELL

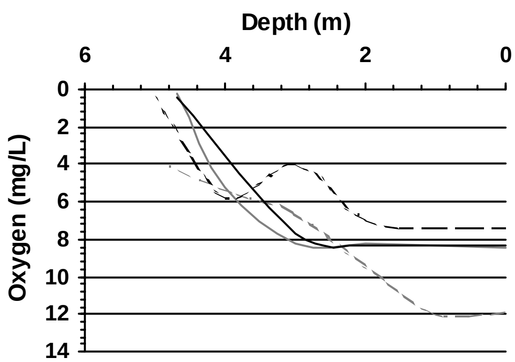
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
6/8/1999		L					1 U			
		L					1 U			
7/14/1999		L					1			
		L					1			
8/10/1999		L					10			
		L					10			
Station 1										
6/8/1999		E	78.3	1.44	18	113		79	17200	8.3
7/14/1999		E	35.1	1.79	51	23.6				2.4
8/10/1999		E	17.4	.98	56	15.4				1.5
9/17/1999		E	29.1	.885	30	15.7				

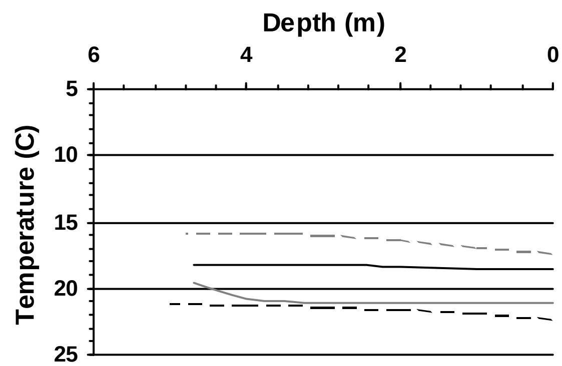
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

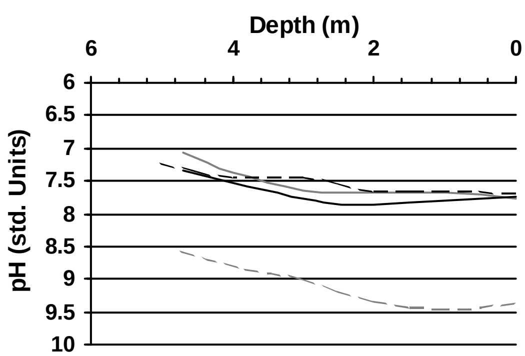
Secchi Depth and Profile Graphics

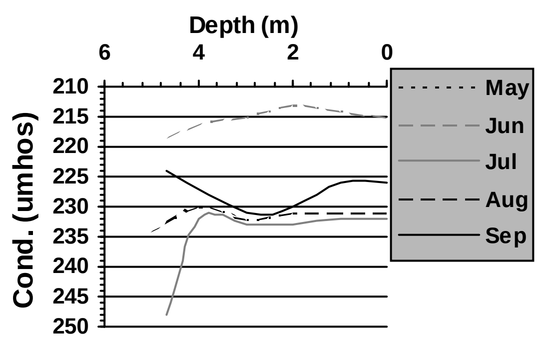
Station: 1 CAMSK1











Secchi Data and Field Observations

CAMPBELL

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/8/1999			2.46	3	0	2	1	4	1	0	1	2	0
	Sampler: SMITH			Remarks: Eagle observed perching on Island. Very little algae at 4 meters. Oxygen plentiful down to bottom. A brilliant blue algae. Looks like Microcyctis--small spherical cells with no sheath. Lake heavily used by jet skis and water skiers.									
7/14/1999			6.23		100	1	1	5	4	0	0	2	0
	Sampler: SMITH			Remarks: Many many zooplankton									
8/4/1999			7.55										
	Sampler: Parsons			Remarks:									
8/10/1999			8.2	6	10	1	1	5	4	0	0	3	1
	Sampler: SMITH			Remarks: A slight blue-green bloom.									
9/17/1999			5.6	3	10	1	1	5	2	0	0	1	0
	Sampler: SMITH			Remarks: Significant algal bloom									

CURLEW

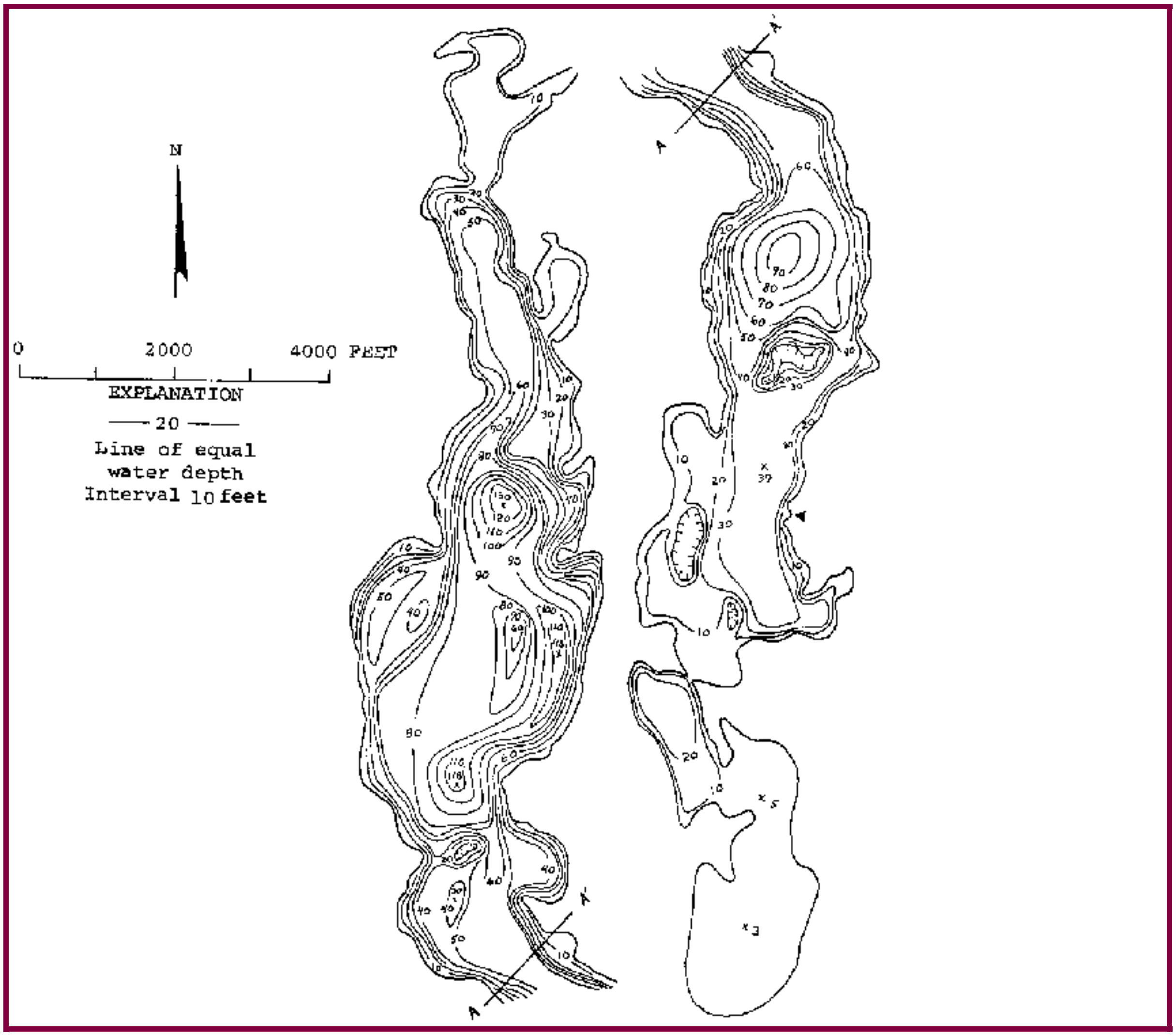
FERRY County

Lake ID: CURFE1

Ecoregion: 8

Curlew Lake is located 4.8 miles northeast of Republic. It is a natural lake, and water level fluctuations are stabilized by a three foot dam built in 1926. The lake extends northerly 4.8 miles to the outlet. There are four islands, totaling 20 acres, that are not included in the reported acreage. Inlets include Herron, Mires, Barrett, and Trout Creeks.

Area (acres)	Maximum Depth (ft)	Mean Depth (ft)	Drainage (sq mi)	
921	130	43	65	
Volume (ac-ft)	**Shoreline (miles)**	**Altitude (ft abv msl)**	**Latitude**	**Longitude**
39519	15.78	2333	48 46 03.	118 39 23.



Station Information

CURFE1

Primary Station	Station # 1	latitude: 48 44 52.0	longitude: 118 39 48.0
	Description:	Deep site: Center of basin north of Fisherman's Cove and Tiffany's Resorts.	
Secondary Station	Station # 2	latitude: 48 44 47.0	longitude: 118 40 05.0
	Description:	Deep spot just north of the first island south of site 1.	

Trophic State Assessment for 1999

CURLEW

Analyst: Sarah O'Neal

TSI_Secchi: [a]	37
TSI_Phos:	47
TSI_Chl:	41
Narrative TSI: [b]	M

Curlew Lake is a large, deep lake with a steep shoreline. Its location in a sizeable watershed increases its susceptibility to anthropogenic eutrophication. In fact, practices throughout the watershed appear to have lead to a decline in the water quality of the lake. While clarity remained exceptionally high, excessive nutrients led to dense plant and algae growth which occasionally interfered with the lake's uses. Frequent algae blooms occurred throughout the summer. The relatively large body size of algae species may explain good transparency in spite of high chlorophyll and phosphorus levels. Plants grew densely, which is unusual in lakes with steep sides and a consequently reduced littoral zone. Dense macrophytes led to herbicide applications in 1988 and 1989 to control particularly weedy species. By 1999, however, those species again dominated the lake. Washington State University studied nutrient sources in Curlew Lake. The study implicated faulty septic tanks, livestock grazing in the watershed, fertilizer application, excessive plants, waterfowl, precipitation, groundwater, surface runoff, and past timber practices in the problem. Findings from the watershed survey agreed with these results. High total phosphorus levels in the hypolimnion also indicated internal loading, in which phosphorus is released from sediments into the water column. This often occurs when dissolved oxygen is absent near the lake bottom, as clearly indicated by the Hydrolab profile data. Anoxia also often leads to hydrogen sulfide near the bottom of the lake, causing an offensive, "rotten-egg" smell about which residents complained.

The lake supported a wide variety of uses. Survey respondents indicated fishing as the primary activity, with relaxing and canoeing/kayaking as other important interests. However, site visits to the lake and surveys also revealed water-skiing, swimming, picnicking, hunting, and bird watching as popular activities. Survey respondents indicated a desire for clearer water, as well as boat speed limits. Coldwater fish composed the majority of Curlew's fishery. WDFW primarily managed the lake for rainbow trout. About 200,000 rainbow trout were released each year. Sixty-thousand of those were released annually from a cooperative net pen on the lake. Approximately 40% of tagged rainbow trout released from the net pen returned, indicating an unusually good utilization of most fish. Trout prefer at least 4.5mg/L dissolved oxygen and water temperatures below 20 degrees Celsius, which limits their range in Curlew Lake to depths of six to sixteen feet during the summer. The dominance of smaller zooplankton suggested an ineffective amount of predators to suppress planktivore density. Tiger muskies were additionally stocked in the lake in an attempt to control an oversized northern pike minnow population. Known warmwater game species in the lake consisted only of largemouth bass.

While uses were supported for most of the year, there were two to three weeks annually during which quality was impaired enough to affect many lake activities. This generally resulted from particularly dense algae blooms. Consequently, we suggest implementation of appropriate best management practices throughout the watershed. We recommend a total phosphorus criterion of 20 ug/L, the action value for Northern Rockies lower mesotrophic lakes. This criterion will likely be exceeded during some years. Ferry County may want to consider adopting boat speed limits in certain areas or during certain times of day.

Mean Secchi = 4.9m; Mean TP = 19.3 ug/L; Mean Chl = 2.8 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

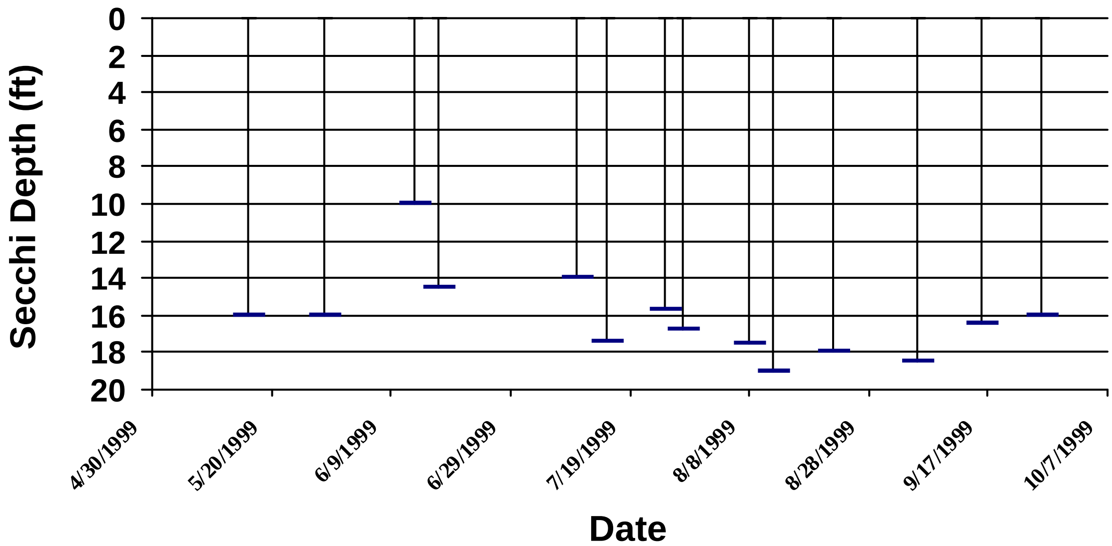
CURLEW

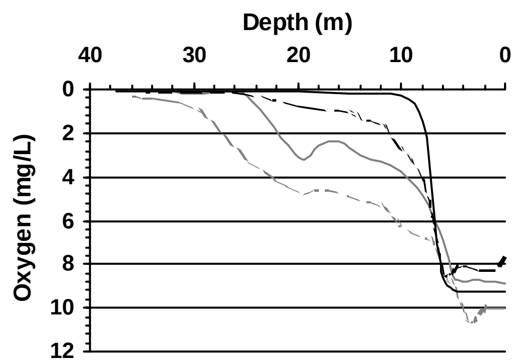
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 1										
6/17/1999		E	23.7	.35	15	3.5		116	32400	.6 J
		H	116	.535	5					
7/15/1999	0900	E	10.5	.369	35	1.93				.8
		H	135	.624	5					
8/12/1999	0900	E	16.3	.392	24	2.5				.6
		H	190	.634	3					
9/16/1999		E	22.2	.358	16	2.9				.6
		H	228	.691	3					
Station 2										
6/17/1999		E	22.9	.326	14	3.7				
7/15/1999	1000	E	13	.375	29	2.13				
8/12/1999	1015	E	14.4	.372	26	2.5				
9/16/1999		E	22	.397	18	3.1				

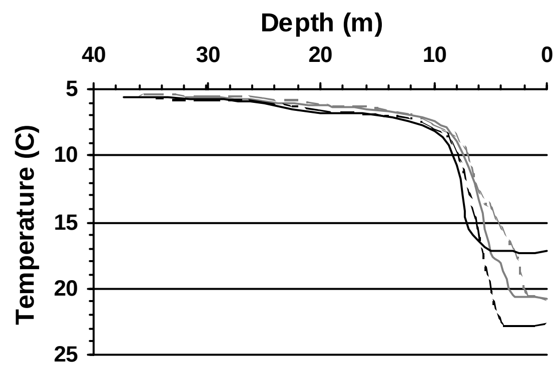
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

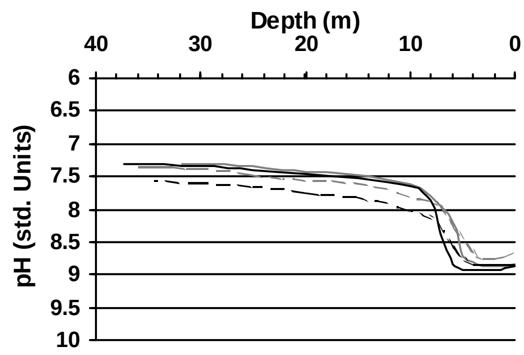
Secchi Depth and Profile Graphics

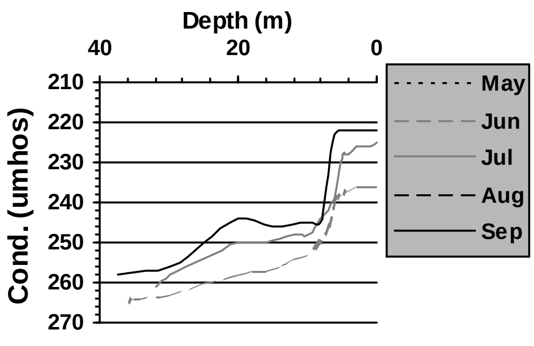
Station: 1 CURFE1











Secchi Data and Field Observations

CURLEW

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
5/16/1999		39	16	2	100	2	5	5	5	25	3	7	0
	Sampler:	PERRY		Remarks:	Used a view tube on the second Secchi reading but not on the first. Cloudburst and hail yesterday. Showers most of the week, sprinkling off and on today.								
5/29/1999		44	16	6	0	1	1	4	4	4	8	7	0
	Sampler:	PERRY		Remarks:	Used a view tube on the second Secchi reading but not the first. Lake has floating algae mats. Saw two live "Anadonta californicus" clams today!								
6/13/1999		48	10	6	100	3	1	4	3	6	10	3	0
	Sampler:	PERRY		Remarks:	Used a view tube on the second Secchi reading but not the first Secchi reading. Aesthetic enjoyment affected by floating algae mats. Thermometer not functioning - fluid has separated. Distrust at least the last two readings.								
6/17/1999		68	14.5	6	5	1	1	3	2	15	5	7	
	Sampler:	PERRY		Remarks:									
7/10/1999		69	14	6	0		1	4	3	0	5	12	0
	Sampler:	PERRY		Remarks:	First Secchi reading taken without a view tube, second Secchi reading is with a view tube. Weed mats in shallows. Geese feed here in afternoon - I sample in the morning.								
7/15/1999			17.4	6	60	2	1	4	4	2	20	8	2
	Sampler:	HALLOCK		Remarks:	Bottom: 31.8M. P. crispus appears to be getting worse. Oxygen < 5 @ 8M, ~0 @ 25M. Some zoopl. and no H2S smell, even at 25M								
7/25/1999		68	15.75	6	50	1	2	4	4	0	2	2	0
	Sampler:	PERRY		Remarks:	First Secchi reading without a view tube, second Secchi reading with view tube.								
7/28/1999			16.73										
	Sampler:	Parsons		Remarks:									
8/8/1999		72	17.5	6	100	3	5	3	4	0	2	1	0
	Sampler:	PERRY		Remarks:	First Secchi reading without a view tube, second Secchi reading with a view tube.								
8/12/1999			19	6	90	1	1	4	3	8		6	3
	Sampler:	PERRY		Remarks:	Bottom: 34.5M. Algae specks clearly visible throughout water column. According to volunteer, there didn't used to be nesting geese on the lake, but now are about 50 goslings/year and people are beginning to perceive them as a problem.								
8/22/1999		68	18	6	0	1	1	4	4	0	0	3	0
	Sampler:	PERRY		Remarks:	First Secchi reading without a view tube, second Secchi reading with a view tube.								

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
9/5/1999		64	18.5	6	75	2	1	4	4	0	2	4	0
	Sampler: PERRY			Remarks: First Secchi reading without a view tube, second Secchi reading is with a view tube.									
9/16/1999			16.4	3	50	1	1	2	2	12	30	6	
	Sampler: PERRY			Remarks: Bottom: 37.6M. Aphanizomenon bloom moderate to severe. Took zebra mussel veliger sample from state park pier.									
9/26/1999		60	16	6	50	1	1	4	4	4	11	5	0
	Sampler: PERRY			Remarks: First Secchi reading taken without a view tube, second Secchi reading is taken with a view tube. Fewer clumps than last time. Lake height taken one week later than rest of data. One brief rain shower in week. The Conductivity result is qualified as an estimate due to postcalibration failing QA/QC requirements.									
Station 2													
6/17/1999			14										
	Sampler: PERRY			Remarks:									
7/15/1999			17.1	6	35	2	1						
	Sampler: HALLOCK			Remarks: Bottom: 32.5M. Site 2 is just north of Dammann's (now Perry's) island.									
8/12/1999			20.34	6									
	Sampler: PERRY			Remarks: Bottom: 28.2M									
9/16/1999			15.1	3									
	Sampler: PERRY			Remarks: Bottom: 32.2M.									

DEER

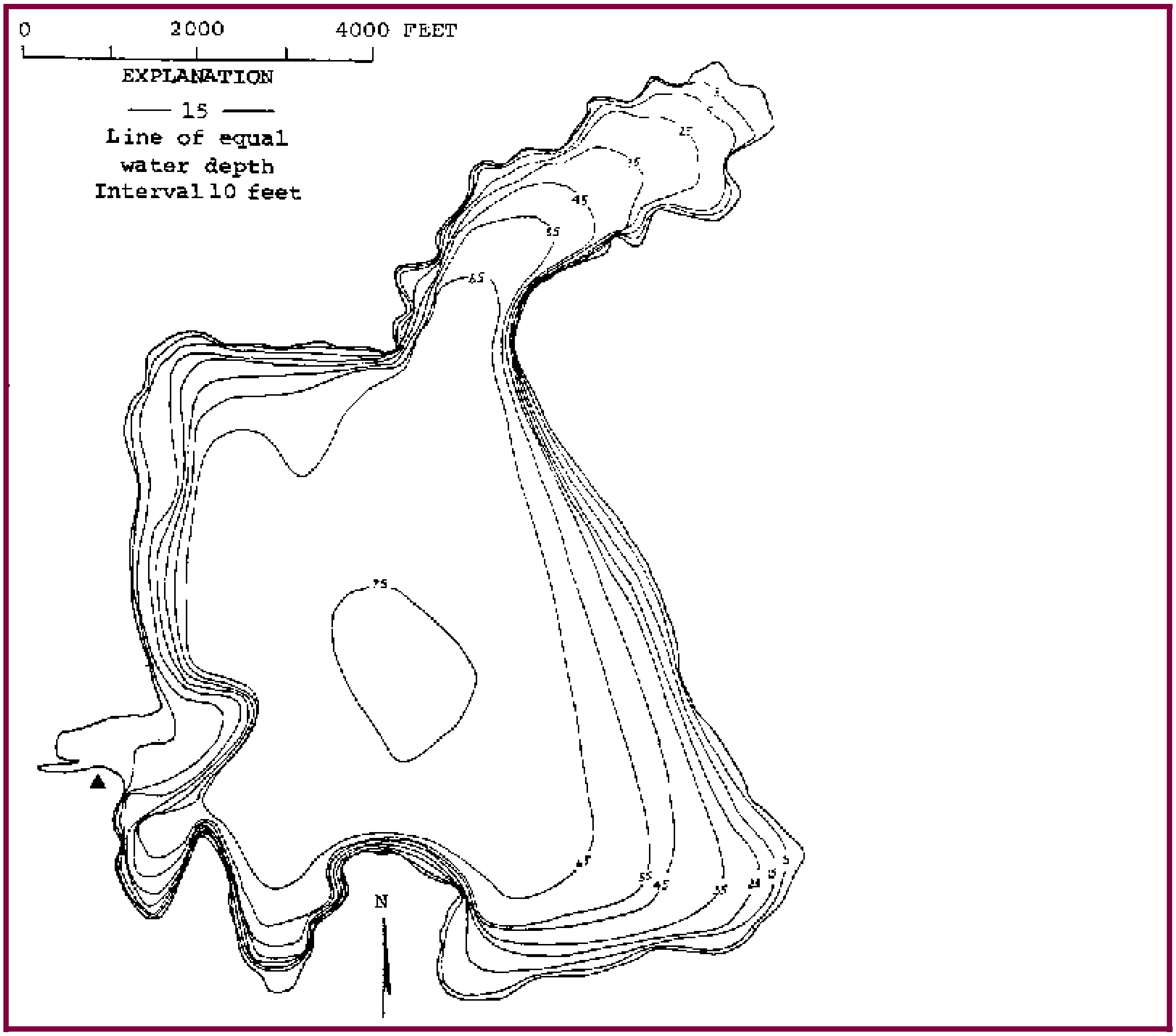
STEVENS County

Lake ID: DEEST2

Ecoregion: 8

Deer Lake is located approximately 25 miles northwest of Spokane, just east of Highway 395.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
1110	75	52	18	
Volume (ac-ft)	*Shoreline (miles)*	*Altitude (ft abv msl)*	*Latitude*	*Longitude*
57000	8.62	2474	48 06 28.	117 36 18.



Station Information

DEEST2

Primary Station	Station # 1	latitude: 48 06 25.0	longitude: 117 35 24.0
	Description: At the deep spot.		
Secondary Station	Station # 2	latitude:	longitude:
	Description: Near the end of the arm at the north end of the lake.		

Trophic State Assessment for 1999

DEER

Analyst: Sarah O'Neal

TSI_Secchi: [a]	29
TSI_Phos:	48
TSI_Chl:	32
Narrative TSI: [b]	OM

Deer Lake is a large, deep lake which displayed many oligotrophic characteristics. Exceptional water clarity in the lake and low chlorophyll-a concentrations indicated little photosynthetic activity. Plants, mostly submerged, grew at moderate densities. No noxious weeds occur in the lake, though milfoil was present in nearby Loon Lake. Algal blooms occurred occasionally, but were not excessive. However, surprisingly high total phosphorus concentrations indicated a high mesotrophic state. Nitrogen limitation may explain why the mean Secchi depth and chlorophyll concentrations were lower than mean total phosphorus concentrations would indicate. Several potential nutrient sources existed in and around the lake. Approximately 600 homes, 450 of which were occupied year round, densely surround the shoreline. These homes were all on individual septic tanks until a sewer was built in 1992. Sparse vegetation around the shoreline resulted largely from development, with either buildings or lawns often extending up to the water's edge. This allowed runoff from the surrounding watershed to more easily enter the lake, including fertilizers used for lawn maintenance. Furthermore, cattle grazed up to and in the inlet to Deer Lake. Fencing cattle out of the lake, which occurred for the first time in 1999, may improve nutrient levels over time. Finally, logging occurred within the surrounding watershed. As well as high total phosphorus levels, one sample taken in August near the boat launch indicated a high fecal coliform concentration. The source of contamination is unknown, but possible sources include stormwater runoff, goose and animal access, and swimmers.

Questionnaire respondents indicated relaxing as their primary activity on the lake. Other uses included fishing, swimming, skiing, and boating. Questionnaire respondents indicated water quality, scenic views, fishing quality, and swimming opportunities added to the enjoyment of the lake and facilitated relaxing. WDFW managed the lake for eastern brook trout, rainbow trout, mackinaw (lake trout), and kokanee. They planted approximately 20,000 rainbow trout annually at a catchable size. Two-hundred-fifty-thousand small kokanee fry were planted between 1998 and 1999. Generally, kokanee exhibited little positive return. Kokanee that survived grew to a healthy size despite high mortality. In addition to the hatchery fish, there were two net pens on the lake. One contained rainbow trout and the other contained eastern brook trout. They each raised and released about 15,000 fish annually. Other species in the lake included yellow perch, sunfish, bullhead, large- and smallmouth bass, black crappie, and pumpkinseed. Zooplankton were exceptionally small considering the diversity of the fishery, which may indicate an ineffective amount of piscivores to control planktivore density.

Three of four earlier Ecology water quality surveys of the lake, from 1989-1992, indicated an oligotrophic state, with low total phosphorous levels ranging from 7 to 17 ug/L. Due to this, the dense development around the lake, and watershed uses, the oligomesotrophic state of the lake may not be natural. Consequently, we recommend an interim total phosphorus criterion of 20 ug/L, the action value for Northern Rockies lower mesotrophic lakes, pending a more thorough study, including a nutrient budget analysis. Phosphorus concentrations exceeded this criterion in 1999. Future studies will likely recommend lowering this criterion. Due to the limitations of the sampling conducted during this study, it is difficult to determine whether nitrogen is also limiting to the system. Future studies may propose a nitrogen criterion.

Mean Secchi = 8.7m; Mean TP = 21.4 ug/L; Mean Chl = 1.2 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

DEER

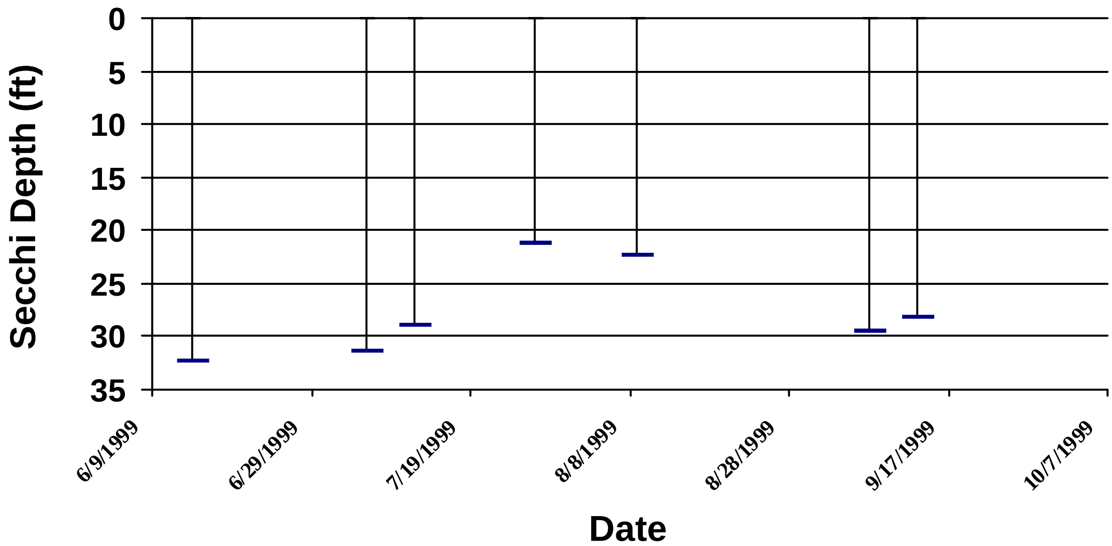
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
6/14/1999		L					1 U			
		L					1			
7/12/1999		L					1 U			
		L					33			
8/9/1999		L					5			
		L					160			
9/13/1999		L					3			
		L					1 U			
Station 1										
6/14/1999		E	23.5	.25	11	.97		32.5	8920	.5
		H	26.7	.237	9					
7/12/1999		E	7.77	.301	39	1.71				.5
		H	21.3	.28	13					
8/9/1999		E	22.8	.288	13	1.1				.6

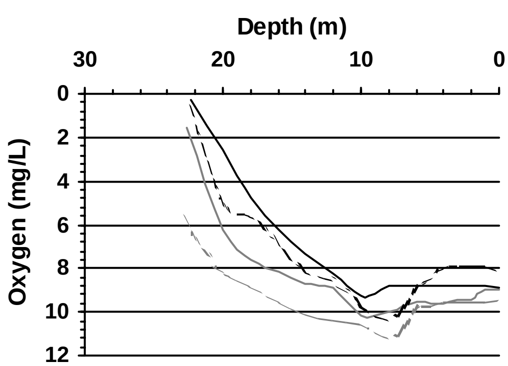
	H	21.7	.261	12		
9/13/1999	E	26.3	.253	10	1.2	.5 U
	H	34.8	.231	7		

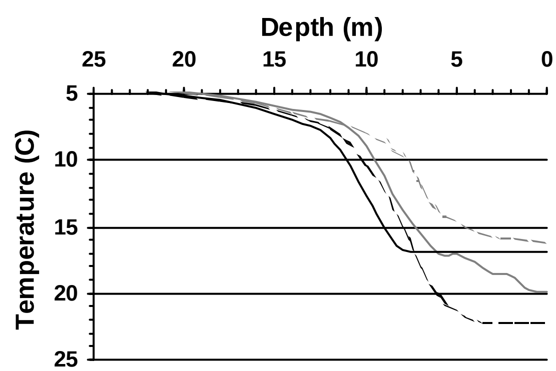
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

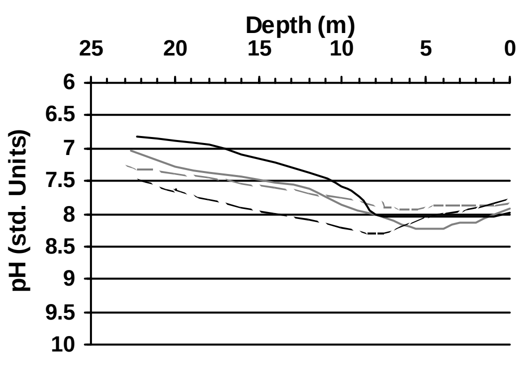
Secchi Depth and Profile Graphics

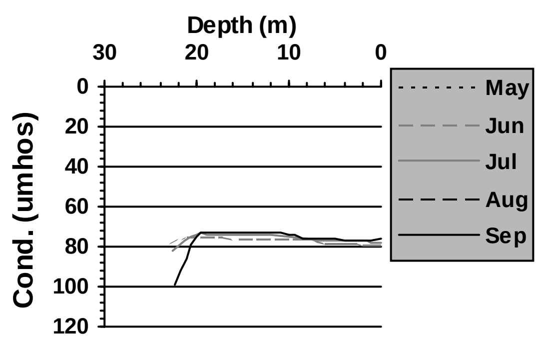
Station: 1 DEEST2











Secchi Data and Field Observations

DEER

Date	Time	Temperature (F)	Secchi (ft)	Color (1-greens, 11-browns	Brightness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/14/1999		17	32.4	6	10	1	1	5	5	0	22	10	0
	Sampler: PHILLIPS			Remarks: Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements									
7/6/1999		18.5	31.5	2	0	1	5	5	5	0	3	3	1
	Sampler: PHILLIPS			Remarks: Did not use a view tube. Some Fourth of July fireworks debris.									
7/12/1999			28.9	6	0	1	1	5	5	0	30	8	0
	Sampler: PHILLIPS			Remarks: Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.									
7/27/1999		22	25	2	0	1	1	5	5	0		2	2
	Sampler: PHILLIPS			Remarks:									
7/27/1999			21.33										
	Sampler: Parsons			Remarks:									
8/9/1999			22.3	2	0	1	1	5	4	0	30	7	1
	Sampler: PHILLIPS			Remarks: Bottom: 22.4M. Vol. Reports 8-9 year flushing time (source: Soltero, EWU). Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.									
9/7/1999		19	29.5	2	0	2	1	5	5	0	6	3	0
	Sampler: PHILLIPS			Remarks: Did not use a view tube.									
9/13/1999			28.2	2	1	1	1	4	4	0	70	6	1
	Sampler: PHILLIPS			Remarks: Bottom: 22.3M. Waterfowl are mostly seagulls and grebes.									
Station 2													
7/6/1999		18	26.5	2	0	1	1	5	5	0	2	3	0
	Sampler: PHILLIPS			Remarks: Did not use a view tube.									
7/27/1999		21.5	20	2	0	2	1	5	5	0		3	1
	Sampler: PHILLIPS			Remarks: Did not use a view tube. Hot weather.									
9/7/1999		18	27	2	0	2	1	5	5	0	4	1	0
	Sampler: PHILLIPS			Remarks:									

DESIRE

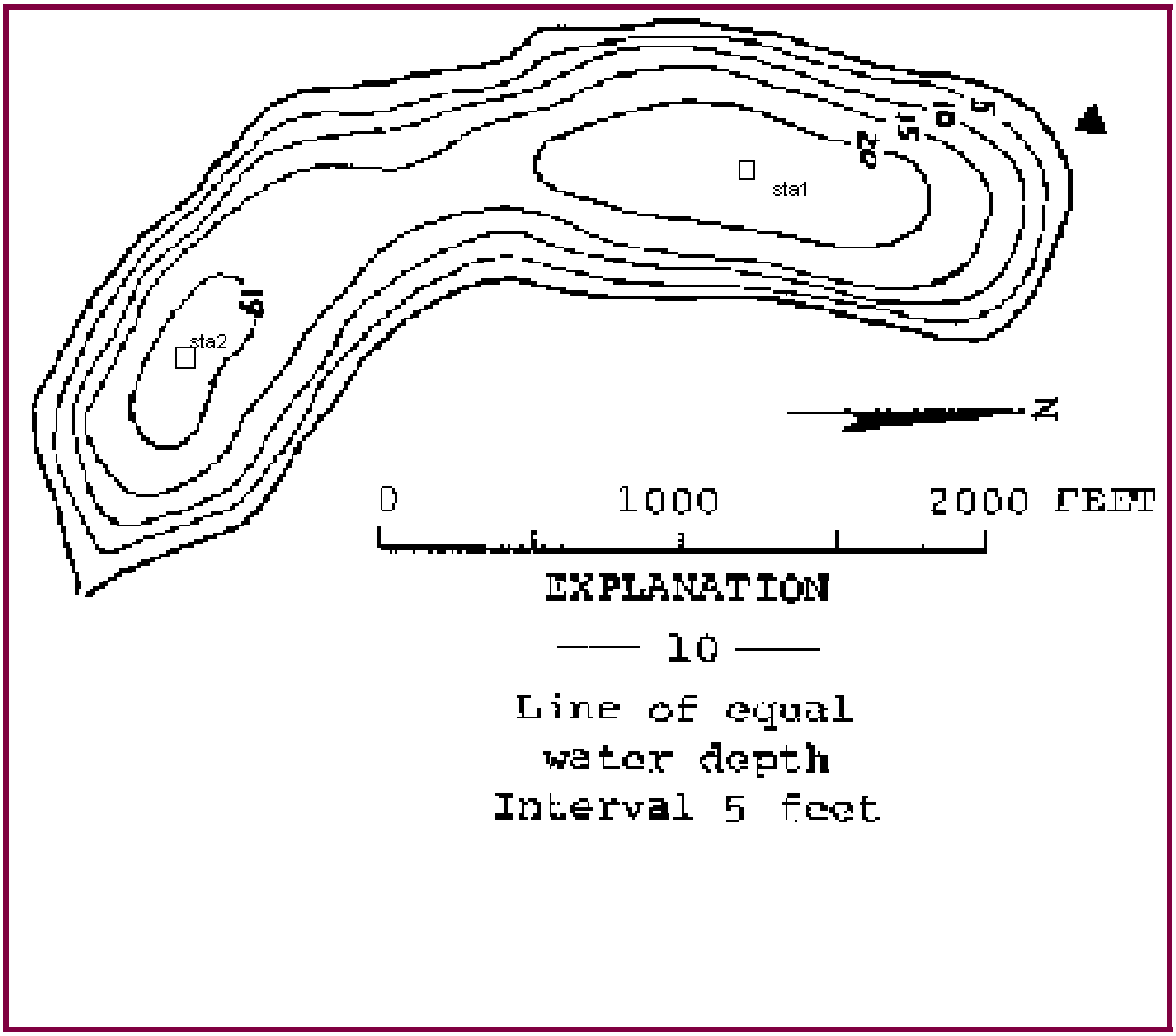
KING County

Lake ID: *DESKI1*

Ecoregion: 2

Lake Desire is located approximately five miles southeast of Renton. It is less than a mile long. It is fed only intermittently, and has no outflow.

Area (acres)	***Maximum Depth (ft)***	***Mean Depth (ft)***	***Drainage (sq mi)***	
71	21	13	1	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
933	1.65	500	47 26 14.	122 06 09.



Station Information

DESKI1

Primary Station	Station # 1	latitude: 47 26 36.0	longitude: 122 06 21.7
	Description: Deep site. In the middle of the lake, approximately 1000 feet south of northern shore.		
Secondary Station	Station # 2	latitude: 47 26 20.1	longitude: 122 06 13.8
	Description: In south end of lake, approximately 750 feet northwest of southeast tip.		

Trophic State Assessment for 1999

DESIRE

Analyst: Sarah O'Neal

TSI_Secchi: [a]	50
TSI_Phos:	50
TSI_Chl:	58
Narrative TSI: [b]	ME

Lake Desire is a little, shallow lake located in a small watershed in a relatively urban setting. Total phosphorus was consistently higher in the hypolimnion than in the epilimnion, and dissolved oxygen concentrations quickly dropped to zero at depths of three to four meters. This indicates nutrient loading in which phosphorus is released from sediments into the water column. Low dissolved oxygen also leads to hydrogen sulfide near the bottom of the lake, causing an offensive, "rotten-egg" smell noted in water samples in August. Secchi readings decreased steadily throughout the summer. Accordingly, chlorophyll-a concentrations also increased throughout the summer. Algae blooms probably caused the decrease in water clarity. Residences constitute the majority of the watershed. Dense residential areas are the likely cause of a number of Canada geese inhabiting the lake. Geese use manicured lawns as habitat. Best management practices observed in the watershed included sediment fences at construction sites, and buffer zones around wetlands and streams. The lake shoreline was surprisingly natural, considering the urban setting of the lake. It was moderately vegetated, however, purple loosestrife (Lythrum salicaria), a noxious wetland plant, grew densely around the lake. Lawns, docks, boats, and buildings made up the majority of human influence on the lake.

Only one visitor to the lake completed a questionnaire. The respondent suggested that poor water quality for swimming, the density of plants, and Canada geese detracted from enjoyment of the lake. The respondent indicated fishing as a primary activity, stating that fishing is particularly good in the lake. According to a 1999 WDFW survey, officials historically managed Lake Desire as a trout fishery, and rehabilitated it with rotenone in 1968 and 1972 to remove introduced warmwater sport fish. After that, however, the lake was managed as a mixed species fishery for annually stocked rainbow and cutthroat trout as well as warmwater species. In 1999, largemouth bass and pumpkinseed dominated the fishery in the lake. Other warmwater fish in Lake Desire included bluegill, yellow perch, and brown bullhead. Rainbow trout were the most abundant salmonid in the lake, and cutthroat trout were also present. WDFW found three coho salmon in the lake in 1999. Inadequate hypolimnetic dissolved oxygen concentrations provided little habitat in the lake for coldwater species, though surface water temperatures were not excessive. Average size of zooplankton decreased noticeably during the summer. This suggests a possible ineffective amount of piscivores to suppress planktivore density.

The meso-eutrophic state of the lake apparently supported primary uses of the lake, especially fishing. Consequently, we recommend a total phosphorus criterion for the lake of 29.8 ug/L (mean 24.3 ug/L plus standard deviation of 5.5 ug/L).

Mean Secchi = 2.0; Mean TP = 24.3 ug/L; Mean Chl = 16.9 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

DESIRE

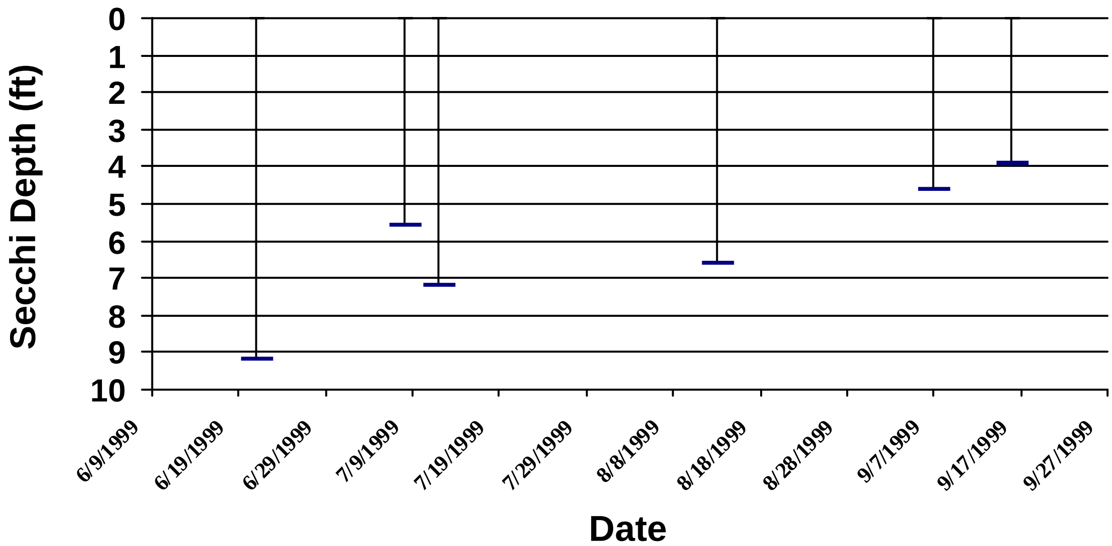
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
6/21/1999		L					6			
		L					22 J			
Station 1										
6/21/1999		E	21.6	.372	17	7.9		23	5470	1.3
		H	55.9	.374	7					
7/12/1999		E	21.2	.468	22	10.7				1.5
		H	240	.793	3					
8/13/1999		E	27.5	.475	17	22.5				1.4 J
		H	65.9	.497	8					
9/16/1999		E	26.7	.601	23	25.7				
		H	73.7	.384	5					
Station 2										
6/21/1999		E	22.3	.419	19	10.9				
7/12/1999		E	21.4	.489	23	9.91				
8/13/1999		E	28.2	.496	18	17.6				
9/16/1999		E	31.3	.716	23	37.6				

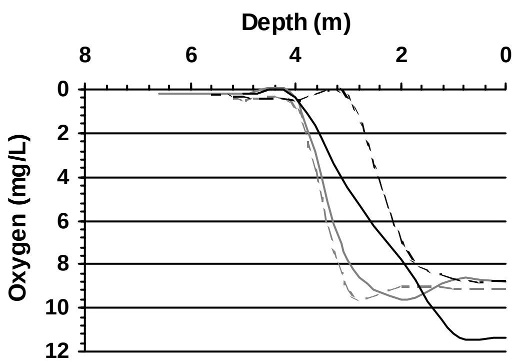
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

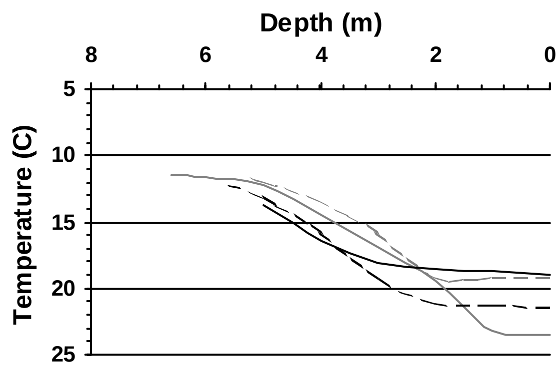
Secchi Depth and Profile Graphics

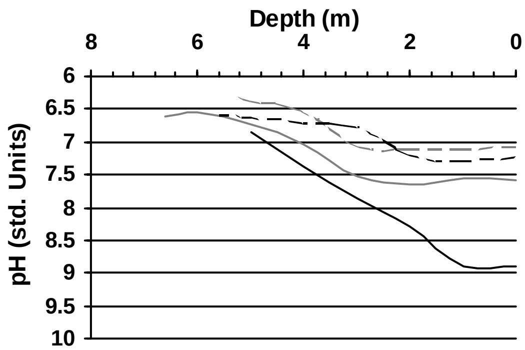
Station: 1

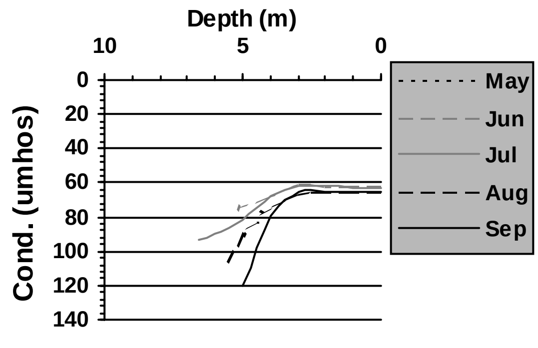
DESKI1











Secchi Data and Field Observations

DESIRE

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/21/1999			9.2	7	0	3	1	5	2	38	3	0	0
	Sampler: SMITH			Remarks: None									
7/8/1999			5.6										
	Sampler: Parsons			Remarks:									
7/12/1999			7.22	8	0	2	1	5	5	30	1	0	0
	Sampler: SMITH			Remarks: None									
8/13/1999			6.6	7	100	1	1	5	4	0	0	0	0
	Sampler: SMITH			Remarks: Strong H2S at 5 meters.									
9/7/1999			4.6										
	Sampler: Parsons			Remarks:									
9/16/1999			3.94	3	100	1	1	5	2	0	3	1	0
	Sampler: SMITH			Remarks: Heavy algal bloom									

DUCK

GRAYS HARBOR County

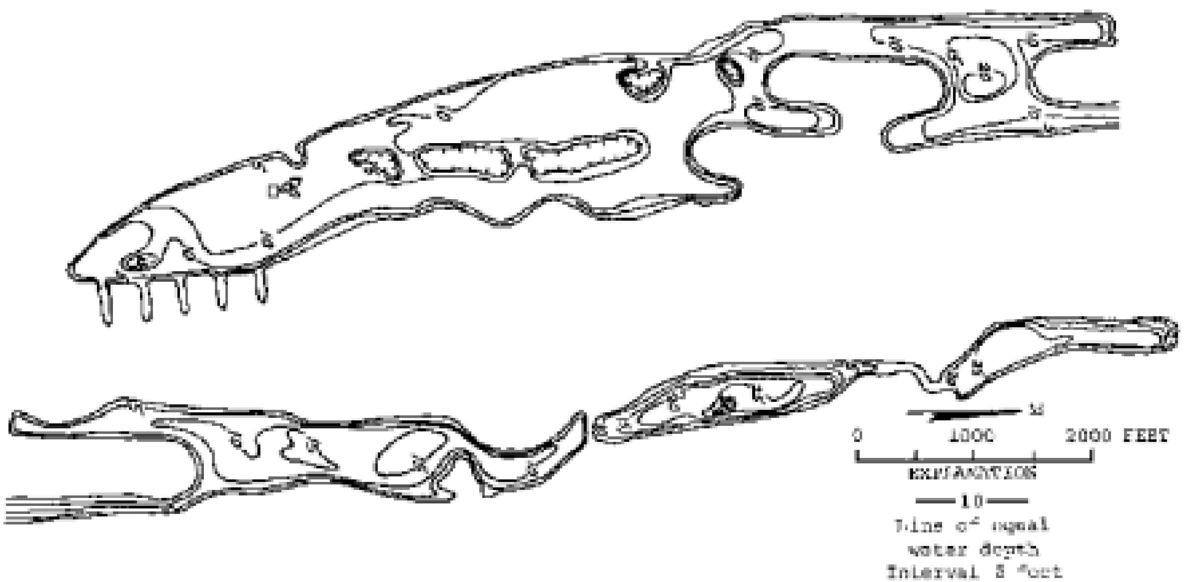
Lake ID: DUCGR1

Ecoregion: 1

Duck Lake is a reservoir just east of the resort city of Ocean Shores. It consists of a series of canals lined with residential homes. At nearly sea level and so close to the ocean, Duck Lake provides a protected haven for many shore birds and other waterfowl.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*
278	30	11	1

Volume (ac-ft)	*Shoreline (miles)*	*Altitude (ft abv msl)*	*Latitude*	*Longitude*
3000	11.3	10	46 57 33.	124 08 12.



Station Information

DUCGR1

Primary Station	Station # 1	latitude: 46 59 42.5	longitude: 124 08 43.2
	Description:	Deep site. One 'basin' south of northernmost basin of lake. Approximately 1500 feet south of bridge, near east shore.	
Secondary Station	Station # 3	latitude: 46 57 48.4	longitude: 124 08 20.0
	Description:	In southernmost portion of lake, about 2000 feet north of southern tip, and about 400 feet southeast of a major point jutting out into water on west shore.	

Trophic State Assessment for 1999

DUCK

Analyst: Sarah O'Neal

TSI_Secchi: [a]	61	J
TSI_Phos:	57	
TSI_Chl:	61	
Narrative TSI: [b]	E	

Duck Lake is a shallow, densely developed lake in Ocean Shores. Dredging and filling expanded the lake in the early 1960s to create land suitable for development. This led to a disproportionate amount of shoreline relative to a small lake area. It additionally allowed for an overwhelming amount of development on the lakeshore. This development likely led to high nutrient levels, typical of an eutrophic system. The lake did not exhibit increasing nutrient loading in 1999. In fact, nutrients were much lower than in a 1990 Ecology study, perhaps due to the creation of a municipal sewer system in the City of Ocean Shores, though most survey respondents reported a decline in water quality. At the time of sampling, the most significant problems in the lake resulted from dense plant and algae growth. Two non-native noxious weeds, Brazilian elodea (Egeria densa), and Eurasian watermilfoil (Myriophyllum spicatum) grew in the lake. The Brazilian elodea, in particular, dominated the plant community to the exclusion of other submerged species in many areas of the lake. Algae also grew densely throughout the summer. Both Diquat and copper sulfate were used to control plant and algae growth in the late 1980s, and an Aquatic Plant Management Plan was developed in 1994 which involved mechanical harvesting, grass carp planting, and hand removal of plants. Unfortunately, these methods appear to us to have had little affect. Dense vegetation surrounds the shoreline. Fortunately, native reeds dominated the shoreline plant community, providing some buffer between lawns and lake water, as well as a barrier to boat wakes.

Twenty-one visitors and residents completed the questionnaire. They indicated types of watercraft, water quality, plants, and swimming opportunities all impaired enjoyment of the lake. Two respondents specifically mentioned a desire to restrict personal watercraft. Primary uses among respondents included fishing, canoeing, kayaking, and watching wildlife. Respondent comments, site visits, and other studies clearly revealed that water skiing, jetskiing, swimming, and irrigation were among other uses. Fish habitat in the lake consisted mainly of plants, as well as some overhanging vegetation and human structures. Anoxia in the lake bottom, particularly later in the summer, created poor habitat for coldwater fish such as trout, though surface waters were not excessively warm. The zooplankton community, however, decreased in average size over the course of the summer, indicating utilization by planktivores and possibly inadequate numbers of piscivores. According to WDFW, poor water quality in Duck Lake limited its fishery to primarily warmwater species including largemouth bass, black crappie, bluegill, and pumpkinseed. Prior to sampling, the lake had not been stocked with trout due to a higher angler demand for bass.

Nutrient levels in the lake were within reasonable ranges considering the lake's wetland origin. In addition, the lake's eutrophic state somewhat supported its primary uses. However, dense plant and algae growth clearly impacted the majority of those uses. Consequently, we recommend a total phosphorus criterion for the lake of 47.2 ug/L (mean 39.3 ug/L plus standard deviation of 7.9 ug/L) as well as continued, perhaps more aggressive, efforts to manage the lake vegetation. Due to the limitations of the sampling conducted during this study, it is difficult to determine whether nitrogen is also limiting to the system. Future studies should investigate the possibility of nitrogen limitation and propose a nitrogen criterion if appropriate.

Mean Secchi = 0.91m; Mean TP = 39.3 ug/L; Mean Chl = 22.0 ug/L; The Secchi TSI is qualified due to duplicate Secchi readings failing to meet quality assurance requirements.

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[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

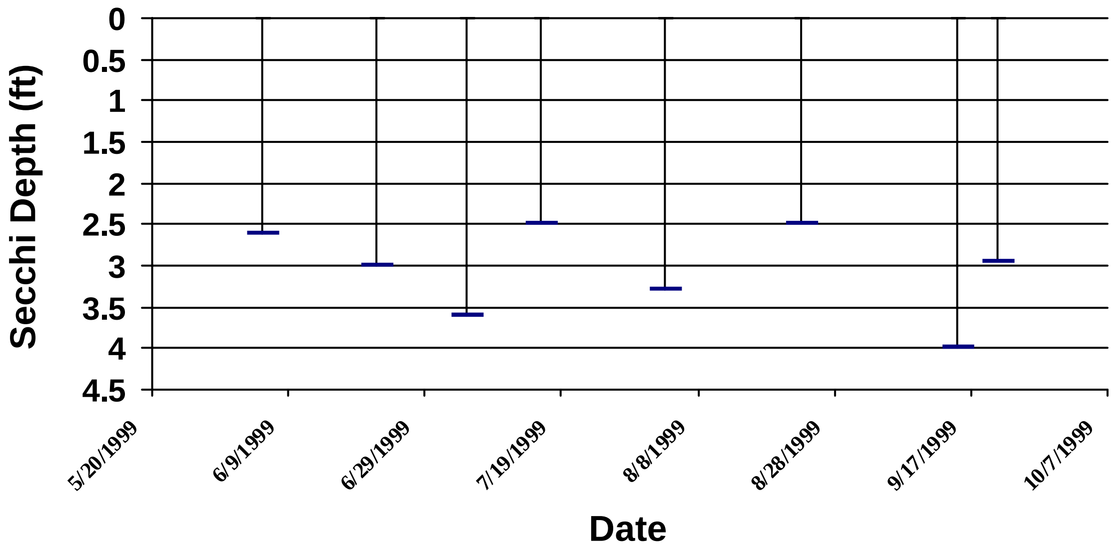
Chemistry Data

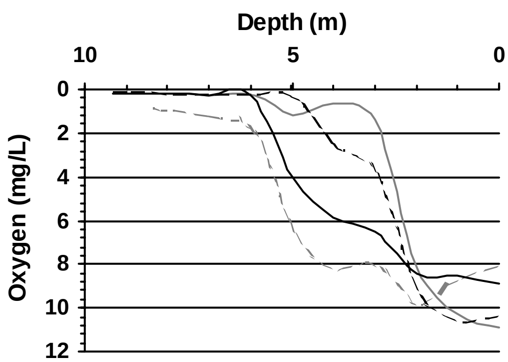
DUCK

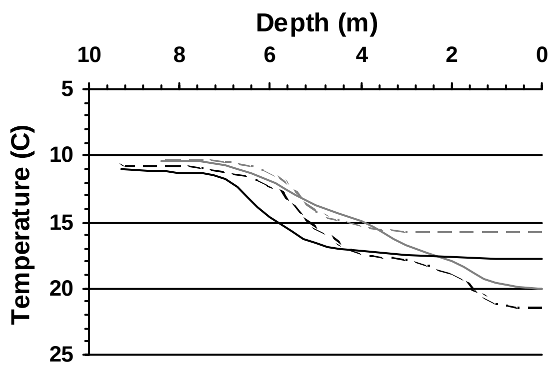
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 1										
6/5/1999		E	66.5	.505	8	15.7				
		H	74.5	.257	3					
7/5/1999		E	45.6	.507	11	45.3				
		H	44.1	.291	7					
8/3/1999		E	35.9	.497	14	18				
		H	37.3	.509	14					
9/15/1999		E	32.5	.439	14	15.7				
		H	37	.612	17					
Station 2										
6/5/1999		E	47.2	.611	13	19.9				
7/5/1999		E	35	.6	17	27.8				
9/15/1999		E	41.7			9.6				

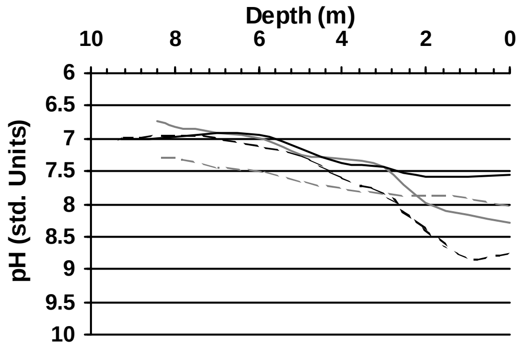
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

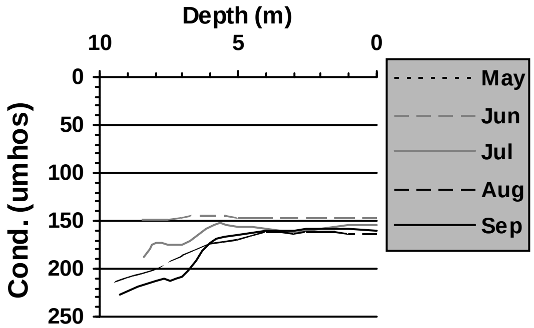
Secchi Depth and Profile Graphics **Station:** 1 DUCGR1











Secchi Data and Field Observations

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/5/1999			2.62	7	50	2	1	4	2	24	1	0	0
	Sampler: SMITH			Remarks: Lots of brownish growth in the water--could be some type of iron bacteria. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.									
6/22/1999		66	3	5	25	2	3	2	1	0	5	0	0
	Sampler: MARCHBANK			Remarks: Did not use a view tube.									
7/5/1999			3.61	7	0	4	1	4	2	0	0	5	5
	Sampler: SMITH			Remarks: Lots of Brazilian elodea fragments in water. Was so thick that the motor started over-heating.									
7/16/1999		64	2.5	5	75	2	1	2	1		4	3	0
	Sampler: MARCHBANK			Remarks: Did not use a view tube. Water color is close to "11", it is very green-brown.									
8/3/1999			3.3	7	0	3	1	5	4	0	1	0	0
	Sampler: SMITH			Remarks: Water very clear compared to the murky iron color seen earlier in the year. Less Brazilian elodea floating around. H2S at 9 meters.									
8/23/1999		67	2.5	5	25	3	1	2	1	0	0	2	0
	Sampler: MARCHBANK			Remarks: Did not use a view tube. Brown water.									
9/15/1999			4	6	100	1	2	5	2	65	8	2	0
	Sampler: MARCHBANK			Remarks:									
9/21/1999			2.95										
	Sampler: Parsons			Remarks:									
Station 2													
6/5/1999			3.3	6									
	Sampler: SMITH			Remarks: Water more green than brown. Bottom covered with Brazilian elodea.									
9/15/1999		65	7	6	100	1	1						
	Sampler: MARCHBANK			Remarks:									
Station 3													
6/22/1999		69	3.5	5	25	2	3	2	1	0	4	1	0
	Sampler: MARCHBANK			Remarks: Did not use a view tube.									

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
7/16/1999		64	4	5	75	2	1	3	2	14		0	0
	Sampler: MARCHBANK			Remarks: Did not use a view tube.									
8/23/1999		70	7	5	25	3	1	3	3	0		1	0
	Sampler: MARCHBANK			Remarks: Did not use a view tube.									

ERIE

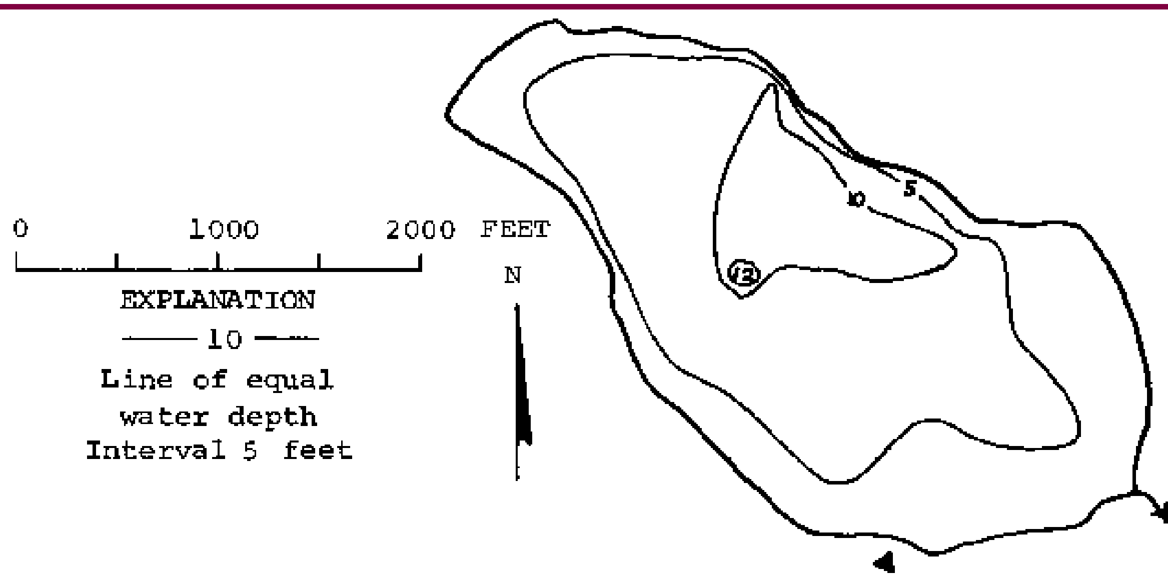
SKAGIT County

Lake ID: ERISK1

Ecoregion: 2

Lake Erie is located approximately three miles south of Anacortes. It is in the upper watershed of Campbell Lake and drains via a small stream and Campbell Lake to Simlik Bay. The abundant macrophytes of this shallow lake are mechanically harvested.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
113	12	6	2	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
711	1.82	140	48 26 59.	122 38 15.



Station Information

ERISK1

Primary Station — Station # 1 — latitude: 48 27 18.5 — longitude: 122 38 27.4

Description: Deep part of lake, about 750 feet west of the northern tip of a small "cove" (very small, really barely a cove), on the western shore.

Trophic State Assessment for 1999

ERIE

Analyst: Sarah O'Neal

TSI_Secchi: [a]	55	W
TSI_Phos:	53	
TSI_Chl:	52	
Narrative TSI: [b]	E	

Erie Lake is a very small, shallow, naturally eutrophic lake. Abundant macrophytes grew in the lake, though the plant community consisted of native and diverse species. Mechanical harvesting throughout the growing season controlled plants for several years. Algae was present, though not particularly problematic in the lake. Secchi measurements decreased over the summer, likely due to increasing algal growth. On one occasion, plants interfered with the Secchi measurement, which caused a slight overestimation of Secchi TSI. Nutrient levels were typical of an eutrophic system. Total phosphorus increased slightly over the course of the summer. Shallow depths prevented stratification. The lake sits in a largely residential watershed, with about twenty houses surrounding the lake itself. The shoreline was mostly natural, and buffers present around streams and wetlands in the watershed likely helped protect water quality.

Unfortunately, no questionnaires were completed for the lake. The lake served as habitat for wildlife including otters and bald eagles. Fishers also heavily used the lake. WDFW managed the lake primarily for rainbow trout. They planted about 15,000 fish each April. Native anadromous cutthroat trout occasionally used the lake, though it requires difficult downstream navigation through Campbell Lake. Warmwater fish species in the lake included large- and smallmouth bass and perch. The fishing season opened from the last Saturday in April through October, and about 2000 anglers regularly visited the lake on opening day alone. Small zooplankton sizes indicated a possible overabundance of planktivorous fish species and an inadequate number of piscivores.

The lake’s presumably natural eutrophic state supported its known beneficial uses. Consequently, we recommend a total phosphorus criterion for the lake of 33.7 ug/L (mean 28.8 ug/L plus standard deviation of 4.9 ug/L).

Mean Secchi = 1.4m (W); Mean TP = 28.8 ug/L; Mean Chl = 8.85 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

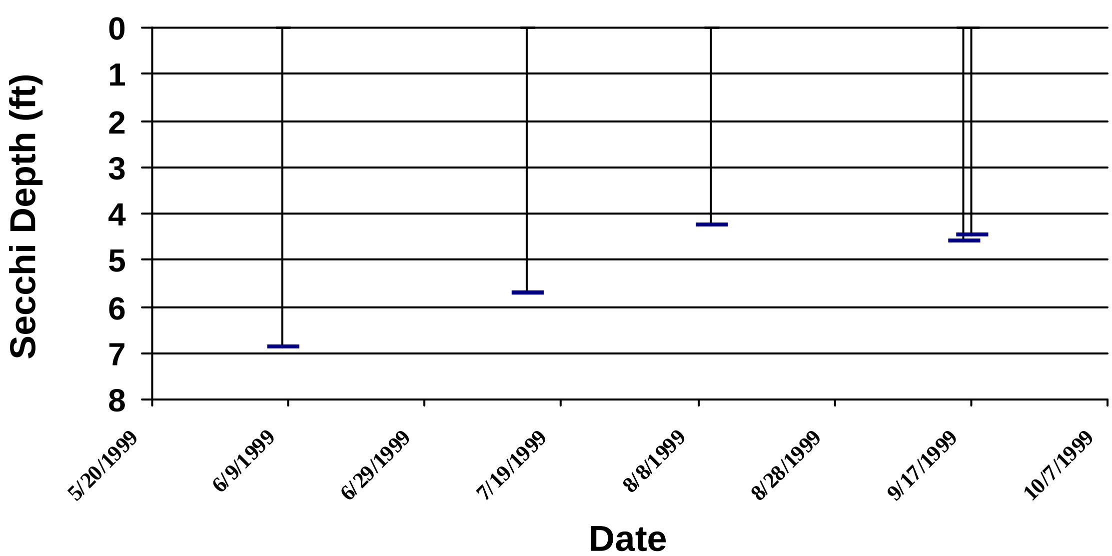
Chemistry Data

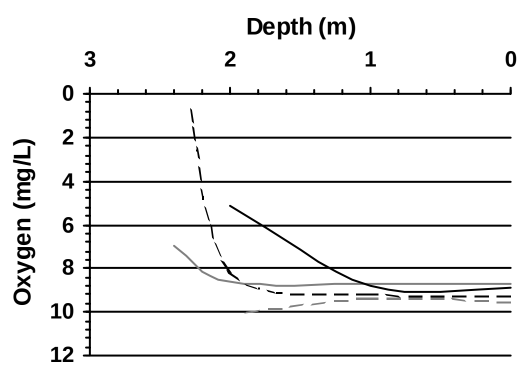
ERIE

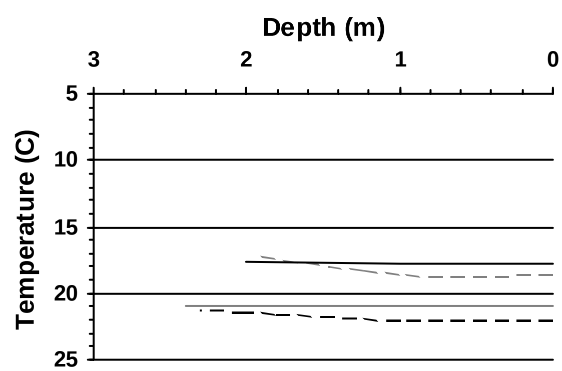
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
6/8/1999		L					2			
		L					5			
7/14/1999		L					12			
		L					1 U			
8/10/1999		L					4			
Station 1										
6/8/1999		E	25.1	.742	30	3.7		78.3	16200	1.2
7/14/1999		E	29.4	.911	31	14.8				2.5
8/10/1999		E	28.2	.877	31	8.8				
9/17/1999		E	32.1	.794	25	9.5				

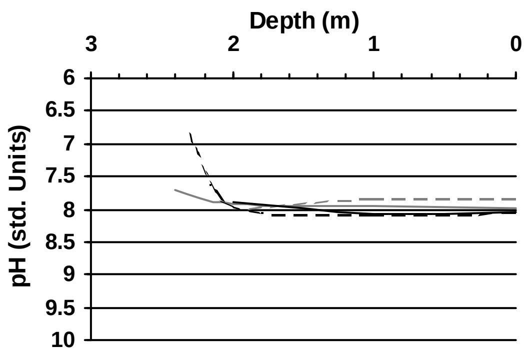
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

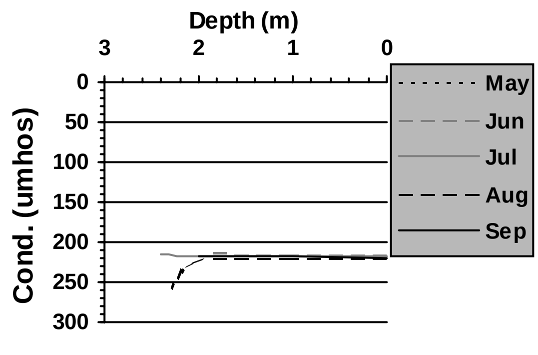
Secchi Depth and Profile Graphics **Station:** 1 ERISK1











Secchi Data and Field Observations

ERIE

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/8/1999			6.89 W		0	1	1	4	2	0	0	0	0
	Sampler:	SMITH		Remarks:	Bottom soft mud and plants (coontail). A bald eagle observed flying overhead.								
7/14/1999			5.74	6	100	4	4	4	1	0	1	0	0
	Sampler:	SMITH		Remarks:	Whole lake covered with plants on the bottom. Shoreline largely natural vegetation.								
8/10/1999			4.26	6	0	1	1	5	2	0	0	0	0
	Sampler:	SMITH		Remarks:	No zooplankton or turbidity taken								
9/16/1999			4.59										
	Sampler:	Parsons		Remarks:									
9/17/1999			4.49	8	100		1	5	2	0	2	1	0
	Sampler:	SMITH		Remarks:	20 homes								

GILLETTE

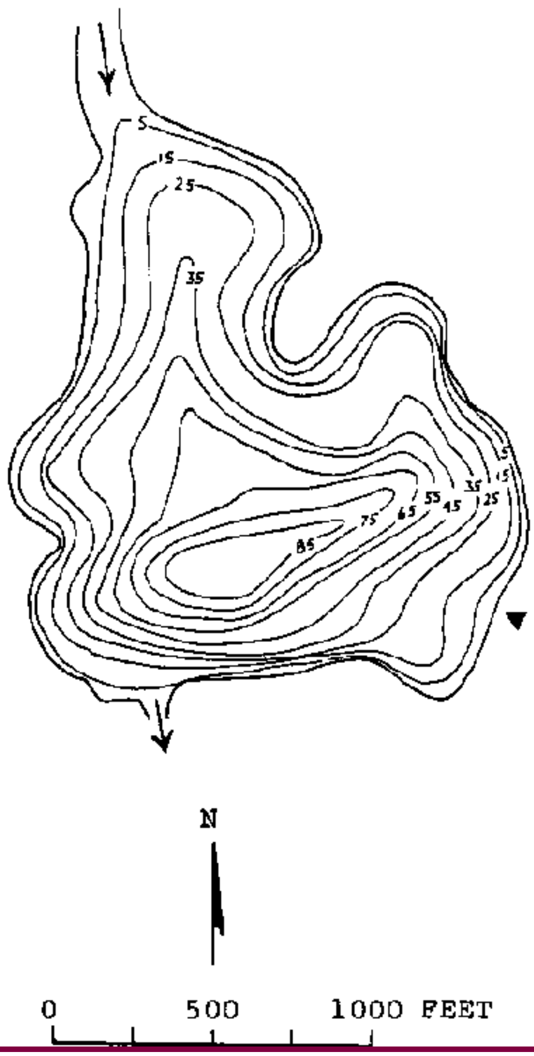
STEVENS County

Lake ID: GILST1

Ecoregion: 8

Lake Gillette is the fourth lake in the Little Pend Oreille chain of lakes. It is located approximately 20 miles northeast of Colville just south of the Pend Oreille County line.

Area (acres)	Maximum Depth (ft)	Mean Depth (ft)	Drainage (sq mi)	
47	85	34	15	
Volume (ac-ft)	**Shoreline (miles)**	**Altitude (ft abv msl)**	**Latitude**	**Longitude**
1600	1.27	3160	48 36 43.	117 32 35.



Station Information

GILST1

Primary Station	Station # 1	latitude: 48 36 42.0	longitude: 117 32 24.0
	Description: Deep site: North and slightly east of outlet to Sherry.		
Secondary Station	Station # 2	latitude: 48 36 50.0	longitude: 117 32 20.0
	Description: Mid-lake on a line between the USFS access and the tip of the pennisula at the north end.		

Trophic State Assessment for 1999

GILLETTE

Analyst: Sarah O'Neal

TSI_Secchi: [a]	38
TSI_Phos:	50
TSI_Chl:	35
Narrative TSI: [b]	M

Lake Gillette is a small, deep lake located in a relatively large drainage. A USFS campground bordered about half of the lake, and the rest was residential. The lake displayed both oligotrophic and mesoeutrophic characteristics. Secchi readings and chlorophyll levels indicated oligotrophy. Good clarity in the lake remained fairly constant throughout the summer. Total phosphorus levels, however, were notably high, at meso-eutrophic levels. TN:TP ratios may be caused by nitrogen limitation, which would explain why the mean Secchi and chlorophyll concentrations were so much lower than mean total phosphorus concentrations would indicate. Chemistry data revealed particularly high phosphorus in the hypolimnion, indicating internal nutrient loading in which nutrients are released from the sediment into the water column. This often occurs with low dissolved oxygen concentrations near the lake bottom, as clearly indicated by the Hydrolab profile data. Low dissolved oxygen also often leads to hydrogen sulfide near the bottom of the lake, causing an offensive, “rotten-egg” smell, and yellow-colored hypolimnetic water, documented throughout the summer. Watershed condition possibly caused the high phosphorus levels in the lake, considering the large size of the watershed relative to the small lake. The primarily residential watershed also contained agricultural, park, forest, and natural land, and a main highway. Several best management practices observed in the watershed included cattle gates and protection from erosion. However, some homeowners around the lake appeared to use fertilizers, which may contribute to higher nutrient levels in the lake. Macrophytes grew fairly densely in the lake, without causing particular problems, however. A 1997 Sonar treatment to control the aggressive, non-native plant, Eurasian watermilfoil (Myriophyllum spicatum) in addition to a 1999 2,4-D treatment possibly reduced plant densities below normal levels. The milfoil subsided since treatment.

No questionnaires were distributed for the lake. During site visits, uses included fishing and water-skiing. The lake appeared both aesthetically pleasing, as well as inviting to swimmers. WDFW managed the fishery for cutthroat trout. They rehabilitated the lake with Rotenone in 1997 in an attempt to curb continued growth of exploding populations of pumpkinseed, sunfish, and yellow perch. Pumpkinseed returned to the lake since the treatment. Five thousand cutthroat yearlings were planted annually in the lake since the treatments.

Despite elevated phosphorus levels, Lake Gillette supported a variety of beneficial uses. Therefore, we recommend a total phosphorus criterion of 27.8 ug/L (mean 23.4 ug/L plus standard deviation of 4.4 ug/L). Due to limitations of the sampling conducted during this study, it is difficult to determine whether nitrogen is also limiting to the system, though this appears likely. Future studies may propose a nitrogen criterion. Consequently, nitrogen applications in the watershed, for example forest fertilization, should be carefully managed.

Mean Secchi = 4.6m; Mean TP = 23.4 ug/L; Mean Chl = 1.6 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

GILLETTE

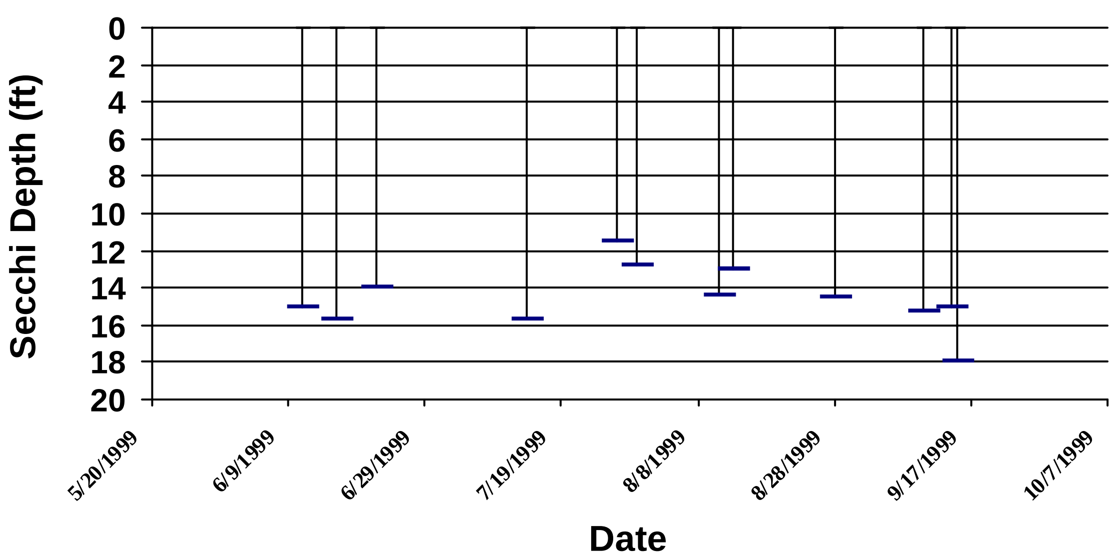
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
6/16/1999		L					4			
		L					3			
7/14/1999		L					5			
		L					5			
8/11/1999		L					2			
		L					6			
9/15/1999		L					1 U			
		L					3			
Station 1										
6/16/1999		E	25.5	.168	7	1.5		19.1	5690	.5
		H	691	3.4	5					
6/22/1999		E	26.3							
7/14/1999		E	23.1	.216	9	1.81				1
		H	269	1.27	5					
8/11/1999		E	22.4	.206	9	1.4				.6
		H	722	3.05	4					
9/15/1999		E	22.1	.193	9	1.7				.5
		H	668	3.9	6					
Station 2										

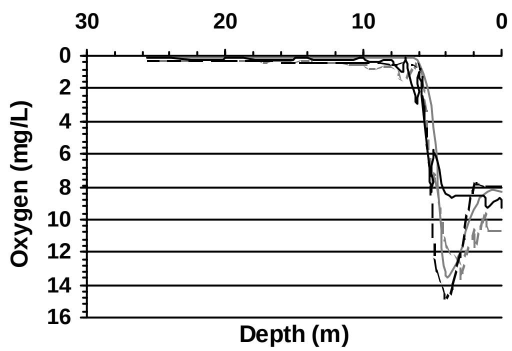
6/16/1999	E	23.2	.182	8	1.2
7/14/1999	E	22.3	.209	9	1.57
8/11/1999	E	23.5	.208	9	1.4
9/15/1999	E	22.8	.192	8	1.8

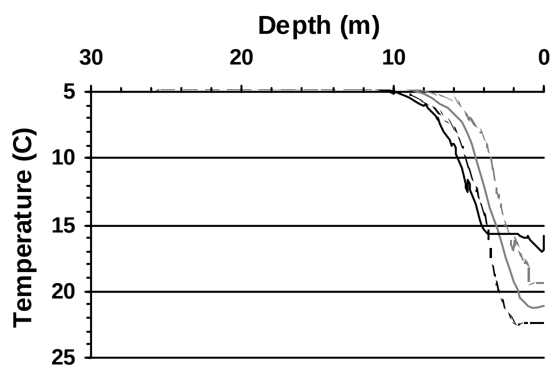
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

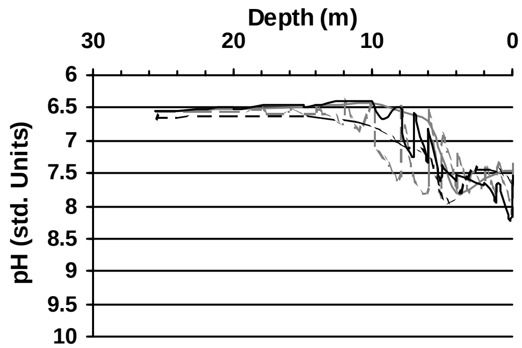
Secchi Depth and Profile Graphics

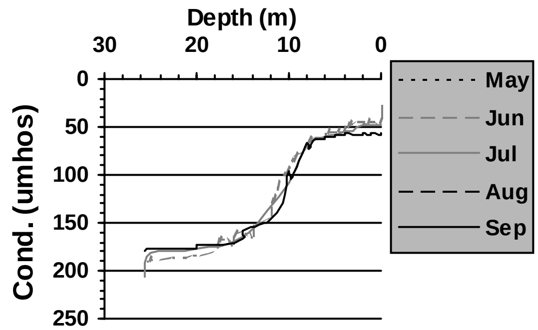
Station: 1 GILST1











Secchi Data and Field Observations

GILLETTE

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/11/1999		62	15	2	25		3	5	5	0	2	3	
	Sampler:	HAWK		Remarks:	Used a view tube.								
6/16/1999			15.7	7	75	1	1	5	4	0	6	2	
	Sampler:	HALLOCK		Remarks:	H2S smell at all hypo depths. Hypo samples yellow. Oxygen dropped to 0.8 @ 6M. Took zooplankton tow from there. About 1/2 of shoreline is USFS campground, remainder is developed.								
6/22/1999		66	14	2	75	2	3	5	5	0	0	2	0
	Sampler:	HAWK		Remarks:	Used a view tube. No algae problems this spring. Only plant problem is Eurasian milfoil. Today's sampling weather was somewhat windy and threatening to rain.								
7/14/1999			15.7	7	5	2	1	5	4	0	9	2	
	Sampler:	HALLOCK		Remarks:	Bottom: 25.6M. Oxygen < 1 below 5M. H2S @ 10 and 15M. Waterfowl mostly grebes and ducks								
7/27/1999			11.48										
	Sampler:	Parsons		Remarks:									
7/30/1999		73	12.83	2	75	1	1	5	5	0	0	0	1
	Sampler:	STRAUSS		Remarks:	Used a view tube.								
8/11/1999			14.4	6.5	50	1	1	4	4	0	4	2	
	Sampler:	HALLOCK		Remarks:	Bottom: 25.6M. USFS placed boulders along eroding bank to west of swimming beach. H2S at all hypo depths. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.								
8/13/1999		73	13	2	25	2	1	5	5	0	0	0	0
	Sampler:	STRAUSS		Remarks:	Used a view tube.								
8/28/1999		73	14.5	2	0	2	1	5	5	0	0	2	0
	Sampler:	STRAUSS		Remarks:	Used a view tube.								
9/10/1999		64	15.25	2	25	3	1	5	5	0	5	2	0
	Sampler:	STRAUSS		Remarks:	Used a view tube.								
9/14/1999			15										
	Sampler:	STRAUSS		Remarks:	No suspended algae or unusual water color. Fish were jumping - hatch was on! Sampling day was sunny and calm.								

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
9/15/1999			18	7	0	1	1	5	5	0	6	1	
	Sampler: HALLOCK			Remarks: Bottom: 25.6M. Hypo samples yellowish with H2S in all. Light mist on the water.									
Station 2													
6/16/1999			16.1	7	20	1	1						
	Sampler: HALLOCK			Remarks: Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.									
7/14/1999			16.1	7	15	2	1						
	Sampler: HALLOCK			Remarks: Bottom: 21.8M.									
8/11/1999			15.7	6.5									
	Sampler: HALLOCK			Remarks: Bottom: 20.2M.									
9/15/1999			17.7	7									
	Sampler: HALLOCK			Remarks: Bottom: 18.8 M									

HARTS

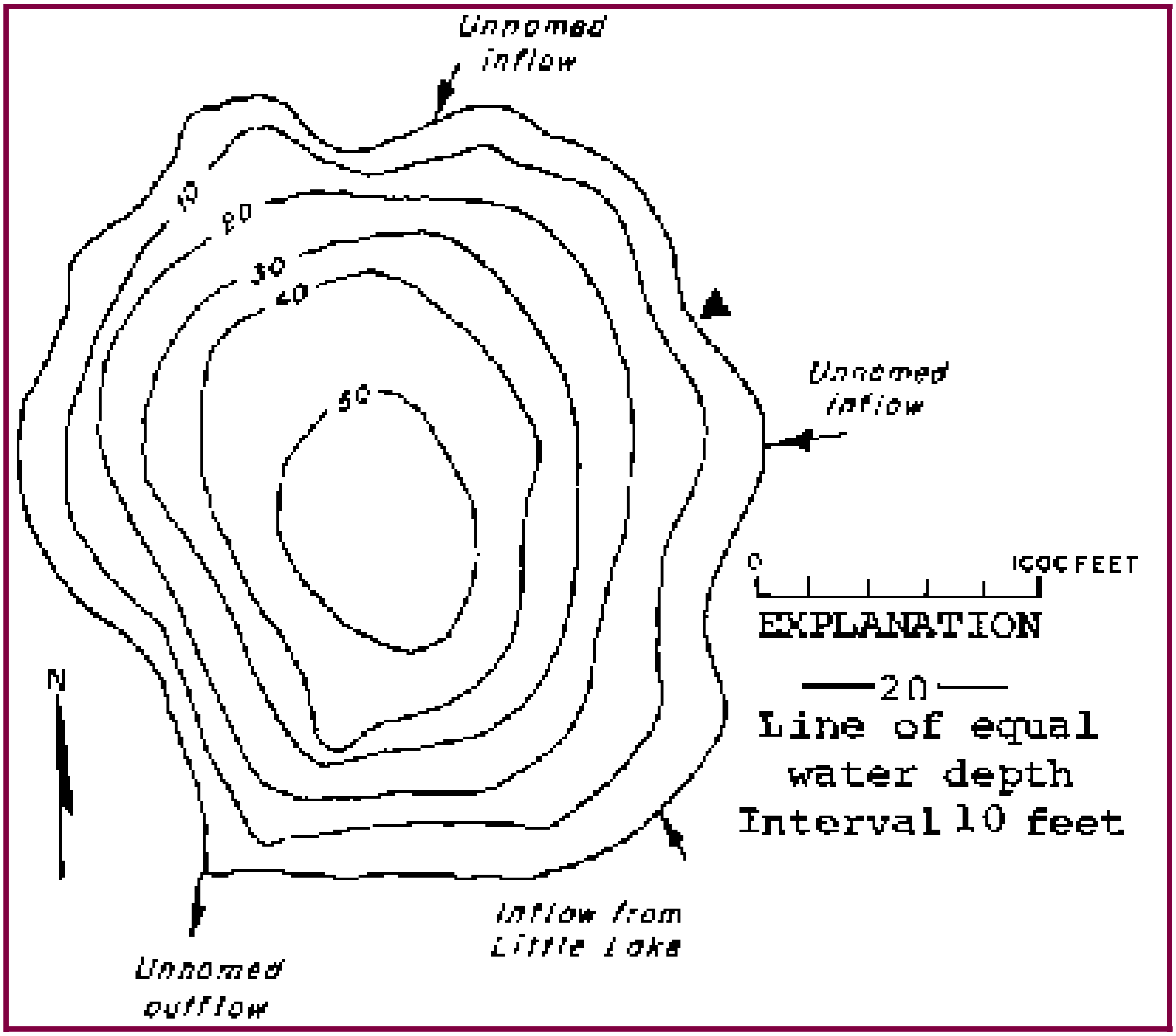
PIERCE County

Lake ID: HARPI1

Ecoregion: 2

Harts Lake is located approximately seven miles southeast of Yelm, just east of the Pierce County line. It is fed by an inflow from Little Lake, to its south, in addition to two other unnamed tributaries. It drains via an unnamed outflow to the Nisqually River. It tends to experience dense summer algal blooms.

Area (acres)	Maximum Depth (ft)	Mean Depth (ft)	Drainage (sq mi)	
120	50	26	4	
Volume (ac-ft)	**Shoreline (miles)**	**Altitude (ft abv msl)**	**Latitude**	**Longitude**
3100	1.61	347	46 53 32.	122 28 18.



Station Information

HARPI1

Primary Station	Station # 1	latitude: 46 53 39.3	longitude: 122 28 01.3
	Description: Deep part of lake, in approximate middle of round lake.		

Trophic State Assessment for 1999

HARTS

Analyst: Sarah O'Neal

TSI_Secchi: [a]	51
TSI_Phos:	65
TSI_Chl:	62
Narrative TSI: [b]	E

Harts Lake is a small, fairly deep lake. While it may be naturally eutrophic, nutrient levels in 1999 were alarmingly high, and appeared to be limiting beneficial uses of the lake more than any other lake studied intensively in 1999. Internal loading, in which nutrients are released from the sediment into the water column, contributed significantly to phosphorus levels in the lake. Severe anoxia in water deeper than 3-4 meters for much of the summer occured with the "rotten-egg" smell generated by hydrogen sulfide, and lead to internal nutrient loading. There were few homes around Harts Lake, and the shoreline was estimated to be eight percent naturally vegetated. However, a very large dairy and egg operation bordered the south inlet stream which artificially accelerated the eutrophication of the lake, according to a 1983 Ecology study. Additionally, a hog farm bordered the north inlet stream, and likely also contributed to nutrient levels. The lake occasionally smelled of manure. Macrophytes and algae grew densely, likely as a result of high nutrient levels. The non-native, aggressive plant, Eurasian watermilfoil (Myriophyllum spicatum), was present, though not in abundance. Water lillies dominated the plant community, encircling the lake in a wide band. Algae bloomed exceptionally densely throughout the summer, however water clarity was relatively good for an eutrophic lake. This may be have been due to the relatively large size of the algae colonies.

The vast majority of questionnaire respondents used the lake for fishing, while a few watched wildlife and relaxed. Primary contact recreation was not popular, likely due to water quality and aesthetics, which most respondents believed had worsened in the 1990s. Many respondents requested WDFW stock higher densities of trout in the lake. However, the anoxic conditions in the hypolimnion and warm summer surface temperatures probably limited trout survival. The zooplankton community decreased in average size over the course of the summer indicating utilization by planktivores and possibly inadequate numbers of piscivores. According to a 1999 WDFW survey, Harts lake was managed as a mixed species lake, and received hatchery trout and channel catfish to support a put-and-take fishery. WDFW considered the warm water fish community of Harts Lake balanced. Yellow perch were the most abundant fish in the lake, though it also contained significant amounts of brown bullhead, black crappie, and largemouth bass. Channel catfish, pumpkinseed, and rainbow trout were also present at lower densities. WDFW sampled a single cutthroat trout in 1999. It is not known if this was a native or a hatchery fish.

The current extreme eutrophic state of the lake limited coldwater fishing and primary contact recreation. Nutrient levels were, we believe, higher than they should be. Further study is required to determine appropriate total phosphorus concentrations. Pending a more thorough investigation, we recommend a tentative total phosphorus criterion for the lake be set at the current concentration of 87.0 ug/L (mean 67.3 ug/L plus standard deviation of 19.7 ug/L). Future studies will likely recommend lowering this criterion.

Mean Secchi = 1.9m; Mean TP = 67.3 ug/L; Mean Chl = 25.7 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

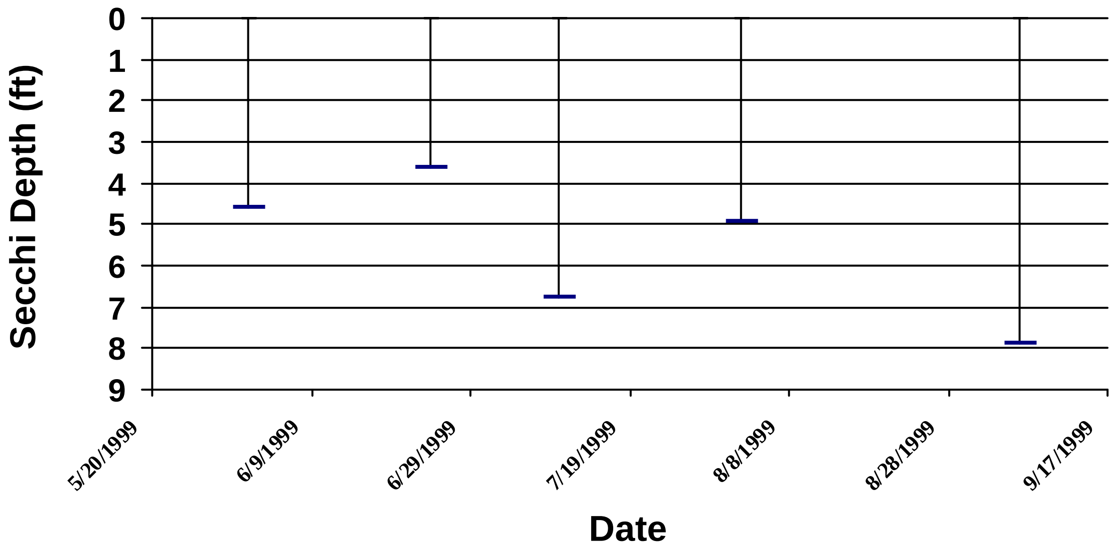
HARTS

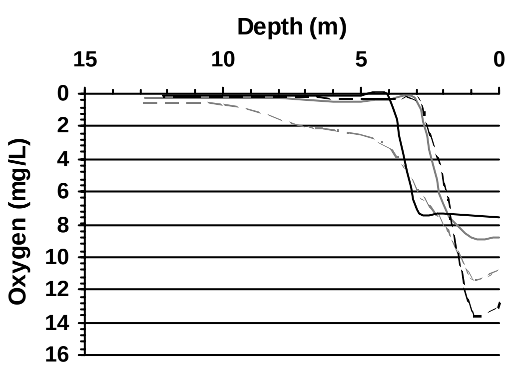
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
6/1/1999		L					1 U			
		L					1 U			
9/6/1999		L					25 U			
		L					50			
Station 1										
6/1/1999		E	93.8	1.14	12	29		63.6	12300	2.6
		H	306							
7/10/1999		E	54.7	1.15	21	33.5				
		H	1000	1.5	2					
8/2/1999		E	57.7	1.19	21	43.3				
		H	453	1.09	2					
9/6/1999		E	62.1	.772	12	10.2				1.4
		H	795	1.33	2					

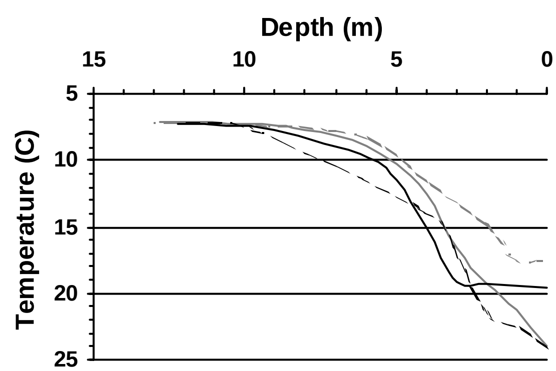
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

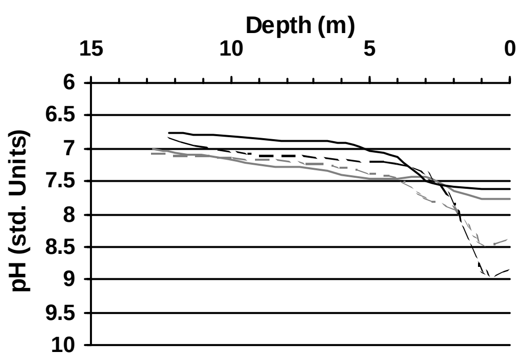
Secchi Depth and Profile Graphics

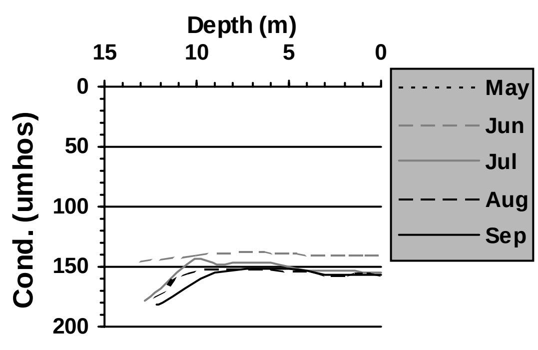
Station: 1 HARPI1











Secchi Data and Field Observations

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/1/1999			4.59	8	50			4	1	0	2	1	0
	Sampler: SMITH			Remarks:	More homes observed in the w-shed than in 1996. Shoreline approx. 80% naturally vegetated. Wilcox farm nearby. Manure odor. Many cattle grazing on slope near Wilcox Farm. Lots of huge Daphnia. 2 bald eagles observed--possible pair.								
6/24/1999			3.61										
	Sampler: Parsons			Remarks:									
7/10/1999			6.79	7	0	1		5	3	0	0	2	0
	Sampler: SMITH			Remarks:	Aphanizomenon bloom--large plates. H2S in hypo at 12 meters.								
8/2/1999			4.92	7	0	1	1	3	1	0	0	2	0
	Sampler: SMITH			Remarks:	One of the thickest Aphanizomenon blooms I've ever seen. Balls of algae the size of nickels. One bald eagle observed.								
9/6/1999			7.87	9	50	1	1	4	3	0	0	3	0
	Sampler: SMITH			Remarks:	Lots of users at boat launch. Heavy black discoloration in the water at 11m. Some discoloration at 8m. Fec#1 at west inlet near cow pasture. pH and conductivity measurements are qualified as estimates due to calibration failing QA/QC requirements.								

LONG (RESERVOIR)

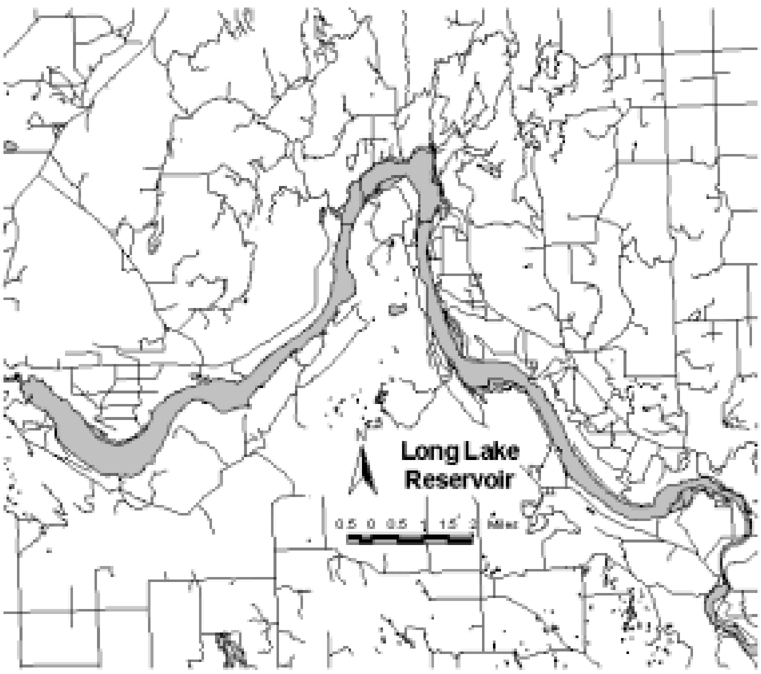
SPOKANE County

Lake ID: LONSP1

Ecoregion: 7

Long Lake is located three miles northwest of the City of Spokane. It is a reservoir of the Spokane River spanning more than twenty miles.

Area (acres)	Maximum Depth (ft)	Mean Depth (ft)	Drainage (sq mi)	
5020	180	49.5		
Volume (ac-ft)	**Shoreline (miles)**	**Altitude (ft abv msl)**	**Latitude**	**Longitude**
243341	53.8	1536	47 46 30.	117 32 30.



Station Information

LONSP1

Primary Station	Station # 1	latitude: 47 49 54.0	longitude: 117 45 46.0
	Description:	Directly across from the DNR Park/campground about four miles from the dam.	
Secondary Station	Station # 3	latitude: 47 51 37.0	longitude: 117 39 57.0
	Description:	About 1 1/2 miles upchannel from Willow Bay Resort, center channel across from an A-frame house.	
Secondary Station	Station # 5	latitude: 47 47 46.0	longitude: 117 34 19.0
	Description:	About 3 miles below Nine Mile Falls, across the channel from Nine Mile Resort.	

Trophic State Assessment for 1999

LONG (RESERVOIR)

Analyst: Sarah O'Neal

TSI_Secchi: [a]	36
TSI_Phos:	46
TSI_Chl:	51
Narrative TSI: [b]	M

Long Lake is a twenty-mile long reservoir of the Spokane River. Trophic state indices varied widely for the lake, each indicating a different trophic state. Water clarity was good, generating an oligotrophic Secchi index. Phosphorus levels were moderate. When the lake was stratified during the second half of the summer, hypolimnetic phosphorus levels were slightly elevated, indicating there may have been some internal nutrient loading. Fortunately, however, hypolimnetic dissolved oxygen levels remained stable during stratification, possibly due to hypolimnion flow through of the Spokane River. Chlorophyll levels were particularly high in Long Lake, consistent with an eutrophic state. However, algae was not reported as a particular problem, and plants were also not excessive. Two non-native, aggressive species were present in the lake: Eurasian watermilfoil (Myriophyllum spicatum) was introduced but not abundant; and a floating leaf plant, yellow floating heart (Nymphoides peltata), which is rare to Washington State, had established and proliferated in the lake. It grew densely wherever habitat was suitable.

While sampling, uses noted included swimming, skiing, and fishing. However, no questionnaires were distributed. WDFW reported a productive warmwater fishery in Long Lake which primarily consisted of large- and smallmouth bass. Other warmwater fish species in the lake included pumpkinseed, yellow perch, and black crappie. A few northern pike also entered the lake from Lake Coeur d' Alene. Long Lake was stocked with 5 - 10,000 brown trout annually. Some rainbow trout also migrated to the lake from the Spokane and Little Spokane Rivers, where they were planted.

The objective for monitoring Long Lake was to support work being conducted by others in 1999. Establishing a nutrient criterion was not an objective. In fact, Long

Lake is the only lake in Washington that has a phosphorus criterion in the Water Quality Standards. Lake Class water quality standards for Long Lake (Chapter 173-201-130 (107a) WAC) state that the average concentrations for total phosphorus in the euphotic zone shall not exceed 25 ug/L from June 1 to October 31. Phosphorus concentrations in 1999 were below this criterion.

Mean Secchi = 5.2m; Mean TP = 18.8 ug/L; Mean Chl = 7.8 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

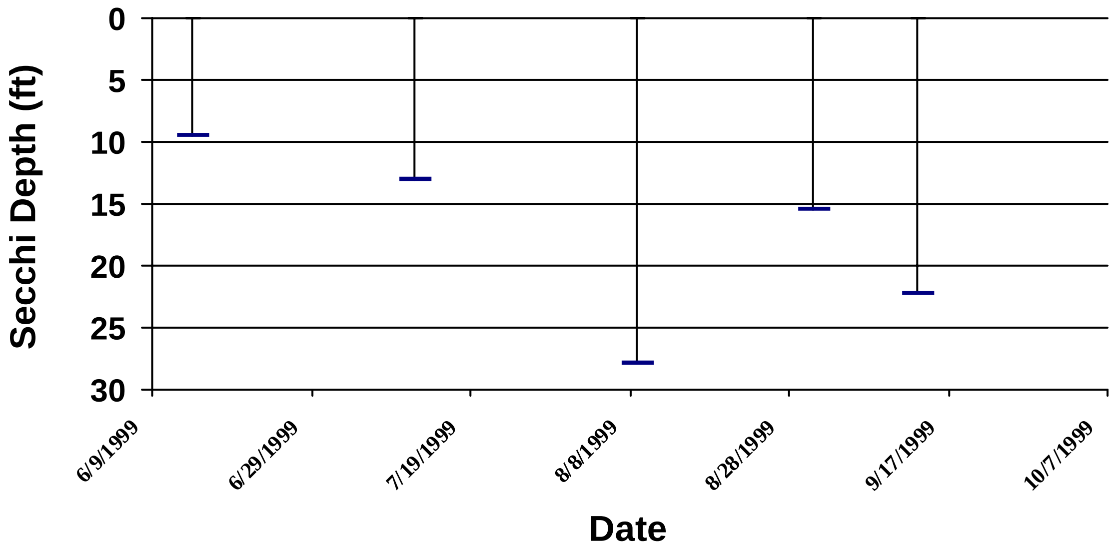
Chemistry Data

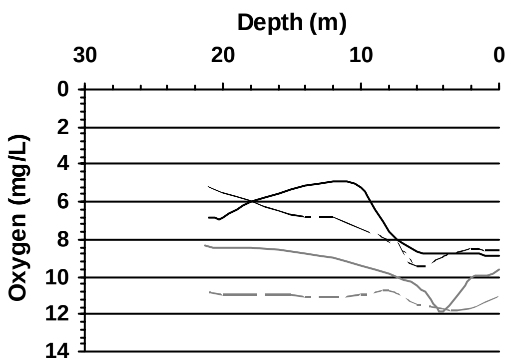
LONG (RESERVOIR)

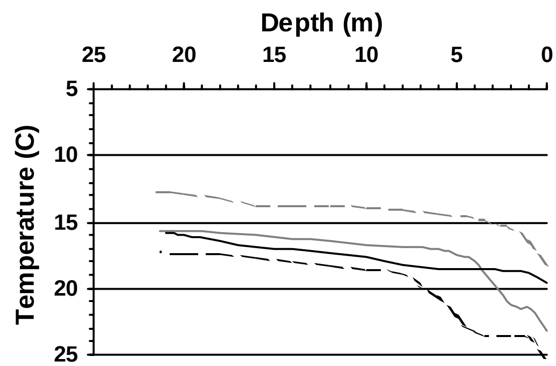
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chlorophyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 1										
6/14/1999		E	21.5	.273	13	5.8		32.9	8360	2.3
7/12/1999	1415	E	21	.372	18	2.68				1.1
		H	20.1	.514	26					
8/9/1999		E	12.4	.519	42	1.9				.6
		H	23.2	1.16	50					
9/13/1999		E	19.1	.873	46	14.6				.8
		H	43.2	1.3	30					
Station 3										
6/14/1999		E	21.6	.298	14	3.9		33.7	8530	2.9
7/12/1999	1215	E	20	.726	36	5.71				2.3
8/9/1999		E	14	.577	41	6.7				1.5
		H	30.8	1.27	41					
9/13/1999		E	24.9	.77	31	4.5				1.5
		H	27.2	1.09	40					

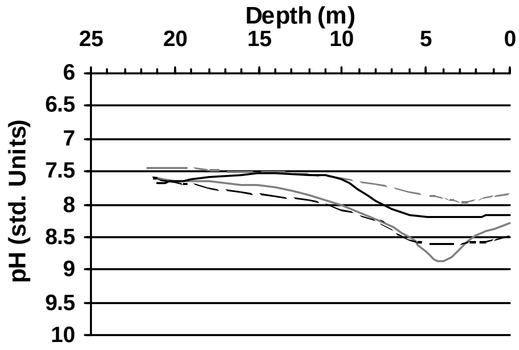
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

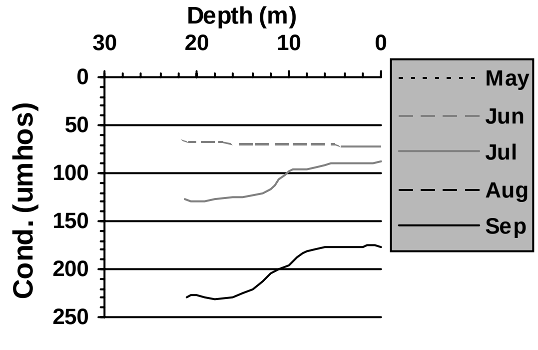
Secchi Depth and Profile Graphics **Station:** 1 LONSP1











Secchi Data and Field Observations

LONG (RESERVOIR)

Date	Time	Temperature (F)	Secchi (ft)	Color (1-greens, 11-browns	Brightness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/14/1999			9.5	2	20	2	1	4	4	0	5	0	4
	Sampler: HALLOCK			Remarks: Bottom: 21.4M. Site 1 is mid-channel directly out from DNR campground access. Lake not stratified. Dissolved oxygen measurement is qualified as an estimate due to calibration failing QA/QC requirements.									
7/12/1999			13.1	6	0	1	1	4	4	0		1	2
	Sampler: HALLOCK			Remarks: Bottom: 21.3M. Lots of kids swimming at DNR park. Quite a bit of debris on surface. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.									
8/9/1999			27.9	1.5	10	1	1	5	5				
	Sampler: HALLOCK			Remarks: Bottom: 21.3M. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.									
8/31/1999			15.42										
	Sampler: Parsons			Remarks:									
9/13/1999			22.3	2	10	1	1	4	4	0	0	0	0
	Sampler: HALLOCK			Remarks: Bottom 21.0M. Lots of dead adult midges on surface.									
Station 3													
6/14/1999			8.2	2	20	2	1	4	4	0	0	0	2
	Sampler: HALLOCK			Remarks: Bottom: 15.4M. Access is via launch at Willow Bay Resort. Go upstream about 1 mile to just before lake widens out (adjacent from an A-frame on N. bank). Lake not stratified. Dissolved oxygen measurement qualified as an estimate due to postcalibration failing QA/QC requirements.									
7/12/1999			12.1	6	0	1	1	4	4	5	1	0	0
	Sampler: HALLOCK			Remarks: Bottom 14.8M. Debris on surface. All boats were in transit. "Other" waterfowl was an osprey. Not stratified. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.									
8/9/1999			18	6	10	2	1	5	5	0	8	1	1
	Sampler: HALLOCK			Remarks: Bottom: 16.8M. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.									
9/13/1999			13.8	2	0	2	1	4	4	25	50	3	0
	Sampler: HALLOCK			Remarks: Bottom: 16.8. Collected discrete TP OP and chl samples at 3M intervals for Jim Carroll at this station.									
Station 5													
8/9/1999			10.5	2	10	2	1						
	Sampler: HALLOCK			Remarks: Bottom at 3.7M. Sampled here for Jim Carroll. Site is directly out from Nine Mile Resort near far bank, but just short of main channel. Abundant weeds in the area. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.									

LOOMIS

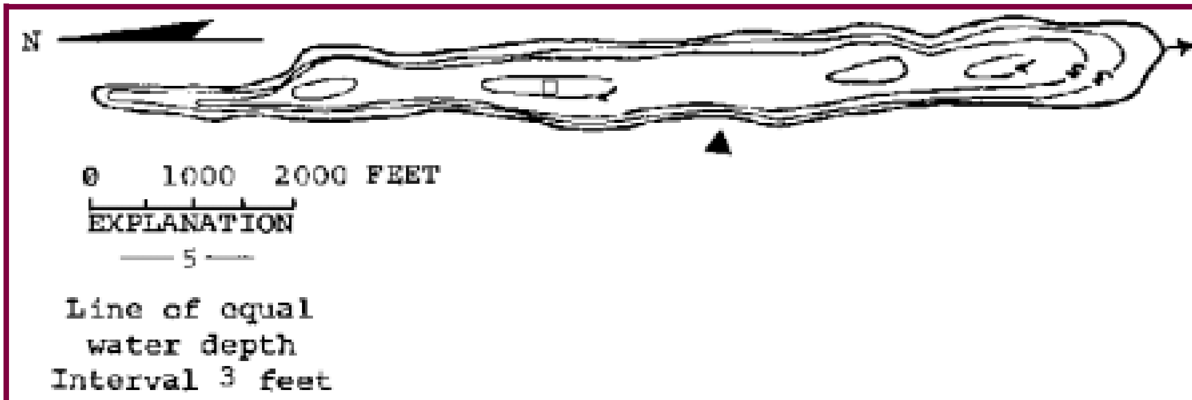
PACIFIC County

Lake ID: LOOPA1

Ecoregion: 1

Loomis is a dune lake located just north of Long Beach in Pacific County. It is a very shallow lake with a distinct tannin color. There is an abundance of macrophytes throughout the lake.

Area (acres)	Maximum Depth (ft)	Mean Depth (ft)	Drainage (sq mi)	
165	9	5	1	
Volume (ac-ft)	**Shoreline (miles)**	**Altitude (ft abv msl)**	**Latitude**	**Longitude**
825	4.32	17	46 25 26.	124 02 27.



Station Information

LOOPA1

Primary Station	Station # 1	latitude: 46 26 32.6	longitude: 124 02 29.5
	Description: Located in middle of lake, about 2000 feet north of boat launch.		

Trophic State Assessment for 1999

LOOMIS

Analyst: Sarah O'Neal

TSI_Secchi: [a]	55	BB
TSI_Phos:	58	
TSI_Chl:	58	
Narrative TSI: [b]	E	

Loomis Lake is an extremely shallow dune lake, which is probably naturally eutrophic. While nutrient levels indicated eutrophy, water clarity was better than the TSI indicated and increased later in the summer. The Secchi disk hit the bottom of the lake twice during the course of sampling, which overestimated the Secchi Trophic State Index. No algal blooms were documented during the summer, though chlorophyll concentrations were very high in the spring. The plants in the lake were somewhat dense, and two aggressive, non-native species were present: Brazilian elodea (Egeria densa), which was discovered in 1999, and Eurasian watermilfoil (Myriophyllum spicatum). Fortunately, neither plant dominated the plant community. Dense native bur-reeds (Sparganium eurycarpum) surrounded the lake, acting as a shoreline buffer. The surrounding shoreline was naturally vegetated and was known to serve as habitat for osprey and swallows. The watershed may suffer from significant disturbance when a planned housing development is built along the southeast shores of the lake.

No questionnaires were completed for the lake. Plant growth throughout the lake likely limited primary contact recreation. The lake was used for fishing. According to WDFW officials, the fishery on Loomis Lake suffered greatly from the dense macrophyte growth. Trout stocking had decreased significantly several years prior to 1999 due to this problem, in addition to a higher angler demand for bass. Twelve thousand rainbow trout were planted in the lake in 1997, though few were caught, particularly in depths less than about eight meters where vegetation was the densest. Consequently, only 2000 - 3000 trout were planted in 1998. On opening day of 1999, only thirty fish were caught by approximately 25 anglers, a very poor return. WDFW planned to reduce rainbow trout stocking even further for the spring of 2000. Unfortunately, cold water temperatures due to the lake's proximity to the ocean render the lake a poor warmwater fish habitat as well. As a result, warmwater fish tend to grow unusually slowly in this lake. The fishery in 1999 primarily consisted of bass and yellow perch, though pumpkinseed, crappie, and brown bullhead were also present at lower densities.

The main beneficial uses of this lake, warmwater fishing and habitat for fish and surrounding wildlife, appeared to be supported by its presumably natural eutrophic state. However, dense plant growth was interfering with the coldwater fishery, and perhaps with primary contact use. Consequently, in addition to a total phosphorus criterion of 48.6 ug/L (mean 40.6 ug/L plus standard deviation of 8.0 ug/L), we recommend the development of an Aquatic Plant Management Plan.

Mean Secchi = 1.5m (BB); Mean TP = 40.6 ug/L; Mean Chl = 16.4 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

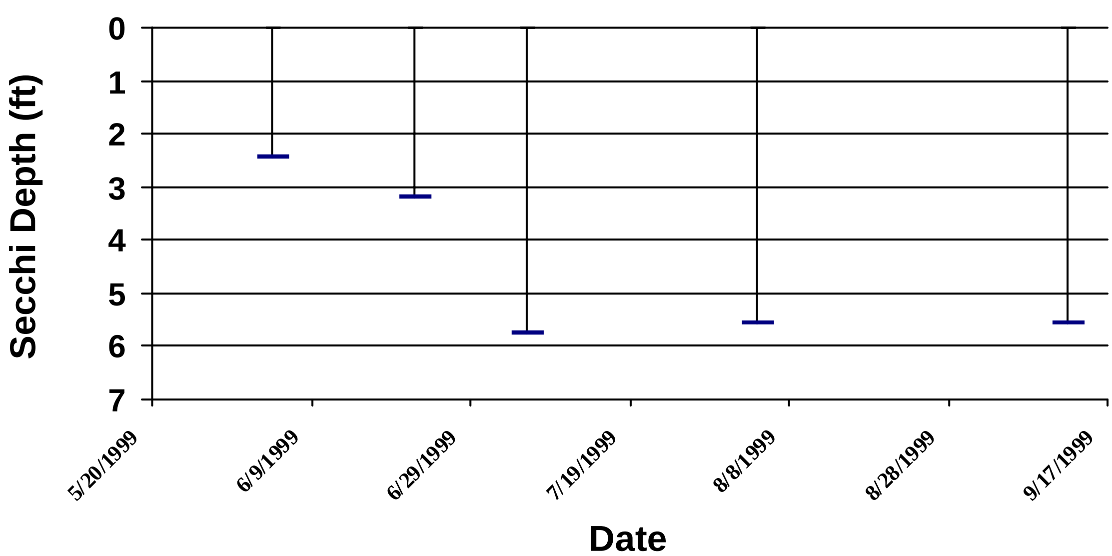
LOOMIS

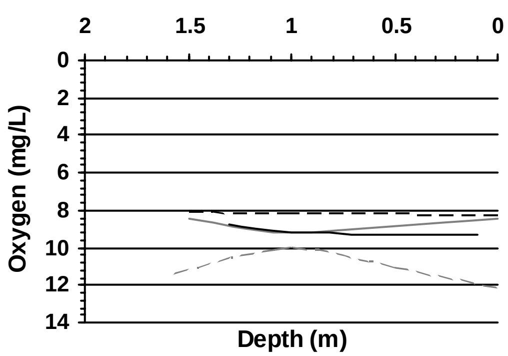
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 1										
6/4/1999		E	56.5	.88	16	50.7		30.6	4560	4.1 J
7/6/1999		E	32.9	.522	16	12.7				
8/4/1999	1100	E	43.3	.399	9	3.3				2.1
9/12/1999		E	32.5	.366	11	3.5				

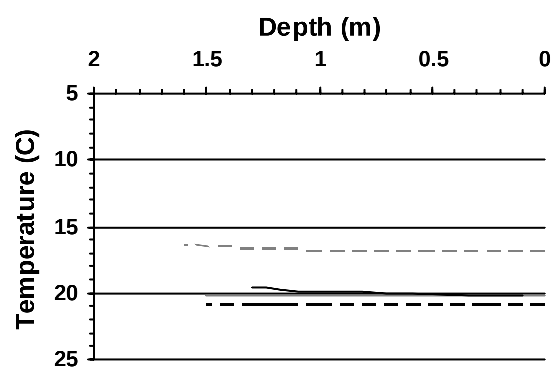
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

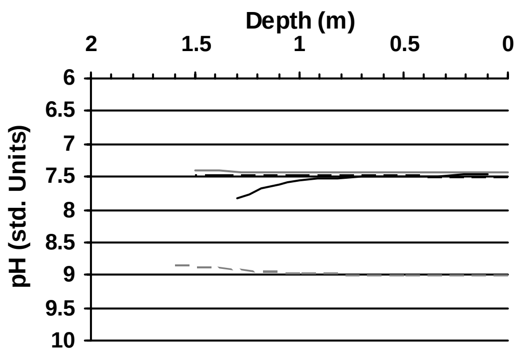
Secchi Depth and Profile Graphics

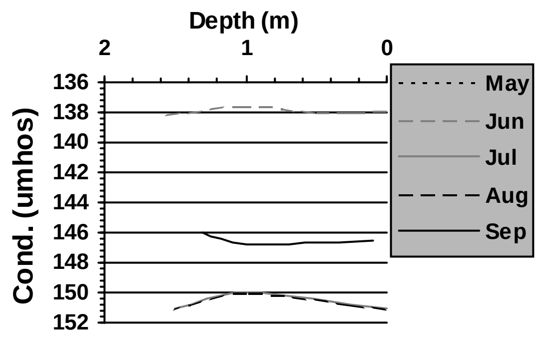
Station: 1 LOOPA1











Secchi Data and Field Observations

LOOMIS

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/4/1999			2.46	8	100	1	1	5	2	0	0	0	0
	Sampler: SMITH			Remarks:	Sparganium dominates the shoreline. Vegetation mapped in '96 by Pacific Conservation District. Lots of pollen and algae in water. Iris is newly invasive. Osprey nest and osprey observed. Barn swallows and other swallows abundant. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.								
6/22/1999			3.2										
	Sampler: Parsons			Remarks:									
7/6/1999			5.74	9	100	3	1	5	3	0	0	0	0
	Sampler: SMITH			Remarks:	None								
8/4/1999			5.58 B	7	100	2	1	5	2	0	0	0	0
	Sampler: SMITH			Remarks:	Too weedy for swimming								
9/12/1999			5.58 B	6	0			5	2	0	0	1	0
	Sampler: SMITH			Remarks:	Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.								

MARTHA (31N-04E-18)

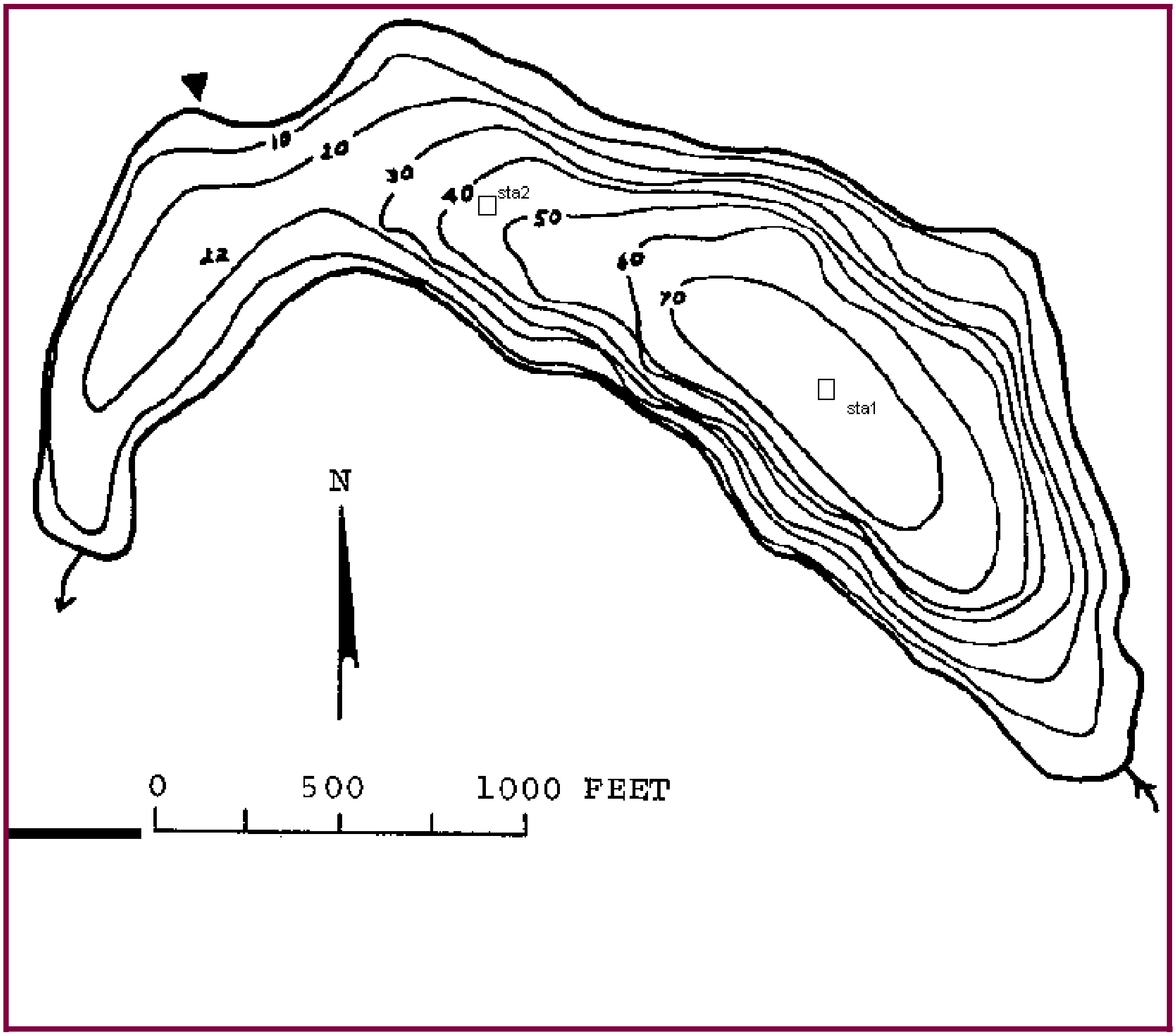
SNOHOMISH County

Lake ID: MARSN1

Ecoregion: 2

Lake Martha is located 10.5 miles northwest of Marysville, and one mile east of Warm Beach. It is fed by Lake Howard and drains to Port Susan. (Lake Martha is not the same lake as Martha Lake, which is located near Alderwood Manor.)

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
62	70	33	2	
Volume (ac-ft)	*Shoreline (miles)*	*Altitude (ft abv msl)*	*Latitude*	*Longitude*
2034	1.76	186	48 10 03.	122 20 46.



Station Information

MARSN1

Primary Station	Station # 1	latitude: 48 10 06.7	longitude: 122 20 12.7
	Description: Deep site. In middle of lake approximate 1250 feet northwest of inflow at southeast corner.		
Secondary Station	Station # 2	latitude: 48 10 10.6	longitude: 122 20 27.5
	Description: Located in middle of lake, about 750 feet east of boat launch (and about 250 feet south of boat launch in to the lake's middle).		

Trophic State Assessment for 1999

MARTHA (31N-04E-18)

Analyst: Sarah O'Neal

TSI_Secchi: [a]	43
TSI_Phos:	41
TSI_Chl:	50
Narrative TSI:[b]	M

Lake Martha is a small, deep lake. While nutrient levels and Secchi depths were consistent with a mesotrophic lake, chlorophyll-a levels were elevated. In fact, we noted that 1999 brought the worst algal conditions observed in many years on the usually clear lake. Slightly elevated hypolimnetic total phosphorus concentrations indicated slight internal nutrient loading. Additionally, dissolved oxygen dropped off in the hypolimnion, particularly in September, another indication of the potential for internal nutrient loading. A number of activities in the watershed may have been responsible for the productivity of the lake. In particular, there was an apparent increase in resident geese, which often add nutrients to a lake system. Homes with manicured lawns, many running down to the shoreline, surrounded the majority of the lake (an estimated two-thirds). Fertilizers, a common nutrient source, were clearly used on many of the lawns. Lawns are known to attract and sustain geese year round. Finally, agriculture was the primary land use within the watershed; farm runoff is another potential source of nutrients. Fortunately, plants were not a problem in the lake. Submerged plants grew only sparsely, and no problem species grew in or around the lake.

Nineteen residents and two visitors completed the questionnaire. They indicated a wide variety of uses including swimming, relaxing, watching wildlife, canoeing, kayaking, and using personal watercraft. All but one respondent answering the question about water quality agreed that water quality had worsened in the past decade or two. The respondents especially desired less algae, clearer water, good swimming, and fewer Canada geese on the lake. The lake and its surroundings provided habitat for eagles, hawks, grebes, and other waterfowl. Fish habitat was somewhat sparse on the lake, and consisted largely of human structures and aquatic plants. However, WDFW managed the lake primarily for rainbow trout. Between 1000 and 2000 catchable fish were planted each spring before opening day. Four inch brown trout were also planted in the fall. The fishery effectively utilized zooplankton, as indicated by a decrease in their average size over the summer. However, smaller forms dominated the zooplankton community, particularly later in the summer, indicating a possible overabundance of prey to predator species. Anadromous fish do not use Martha Lake. Warmwater fish species in the lake included largemouth bass, yellow perch, and brown bullhead. The lake received only about 50 anglers on opening day of its year-round season.

Despite increasingly dense algal growth, uses of the lake appeared to be largely supported. In order to maintain water quality of the lake and prevent increased nutrient loading, we recommend a total phosphorus criterion of 15.8 ug/L (mean 12.5 ug/L plus standard deviation of 3.3 ug/L).

Mean Secchi = 3.2m; Mean TP = 12.5 ug/L; Mean Chl = 7.6 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

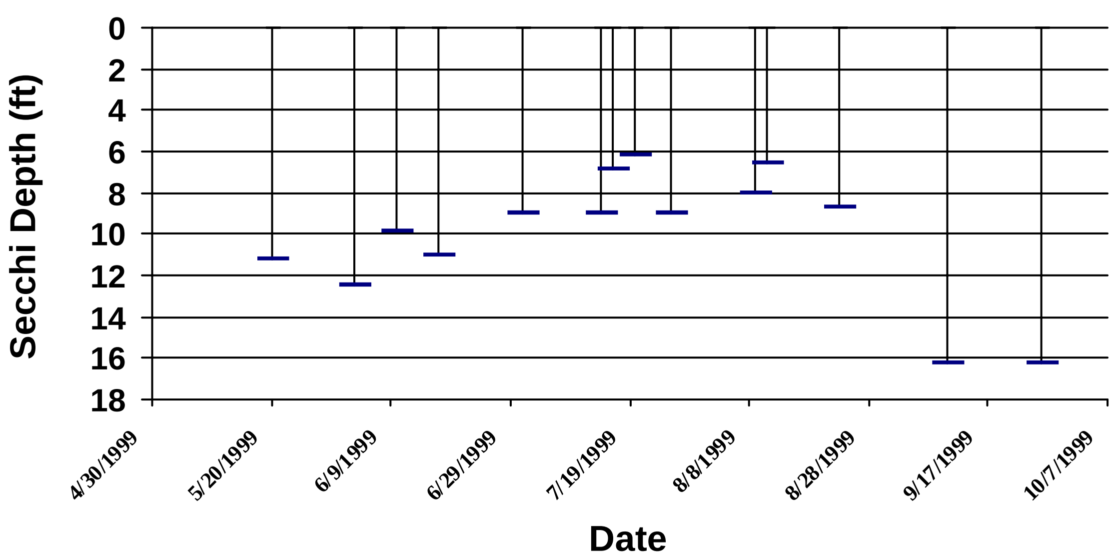
Chemistry Data

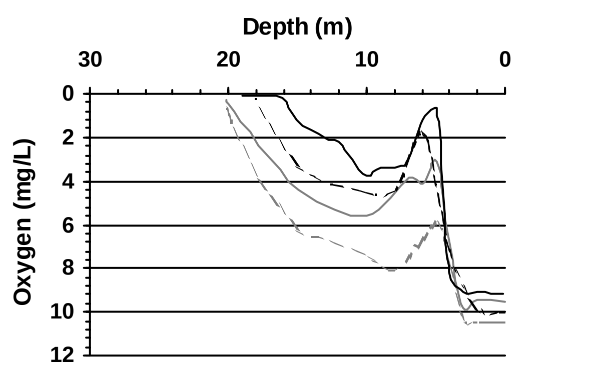
MARTHA (31N-04E-18)

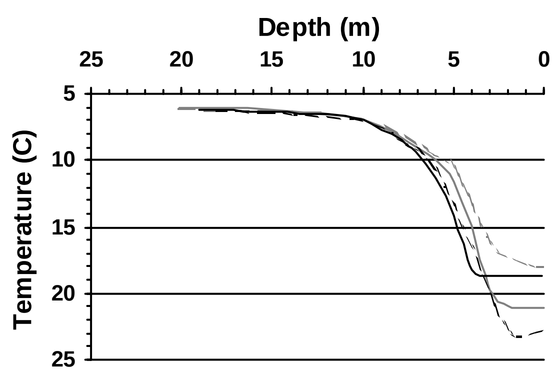
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
6/10/1999		L					3			
		L					4			
8/11/1999		L					13			
		L					9			
Station 1										
6/10/1999		E	15.1	.455	30	8.1		30.5	5760	.8
		H	57.5	.635	11					
7/16/1999		E	12.4	.584	47	10.5				
		H	75.5	.729	10					
8/11/1999		E	11.2	.637	57	11.2				1.2
		H	26.1	.728	28					
9/10/1999		E	11.1	.416	37	3.2				
		H	33.8	.811	24					
Station 2										
6/10/1999		E	11.9	.448	38	8.2				
7/16/1999		E	11.1	.571	51	11.6				
8/11/1999		E	11.1	.652	59	11.6				
9/10/1999		E	8.45	.415	49	3				

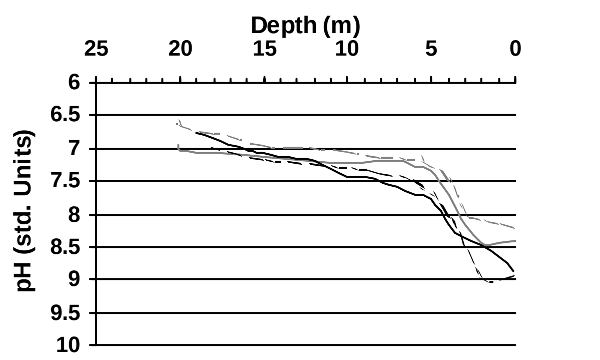
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

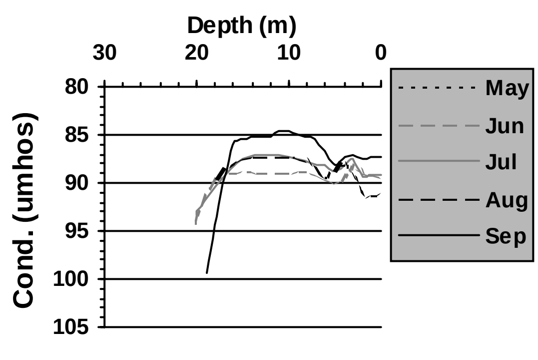
Secchi Depth and Profile Graphics **Station:** 1 MARSN1











Secchi Data and Field Observations

MARTHA (31N-04E-18)

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
5/20/1999		15	11.25	8	50	2	4	4	3	3	7	1	0
	Sampler: DEAN			Remarks: Used a view tube. Very large clumpy particulate.									
6/3/1999		18	12.5	7	0	2	1	4	4	0	5	1	0
	Sampler: DEAN			Remarks: Used a view tube. Beautiful day. Total of 1.1 inches rain Memorial Day and Sunday.									
6/10/1999			9.84	7	75	1	1	5	5	30	1	0	0
	Sampler: SMITH			Remarks: Mostly residential, some timber but a church has purchased nearby timber land. Some new homes just built in shed. Only about a third of shoreline natural--rest residents.									
6/17/1999		21	11	8	25	1	1	5	4	27	2	0	0
	Sampler: DEAN			Remarks: Used a view tube. Small particulate. Rosa nutkana in bloom.									
7/1/1999		19	9	8		1	5		3	24	0	0	0
	Sampler: DEAN			Remarks: Used a view tube. Within the last two days rained 0.8 inches. Water like looking through snow storm. Algae scum in cove around dock - pale green.									
7/14/1999		21.5	9		75	3	2	4	4	0	0	0	0
	Sampler: DEAN			Remarks: Used a view tube. Still a whiteout!									
7/16/1999			6.89	6	80	3	1	4	2	18	1	0	0
	Sampler: SMITH			Remarks: Considerable algal bloom--worst I've seen on this lake. Bald eagle observed.									
7/20/1999			6.23										
	Sampler: Parsons			Remarks:									
7/26/1999		21	9	7	0	3	2	4	4	0	0	1	0
	Sampler: DEAN			Remarks: Used a view tube. Still heavy algae. Two families of geese are still on the lake. Heard pied-billed grebe.									
8/9/1999		23	8	6	25	1	2	4	3	9	11	1	0
	Sampler: DEAN			Remarks: Used a view tube. The clarity is beginning to worry me. Color #6 isn't really correct but I wanted to indicate a color change.									
8/11/1999			6.6	3	100	3	1	4	3	0	0	0	0
	Sampler: SMITH			Remarks: The greenist I've ever seen the lake. Fec #1 approx. 70 meters east of boat launch near old pier. Fec #2 at boat launch. Red tailed hawk observed.									

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
8/23/1999		22	8.75	7	0		2	4	4	0	0	0	0
	Sampler: DEAN			Remarks: Used a view tube.									
9/10/1999		18.5	16.25	7	0	1	1	5	5	0	0	0	0
	Sampler: DEAN			Remarks:									
9/26/1999		17	16.25	6	50	1	5	5	5	0	0	0	0
	Sampler: DEAN			Remarks: Used a view tube. Rained 0.6 inches in about 45 minutes last night. Very windy yesterday. Some small particulate.									

MCMURRAY

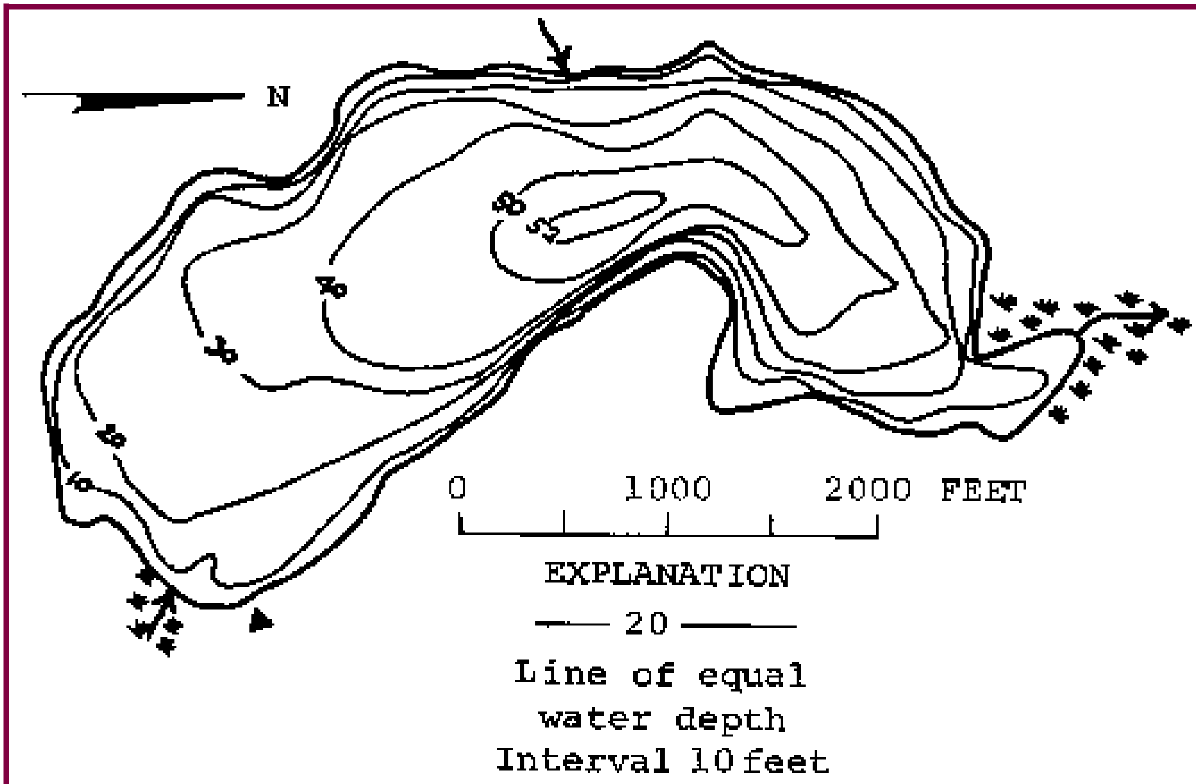
SKAGIT County

Lake ID: MCMSK1

Ecoregion: 2

Lake McMurray is a largely forested lake located 7.5 miles southeast from Mount Vernon. It is fed by two tributaries and drains via Lake Creek to Big Lake.

Area (acres)	Maximum Depth (ft)	Mean Depth (ft)	Drainage (sq mi)	
160	52	29	3	
Volume (ac-ft)	**Shoreline (miles)**	**Altitude (ft abv msl)**	**Latitude**	**Longitude**
4500	2.65	158	48 19 28.	122 13 22.



Station Information

MCMSK1

Primary Station	Station # 1	latitude: 48 19 00.4	longitude: 122 13 36.8
	Description: Deep part of lake, about 750 feet east of inlet on western shore.		

Trophic State Assessment for 1999

MCMURRAY

Analyst: Sarah O'Neal

TSI_Secchi: [a]	38	N
TSI_Phos:	48	
TSI_Chl:	45	
Narrative TSI: [b]	M	

Lake McMurray is a fairly small, deep lake. It is located in a watershed that was predominantly forested, and harvested. Although numerous dwellings surrounded the lake, most appeared to be seasonal cottages. Fertilizers were apparently used on yards bordering the lake, and no significant buffer protected the shoreline. Hypolimnetic anoxia, apparent in Lake McMurray particularly later in the summer, caused internal nutrient loading in which nutrients are released from the sediment into the water column. Anoxia also led to the formation of hydrogen sulfide, which caused the distinct, “rotten-egg” smell noted in September. The lake appeared to be in good condition and supported primary uses. Fortunately, nutrient loading had not yet led to extraordinarily dense algal blooms. The aggressive noxious weed, Eurasian watermilfoil (Myriophyllum spicatum), dominated the submerged plant community in the lake and elicited complaints. Lake McMurray underwent a whole lake Sonar treatment for the eradication of Eurasian watermilfoil during the summer of 2000. It will be interesting to observe the algae response to this treatment.

Uses of the lake, as indicated by questionnaires as well as site visits, consisted primarily of fishing, in addition to some canoeing, kayaking, and watching wildlife. The lake additionally served as habitat for eagles. WDFW managed the fishery primarily for rainbow trout. About 15,000 - 18,000 catchable trout were planted each April in preparation for opening day. Native anadromous cutthroat trout and coho salmon also used the lake, and spawned in its tributary inlet. Warmwater fish species present included large- and smallmouth bass, black crappie, and yellow perch. The fishing season was open from the last Saturday in April through October, and the lake was visited by about 5000 anglers on opening day alone.

Despite possible internal nutrient loading, the lake’s water quality supported primary uses. Therefore, we recommend a total phosphorus criterion of 25.8 ug/L (mean 21.5 ug/L plus standard deviation of 4.3 ug/L).

Mean Secchi = 4.5m (N); Mean TP = 21.5 ug/L; Mean Chl = 4.2 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

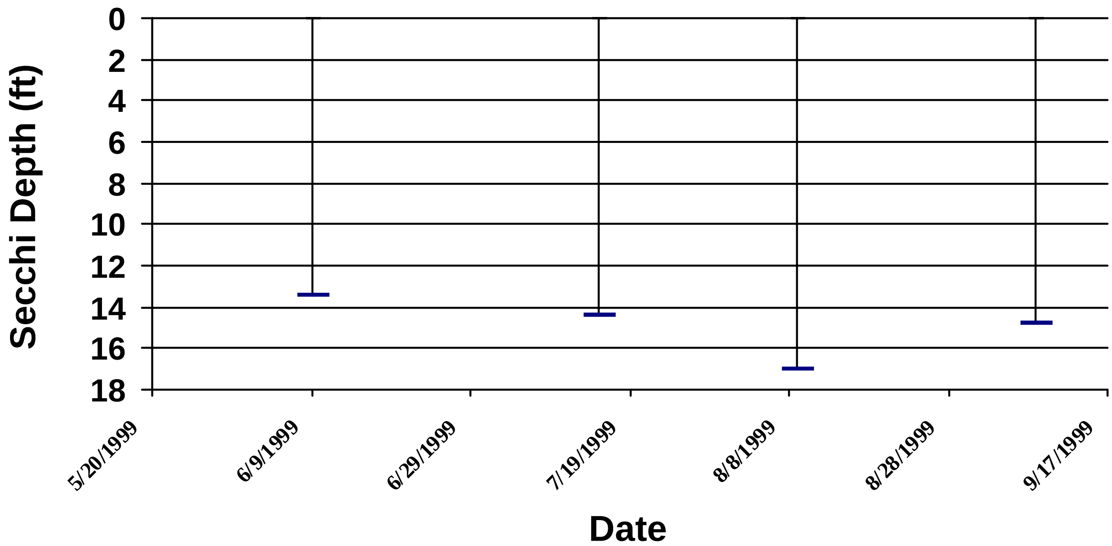
Chemistry Data

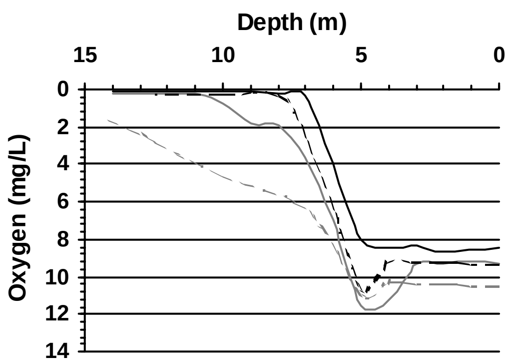
MCMURRAY

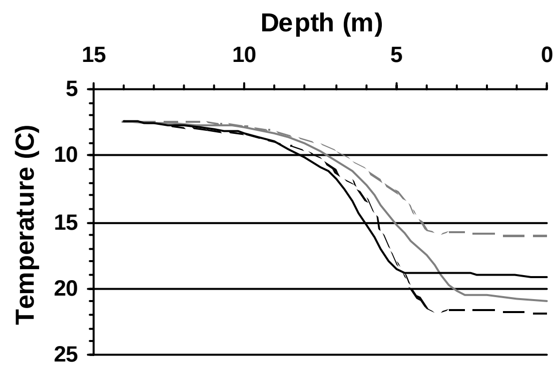
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
6/9/1999		L					3			
		L					3			
8/9/1999		L					5			
		L					6			
9/8/1999		L					3			
		L					1			
Station 1										
6/9/1999		E	22	.886	40	4.9		28.2	6690	.7
		H	31.8	.933	29					
7/15/1999		E	23.6	.793	34	3.15				.6
		H	27.3	.958	35					
8/9/1999		E	19.7	.639	32	4.9				1.2
		H	29.4	.77	26					
9/8/1999		E	20.8	.491	24	3.8				.8
		H	61	.604	10					

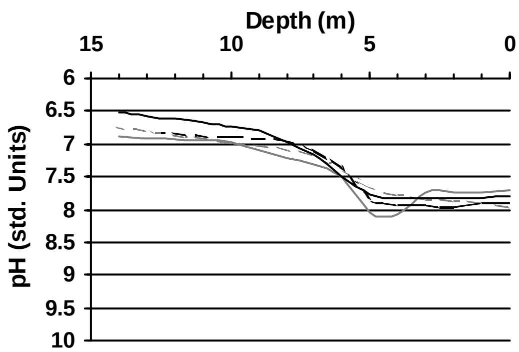
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

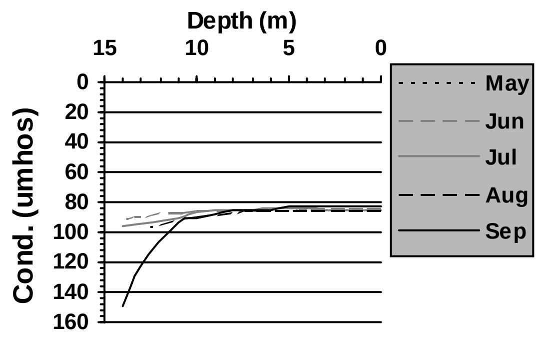
Secchi Depth and Profile Graphics **Station:** 1 MCMSK1











Secchi Data and Field Observations

MCMURRAY

Date	Time	Temperature (F)	Secchi (ft)	Color (1-greens, 11-browns	Brightness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/9/1999			13.45	2	100	3	1	5	5	18	0	3	0
	Sampler: SMITH			Remarks: None. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.									
7/15/1999			14.44	2	50	3	1	5	5	0	0	2	0
	Sampler: SMITH			Remarks: Abundant Eurasian milfoil									
8/9/1999			17.06	2	100	1	1	5	3	0	0	2	0
	Sampler: SMITH			Remarks: 1 bald eagle. Fec #1 taken in front of smallest cabin close to water approx. 200 meters west of boat launch. Fec #2 taken at boat launch.									
9/8/1999			14.76	2	0	1	1	4	1	0	0	2	0
	Sampler: SMITH			Remarks: Milfoil thick in places, especially near boat launch. A slight blue-green bloom. H2S odor at 13 meters. Fec #1 at Sons of Norway. Fec #2 at boat launch.									

SKOOKUM, NORTH

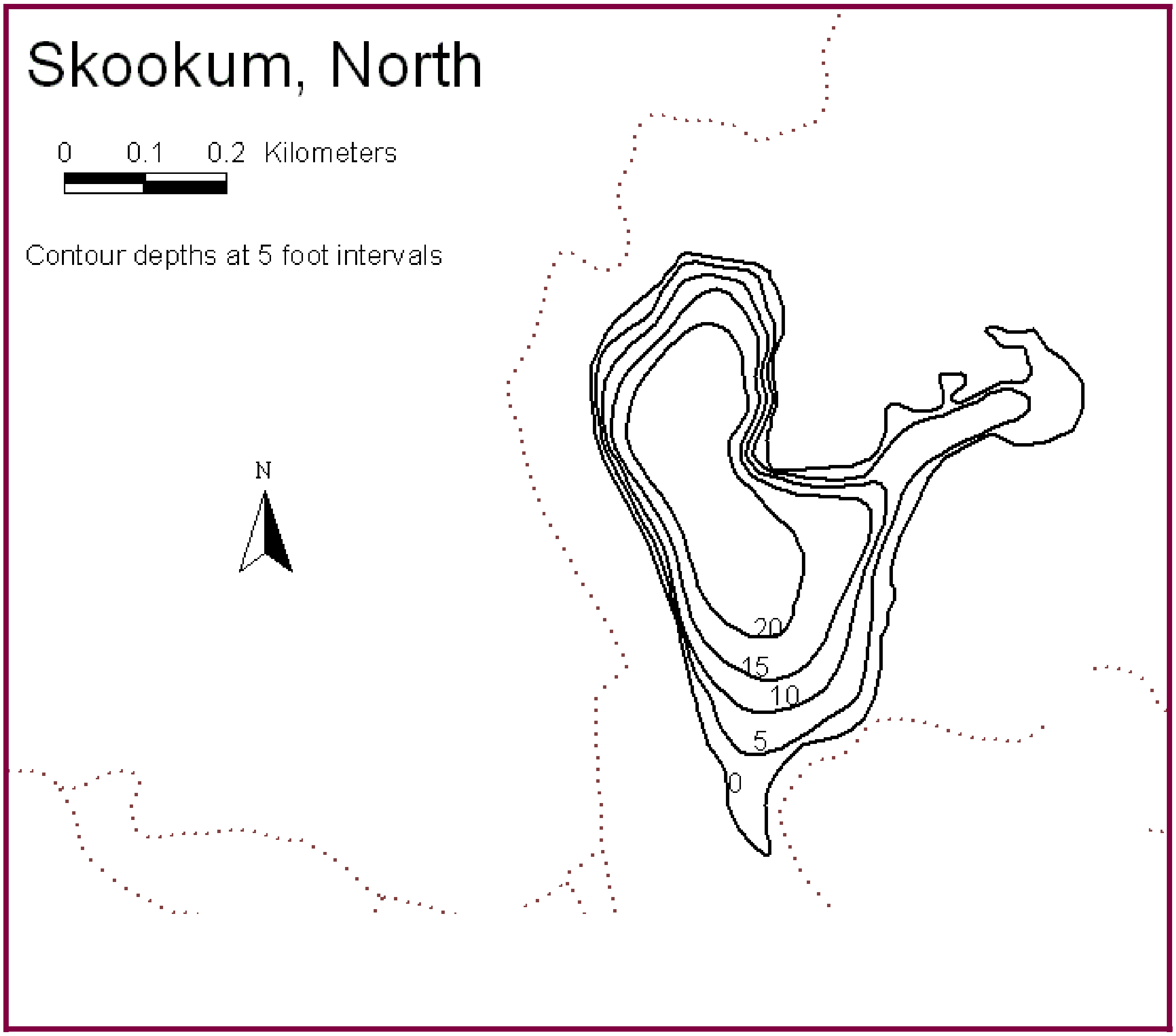
PEND OREILLE County

Lake ID: SKOPE2

Ecoregion:

North Skookum Lake is located approximately eighteen miles north of the border of the town of Newport in the Colville National Forest. It is fed by a small creek and drains via the North fork of the Skookum River and South Skookum lake to the Pend Oreille River.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*	
39	20			
Volume (ac-ft)	*Shoreline (miles)*	*Altitude (ft abv msl)*	*Latitude*	*Longitude*
540		3550		



Station Information

SKOPE2

Primary Station	Station # 1	latitude: 48 24 27.0	longitude: 117 10 50.0
	Description: Deep part of the lake, at the north side of where an arm enter to the east.		

Trophic State Assessment for 1999

SKOOKUM, NORTH

Analyst: Sarah O'Neal

TSI_Secchi: [a]	45
TSI_Phos:	54
TSI_Chl:	64
Narrative TSI: [b]	E

North Skookum is a small, popular lake surrounded by the Colville National Forest. Except for campgrounds, a forested watershed surrounded the lake. Some logging occurred in the watershed. The lake is likely naturally eutrophic. Even though tannins in the water colored the lake brown, Secchi transparency was better than total phosphorus and chlorophyll would predict. Nutrient levels indicated eutrophy. Some anoxia occurred in the hypolimnion, particularly later in the summer when the lake also showed evidence of possible slight internal nutrient loading. In September, conductivity levels increased sharply in the hypolimnion. Significant algal growth occurred, particularly late in the summer. It was reported to have gotten worse in the few years prior to sampling. Lake visitors indicated less algae growth as a priority in the questionnaire. However the lake supported a healthy, diverse plant community and served as habitat for a variety of fish and wildlife. Beavers, ducks, osprey, and great blue heron used the lake. Additionally, WDFW managed the lake for rainbow trout, planting about 6000 fry each spring. Because snowmelt mainly feeds it, fish tend to grow much slower in North Skookum than in neighboring, higher nutrient, South Skookum Lake. Hypolimnetic anoxia reduced the available habitat for salmonids. Just prior to our sampling, WDFW attempted to improve the fishery by shortening the fishing season.

Lake uses consisted mainly of fishing, although questionnaire respondents also indicated hiking, watching wildlife, relaxing, and swimming as lake activities. Fishers often used the campground near the lakeshore. The natural eutrophic state of the lake adequately supported uses. A close eye should be kept on this nice resource, however, to prevent any further anthropogenic eutrophication. The lake may be at particular risk because any increase in eutrophication may increase hypolimnetic anoxia, resulting in increased internal nutrient loading and accelerating the eutrophication process. Possible nitrogen limitation was also indicated. Due to the limitations of the sampling conducted during this study, it is difficult to determine whether nitrogen is also limiting to the system. Consequently, any forest fertilizer applications should be carefully managed. We recommend a total phosphorus criterion of 35.9 ug/L (mean 31.6 ug/L plus standard deviation of 4.3 ug/L). Future studies may propose a nitrogen criterion.

Mean Secchi = 4.0m; Mean TP = 31.6 ug/L; Mean Chl = 30.0 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples
[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

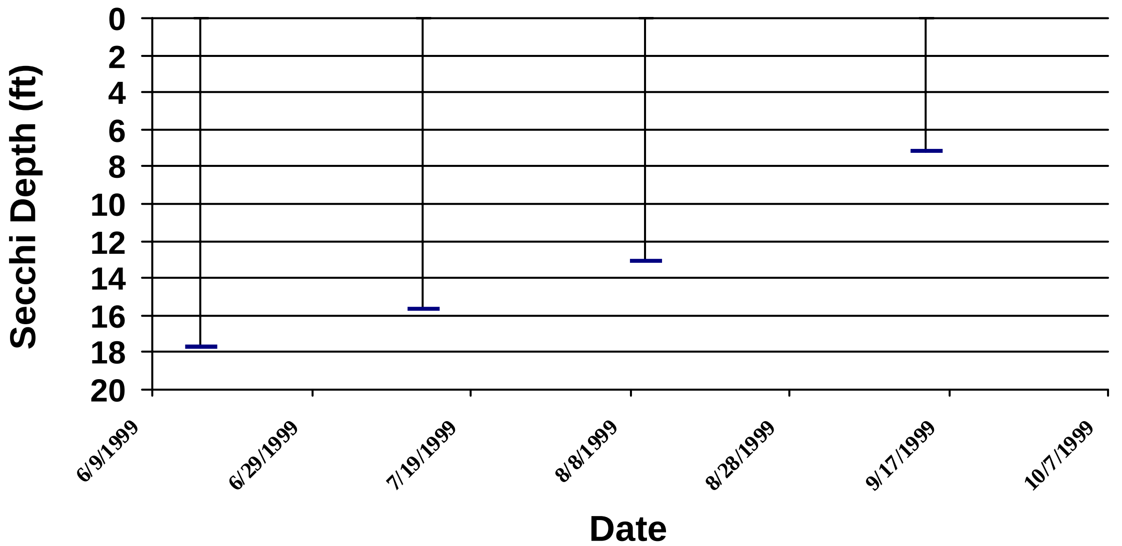
Chemistry Data

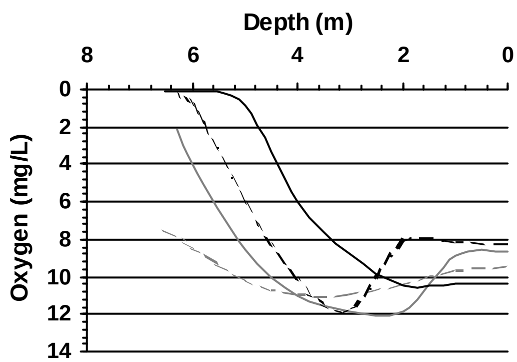
SKOOKUM, NORTH

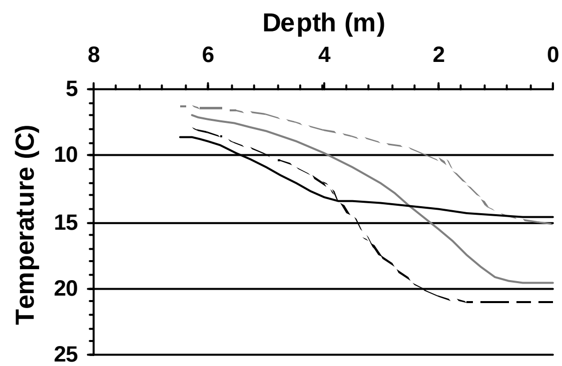
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 1										
6/15/1999	0900	E	25.2	.104	4	1.2		4.19	1290	.9
		H	27.7	.121	4					
7/13/1999	0900	E	12.1	.19	16	1.93				.5 U
		H	13.5	.223	17					
8/10/1999	0845	E	22.2	.264	12	4.6				.7
		H	37	.27	7					
9/14/1999	0900	E	28.4	.561	20	25.9				2
		H	33.9	.317	9					

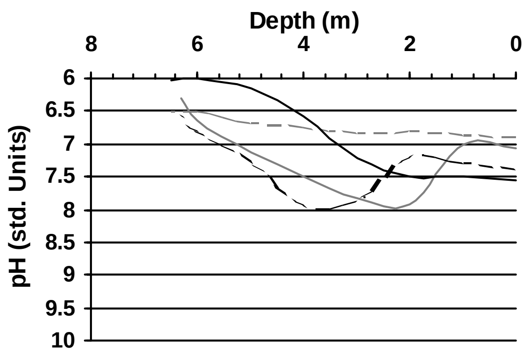
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

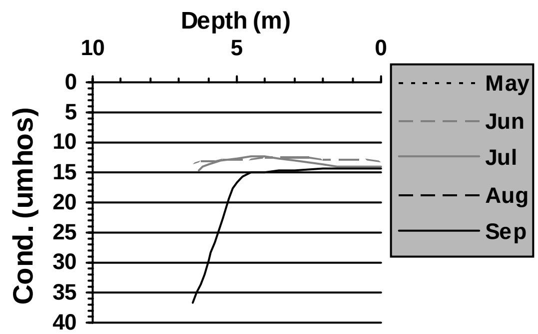
Secchi Depth and Profile Graphics **Station:** 1 SKOPE2











Secchi Data and Field Observations

SKOOKUM, NORTH

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/15/1999			17.72	6	0	2	1	4	4	0	5	0	0
	Sampler: HALLOCK			Remarks:	Bottom 6.5M. Large leeches, osprey, great blue heron. Not much zooplankton. Long-time visitors (5 and 20 years) report more algae at outlet stream last couple years. Lake is exclusively used for fishing. RBT are stocked. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.								
7/13/1999			15.7	7	0	1	1	4	4	0	0	3	
	Sampler: HALLOCK			Remarks:	Bottom 6.4M. Water is brown with tannins. Some faint algae colonies in 5M cast. Lots of salmonid fry near access. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.								
8/10/1999			13.1	7	0	2	1	4	3	0	9		
	Sampler: HALLOCK			Remarks:	Bottom 6.3M. A few campers. Private CG full (32 sites) last weekend, but not busy this year due to cold weather. Large hatch of small midges. Lots of fry rising. Blue-green algae clumps through water column. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.								
9/14/1999			7.2	7	0	1	1	3	2	0	10	0	0
	Sampler: HALLOCK			Remarks:	Bottom: 6.5M. Algae (possibly Anabaena with some Gloeotrichia) fairly thick (took sample). No oxygen below 5M.								

POTHOLES

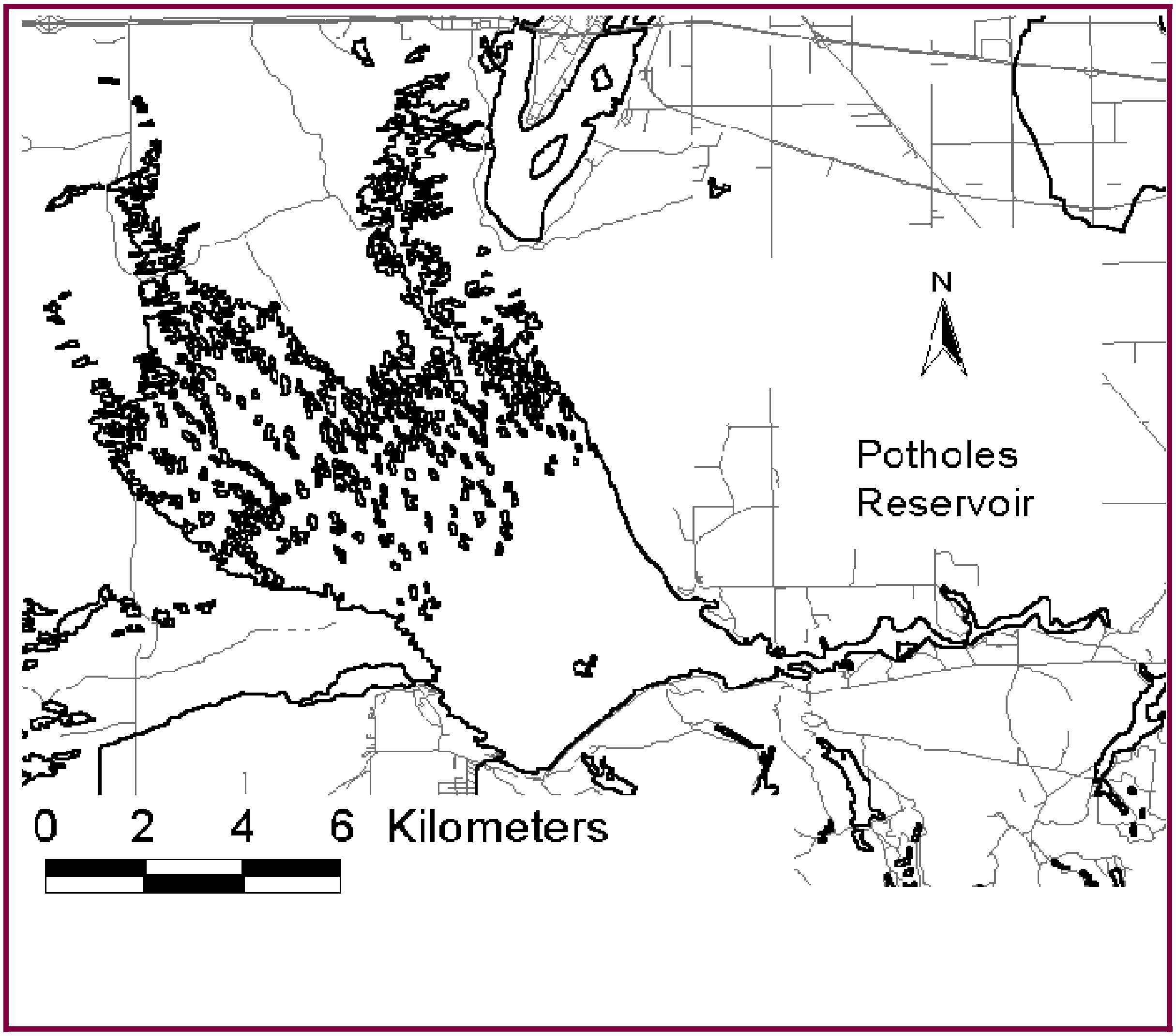
GRANT County

Lake ID: POTGR1

Ecoregion: 7

Potholes Reservoir is approximately 5 miles south of the City of Moses Lake and provides a large recreational opportunity for water enthusiasts. It receives water from Moses Lake and irrigation canals and provides water to the Columbia National Wildlife Refuge and the Seep Lakes Wildlife Area as well as many irrigation canals.

Area (acres)	Maximum Depth (ft)	Mean Depth (ft)	Drainage (sq mi)	
28000	142	18		
Volume (ac-ft)	**Shoreline (miles)**	**Altitude (ft abv msl)**	**Latitude**	**Longitude**
500000		1046	46 58 58.	119 15 49.



Station Information

POTGR1

Primary Station	Station # 1	latitude: 46 59 40.0	longitude: 119 19 53.0
	Description: Approx due east out from State Park launch, half-way to island.		
Secondary Station	Station # 2	latitude: 46 59 30.0	longitude: 119 20 30.0
	Description: From primary station, go parallel to shore about half-way to north-end islands.		

Trophic State Assessment for 1999

POTHOLES

Analyst: Sarah O'Neal

TSI_Secchi: [a]	45	N
TSI_Phos:	54	
TSI_Chl:	64	
Narrative TSI: [b]	E	

Potholes is an enormous waterbody which receives water from extremely eutrophic Moses Lake as well as a number of return waters from various irrigation wasteways. Consequently, high nutrient levels in the reservoir were not surprising. Some internal nutrient loading occurred in the lake, as indicated by elevated hypolimnetic phosphorus concentrations. Anoxia in the lake bottom likely caused the nutrient loading, particularly during late summer. High nutrient levels generated dense algal blooms in the reservoir. This reduced water clarity, especially toward the end of the summer. However, plant growth was not dense. Plants occurred generally only in patches in protected areas. Large water fluctuations likely prevented plants from establishing. Water level fluctuations and an unprotected, largely unvegetated shoreline combined with heavy boat traffic and high winds likely generated high turbidity in the lake.

Questionnaires were not distributed for Potholes this year (see the 1998 LWQAP report). The reservoir is quite popular for water-skiing, jetskiing, swimming, and especially fishing. WDFW stocked the lake with 120,000 rainbow trout annually, which were reared in net pens from October through early Spring when they were released. The trout, in addition to walleye, and largemouth bass were the most popular fish with anglers. Other warmwater fish species in the lake included yellow perch, bluegill, and crappie in addition to smallmouth bass, brown bullhead, carp, and lake whitefish to a lesser extent. The reservoir also served as habitat to an abundance of overwintering waterfowl.

The primary purpose for monitoring Potholes was to support WDFW fisheries work. The system is large and complicated, and our simple sampling design is inadequate to precisely identify a protective nutrient criterion for the lake. Last year we recommended a tentative total phosphorus criterion of 44.0 ug/L. Mean epilimnetic phosphorus concentrations did not exceed that criterion in 1999.

Mean Secchi = 2.7m (N); Mean TP = 31.6 ug/L; Mean Chl = 30.0 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples
[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

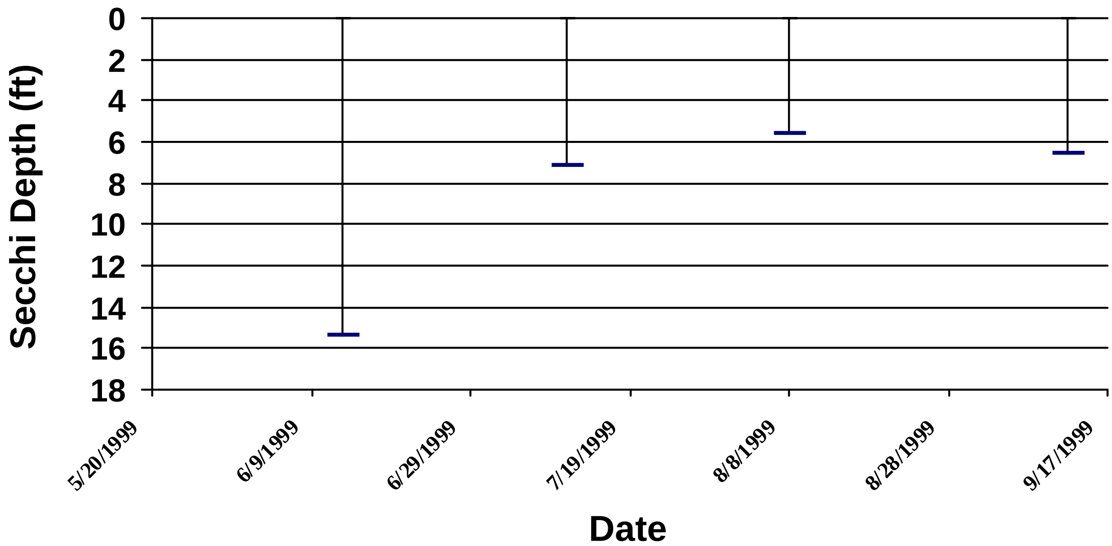
POTHOLES

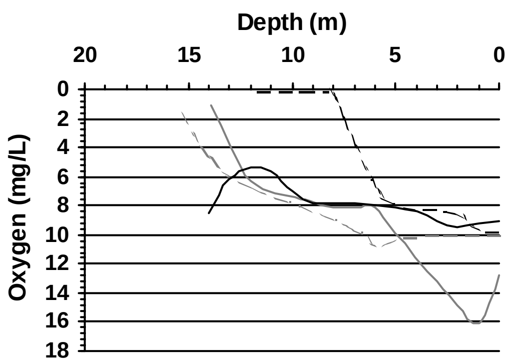
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 1										
6/13/1999	1130	E	17.5	.886	51	4.6		141	29600	1.2
		H	88.4	1.3	15					
7/11/1999	1300	E	32.5	1.21	37	65.4				9.7
		H	25.8	1.07	41					
8/8/1999	1145	E	28.8	.854	30	24.5				6.7 J
		H	51.6	1.17	23					
9/12/1999	1300	E	44.8	1.19	27	35.5				3.5
		H	71.5	1.55 J	22					
Station 2										
6/13/1999	1330	E	18.9	.924	49	4.6				
7/11/1999	1430	E	28.8	.856	30	32.1				
8/8/1999	1250	E	32.1	.885	28	32.1				5.8 J
9/12/1999	1345	E	44.3	1.09	25	36				

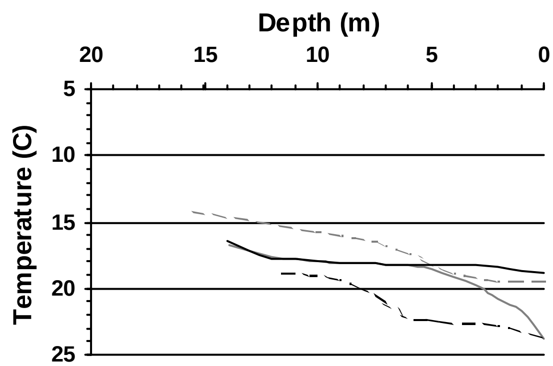
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

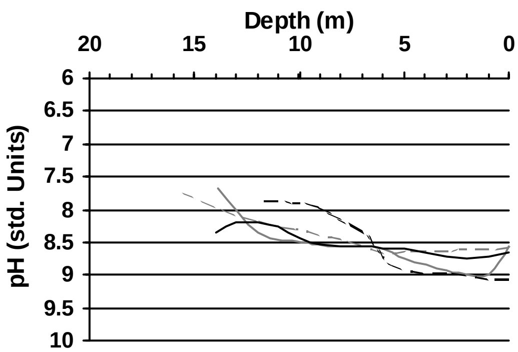
Secchi Depth and Profile Graphics

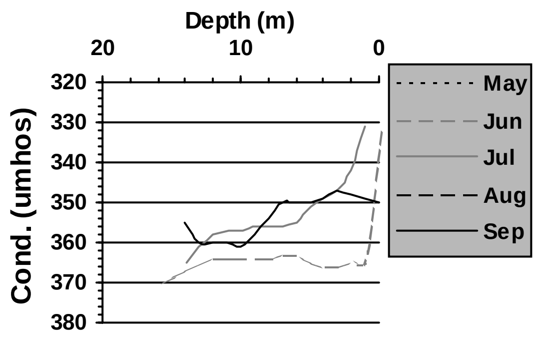
Station: 1 POTGR1











Secchi Data and Field Observations

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/13/1999			15.4		20	3	1	4	4	0	6	5	0
	Sampler:	HALLOCK		Remarks:	The state park is very busy. Water level is high (just above the 9th hold-down on center rail at the SP launch. Bottom at 15.4 M. No clear thermocline, but DO drops at 14M.								
7/11/1999			7.2		0	2	1	3	2	0	12	20	15
	Sampler:	HALLOCK		Remarks:	Very crowded. Bottom at 13.8M. Kids swimming at SP beach.								
8/8/1999			5.6	2	0	2	1	2	2	0	12	18	6
	Sampler:	HALLOCK		Remarks:	Bottom at 11.8M. Water level between 23rd and 24th clamp at rail at SP access.								
9/12/1999			6.6	6	0	2	1	2	1	0	60	30	5
	Sampler:	HALLOCK		Remarks:	Bottom at 13.9M								
Station 2													
6/13/1999			14.1		15	2	1						
	Sampler:	HALLOCK		Remarks:	Bottom at 13.4 M. Site 2 is toward the islands and at the corner of an equilateral triangle with the state park and site 1 as the other two corners.								
7/11/1999			7.9	2	0	2	1						
	Sampler:	HALLOCK		Remarks:	Bottom at 8.0M. 20cm dia clumps of senescing blue-green algae. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.								
8/8/1999			5.2	2	0	2	1						
	Sampler:	HALLOCK		Remarks:									
9/12/1999			5.9	6	0	2	1						
	Sampler:	HALLOCK		Remarks:									

ROWLAND

KLICKITAT County

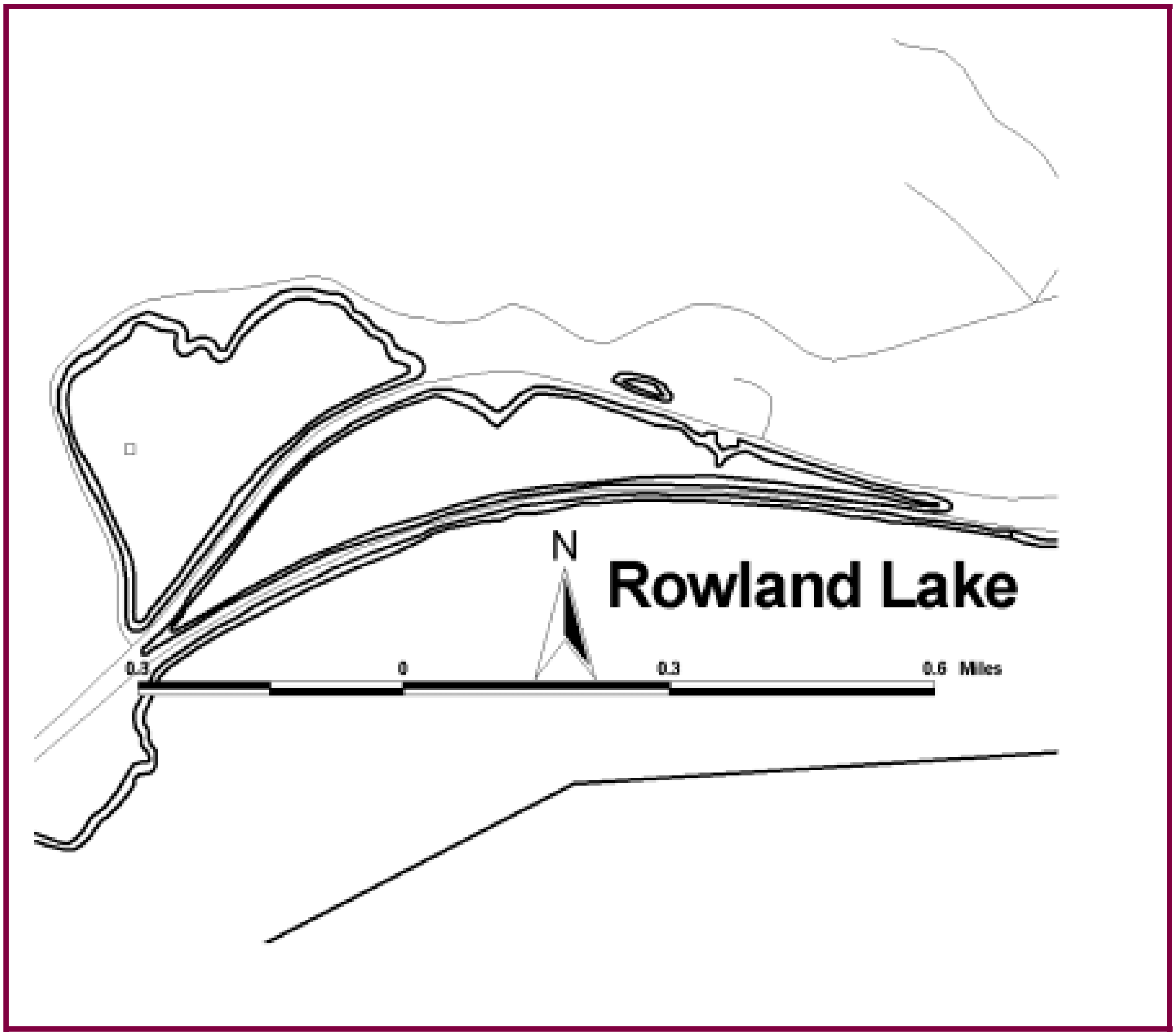
Lake ID: ROWKL1

Ecoregion:

Orginally an arm of the Columbia River. The lake was formed by fill when the railroad was constructed here. The lake was originally called DuBois Lake and is better known by that name locally. It is located 4 miles east from Bingen, adjacent to the north side of Bonneville Pool and connected via culvert.

Area (acres)	*Maximum Depth (ft)*	*Mean Depth (ft)*	*Drainage (sq mi)*
84.7			

Volume (ac-ft)	*Shoreline (miles)*	*Altitude (ft abv msl)*	*Latitude*	*Longitude*
		72		



Station Information

ROWKL1

Primary Station	Station # 1	latitude: 45 42 27.5	longitude: 121 22 50.7
	Description:	Located directly north of southwest tip of northwest portion (about 1200 feet).	

Trophic State Assessment for 1999

ROWLAND

Analyst: Sarah O'Neal

TSI_Secchi: [a]	42	N
TSI_Phos:	57	
TSI_Chl:	57	
Narrative TSI: [b]	E	

Rowland Lake is a small lake formed as a gravel pit during railroad construction. Major transportation corridors, one of which was quite busy, surrounded the lake on all sides. There were no homes around the lake, and, with the major exception of roads, the surrounding area was natural. Despite reasonably good water clarity, total phosphorus and chlorophyll levels in the lake indicated a eutrophic system. Macrophytes grew surpsingly sparsely, and algae was not noted as a particular problem. The lake did not thermally stratify, although dissolved oxygen levels dropped sharply between three and four meters in depth.

We did not conduct aquatic plant or habitat surveys on Rowland Lake due to inclement weather. We received only one completed questionnaire for the lake. The respondent, who primarily fished, desired good coldwater fishing, better parking, and a decrease in plant growth. Field observations indicated that fishing was far and away the most popular activity on the lake. Anecdotal evidence from WDFW indicated that the fishery is impaired. They attempted to improve the fishery with a rotenone rehabilitation in 1968. A 1991 WDFW Survey indicated bluegill were the most abundant species in the lake, with brown bullhead, largemouth bass, yellow perch, pumpkinseed, and squawfish also present. Few rainbow trout utilized the lake, though trout have been planted in the past. High temperatures likely severely stressed coldwater fish such as rainbow trout. In addition, field notes indicated that the lake lacked cover provided by macrophytes, or even human structures. This likely stressed cold- and warmwater species alike. The zooplankton community appeared healthy with a large average size that decreased over the summer, indicating utilization by planktivores. However, this suggests a possibly ineffective number of piscivores to effectively suppress planktivore density. The area surrounding the lake also provided habitat for osprey.

The condition of the lake may not support primary uses, particularly coldwater fishing. However, this is a reflection more of the lake's formation and composition than of its trophic state. Consequently, we recommend a total phosphorous criterion of 51.4 (mean 39.9 ug/L plus standard deviation of 11.5 ug/L). Additionally, methods of introducing structure in the form of aquatic plants, woody debris, or some other form of fish cover should be explored.

Mean Secchi = 3.5m (N); Mean TP = 39.9 ug/L; Mean Chl = 14.4 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

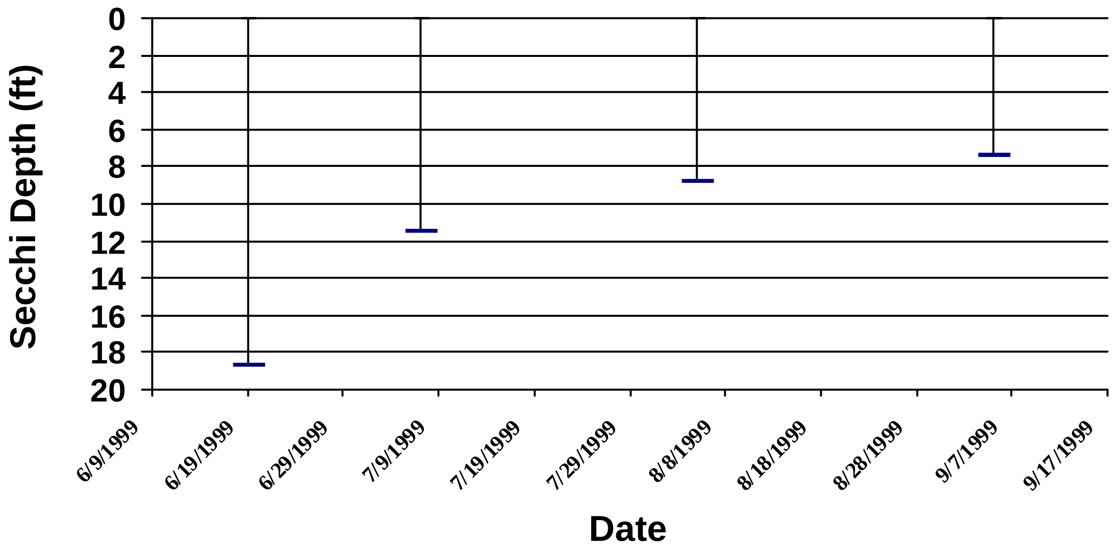
ROWLAND

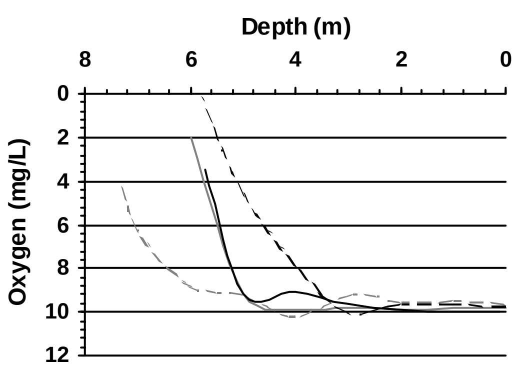
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 1										
6/19/1999		E	40.1	.214	5	6		62.1	16300	
7/7/1999		E	29	.367	13	24.3				
8/5/1999	1300	E	37.3	.315	8	16.1				1.6
9/5/1999	1445	E	45.7	.306	7	15.9				2.5

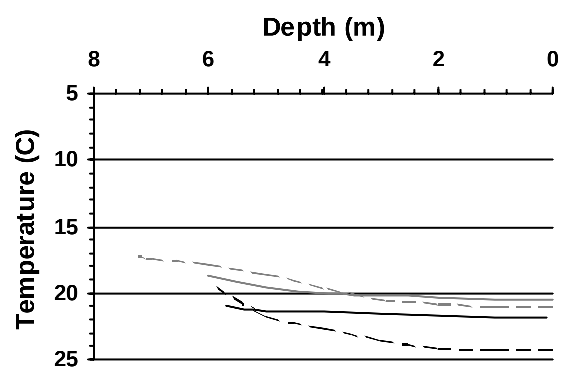
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

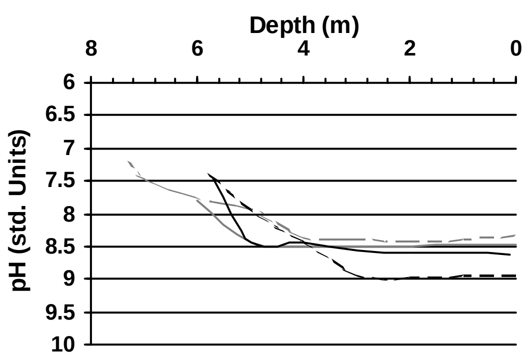
Secchi Depth and Profile Graphics

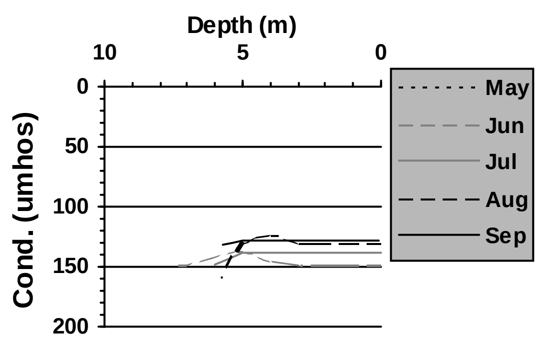
Station: 1 ROWKL1











Secchi Data and Field Observations

ROWLAND

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/19/1999			18.7	2	0	5	1	5	5	0	0	2	0
	Sampler: SMITH			Remarks: People on shore fishing--lots of public access. Lots of large zoo at all depths. Osprey flying above, lots of turkey vultures. Rocky bluffs right off Col. River. 100% road all around lake but most traffic is on Rt. 14.									
7/7/1999			11.48	2	10			5	5	0	0	0	0
	Sampler: SMITH			Remarks:									
8/5/1999			8.86	2	100	1	2	5	5	0	0	2	0
	Sampler: SMITH			Remarks: Osprey observed. Lots of people visiting lake. Six people fishing from shore.									
9/5/1999			7.38	2	0			5	3	0	0	1	0
	Sampler: SMITH			Remarks: Water greener than normal for the season. One osprey fishing.									

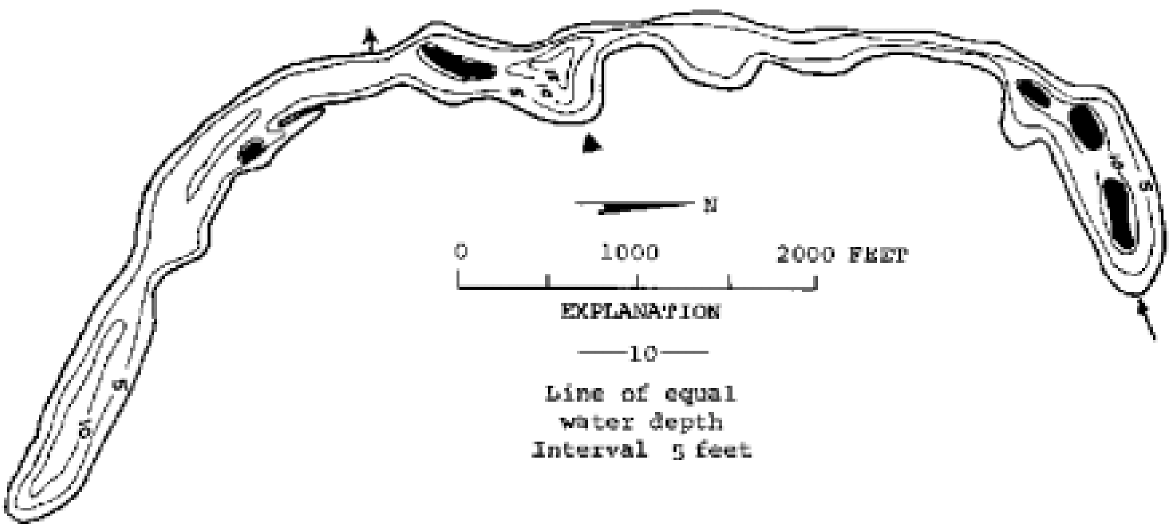
SACAJAWEA

COWLITZ County | **Lake ID:** SACCO1 | **Ecoregion:** 2

Sacajawea Lake is a long, crescent-shaped lake located in the city of Longview. The shoreline is surrounded by a city park. It is supplied with water from the Cowlitz River and drains to an unnamed creek.

Area (acres)	Maximum Depth (ft)	Mean Depth (ft)	Drainage (sq mi)
61	21	6	5

Volume (ac-ft)	Shoreline (miles)	Altitude (ft abv msl)	Latitude	Longitude
353	4.6	10	46 07 39.	122 56 27.



Station Information

SACCO1

Primary Station	Station # 1	latitude:	longitude:
	Description:	Deep part of lake, about 400 feet southwest of boat launch.	

Trophic State Assessment for 1999

SACAJAWEA

Analyst: Sarah O'Neal

TSI_Secchi: [a] 53
TSI_Phos: 67
TSI_Chl: 64
Narrative TSI: [b] E

Lake Sacajawea is a small, long, narrow lake. The exceptionally high shoreline length to area ratio increases its susceptibility to anthropogenic eutrophication. A heavily manicured city park bordered by roads in a highly residential watershed surrounded the lake. Fertilizers were clearly used not only by homeowners in the watershed, but also by city park management. Park lawns attracted, and provided habitat for, hundreds of ducks and even barnyard geese. Waterfowl possibly generated the high fecal bacteria counts measured in June. A small buffer zone around the lake consisted of a monospecific band of a non-native, occasionally aggressive plant, yellow iris (Iris pseudacorus). Few other macrophytes grew either in or around the lake. Grass carp planted in the lake to control aquatic plants eliminated virtually all submerged macrophytes. Water chemistry clearly reflected the human influence on this lake. The trophic state approached hypereutrophy with an average total phosphorus concentration for the summer of 76.6 ug/L. TN:TP ratios indicated possible nitrogen limitation. Nutrient sources were abundant. Elevated hypolimnetic total phosphorus and total nitrogen levels indicate extreme internal nutrient loading. This likely resulted from severe anoxia in the hypolimnion, a problem that the City of Longview attempted to resolve with the installation of a fountain approximately 100 feet from the sample site. Unfortunately, the fountain did not appear to help with the hypolimnetic oxygen deficit in 1999. Other nutrient sources included goose and duck droppings and lawn fertilizers. In spite of high nutrient concentrations, which can often lead to extraordinary algal blooms, problem blooms have not been documented. The lake exhibited exceptionally high conductivity, much higher than the Cowlitz River (the lake's water source) which rarely has conductivities greater than 100 umhos/cm. The water was particularly turbid, possibly due to sediment entering the lake from the Cowlitz River, and exacerbated by the presence of grass carp and lack of macrophytes to filter and anchor particulate matter.

The lake had no public boat access, so uses were restricted to swimming, fishing from the shoreline, and park-related activities. Questionnaires revealed relaxing and watching wildlife as particularly popular uses. Respondents indicated poor water quality for swimming detracted from enjoyment of the lake. The lake supported a surprisingly diverse fishery, considering the lack of cover. WDFW described a fairly balanced population of bass and bluegill. Largemouth bass, bluegill, yellow perch, and warmouth respectively dominated the fishery. Brown and yellow bullhead, largescale sucker, grass carp, common carp, northern pike minnow, and goldfish were also present at lower densities. WDFW stocked the lake annually with brown trout. Trout, in particular, were likely stressed by anoxia in deeper, cooler waters. Small zooplankton sizes indicated a possible overabundance of planktivores relative to piscivores.

The highly eutrophic state of the lake and management practices severely threatened its uses. Relaxing and swimming, while generally supported, had the potential to be dampened by high nutrient levels causing dense algal blooms. The lack of in-lake fish cover as well as hypolimnetic anoxia also endangered fishing. Appropriate nutrient concentrations for Sacajawea Lake are unknown. A more thorough investigation is needed to determine not only appropriate nutrient levels for the lake, but also whether nitrogen is also limiting to the system. Future studies may propose a nitrogen criterion. In the meantime, we recommend a tentative total phosphorous criterion of 101.2 (mean 76.6 ug/L plus standard deviation of 24.6 ug/L) in order to protect against further degradation. Additionally, current management practices for the lake should be re-evaluated.

Mean Secchi = 1.6m; Mean TP = 76.6 ug/L; Mean Chl = 30.5 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

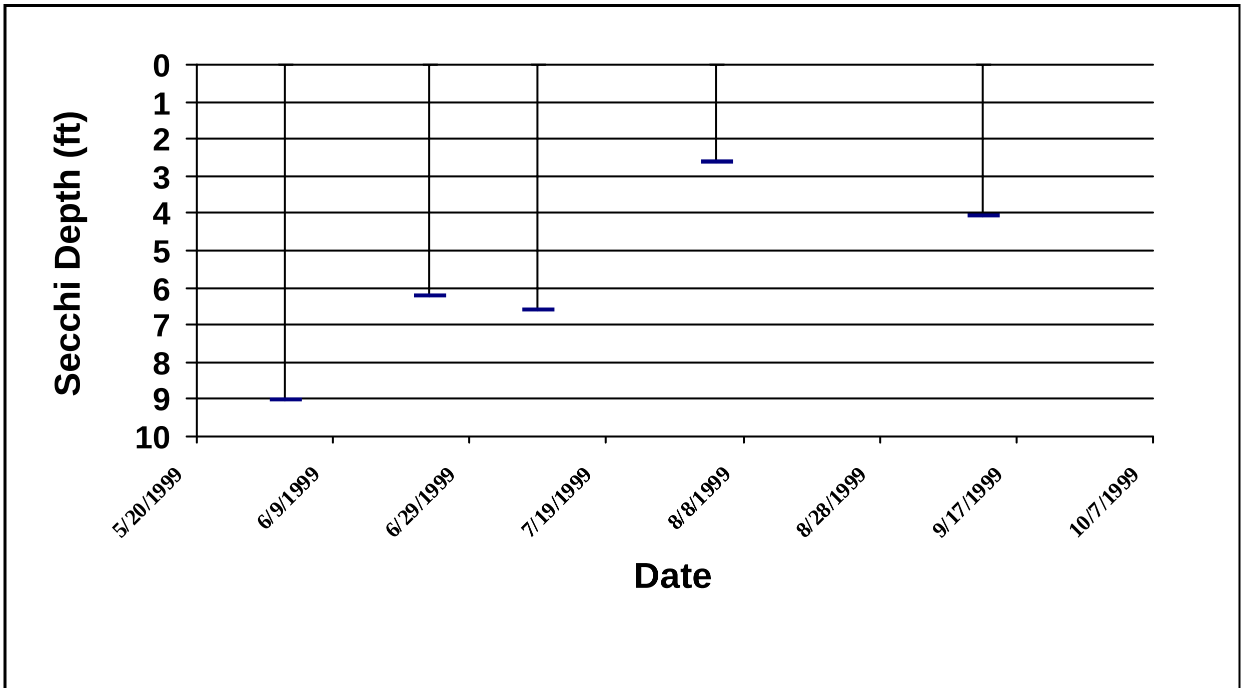
SACAJAWEA

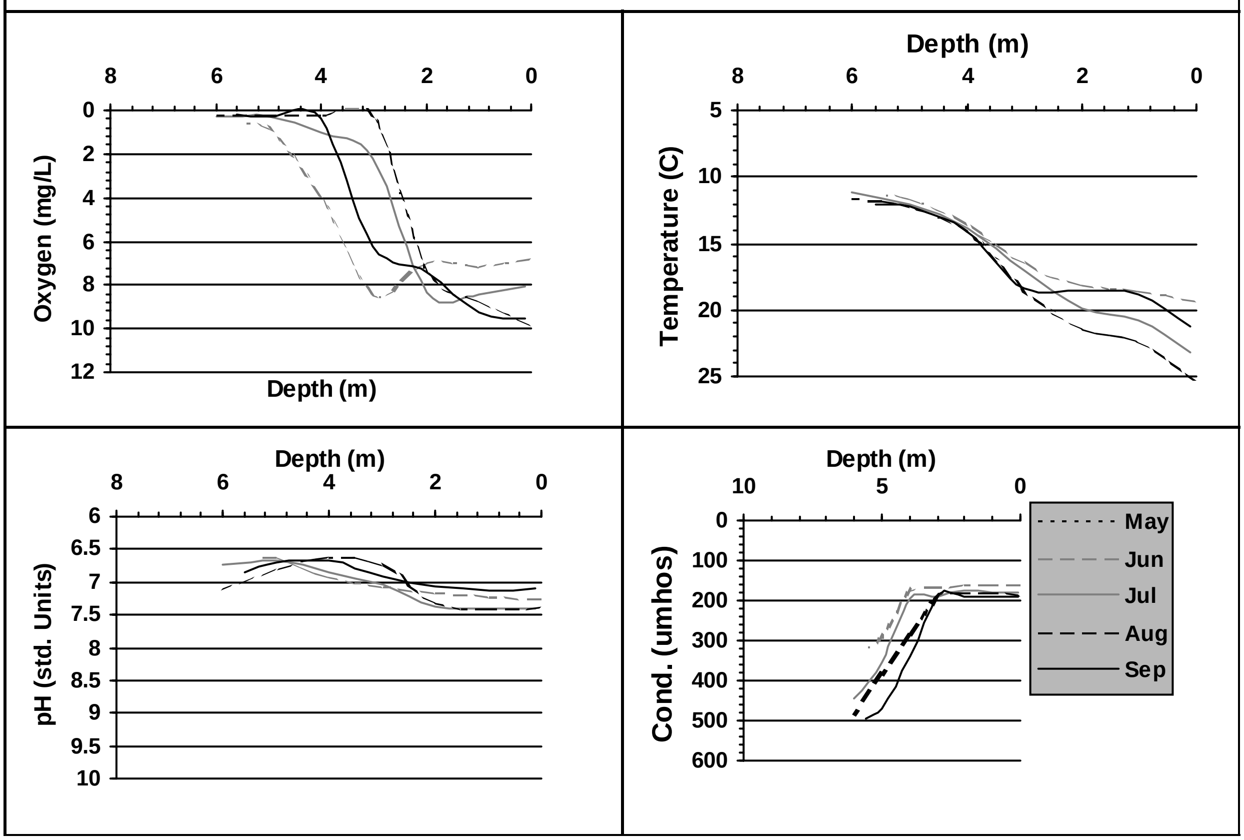
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
6/2/1999		L					60			
		L					150 J			
Station 1										
6/2/1999		E	68	.301	4	3.9		66.4	14200	2.5
		H	110	.606	6					
7/9/1999		E	52.2	.336	6	23.3				
8/4/1999		E	71.9	.618	9	34				6.2
		H	166	1.43	9					
9/12/1999		E	99.9	.461	5	51.4				
		H	114	.544	5					

Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

Secchi Depth and Profile Graphics

Station: 1 SACCO1





Secchi Data and Field Observations

SACAJAWEA

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/2/1999			9.02	2	10	3	1	4	4	0	0	0	0
	Sampler:	SMITH		Remarks:	Water is very turbid near the bottom. Could be sediment from the Cowlitz. Cowlitz pumped into the lake all summer long. Has grass carp. Only iris and some lilies observed--no other macros. Lake is totally enclosed by roads and city park.								
6/23/1999			6.23										
	Sampler:	Parsons		Remarks:									
7/9/1999			6.6	2	0	1	1	5	4	0	28	0	0
	Sampler:	SMITH		Remarks:									
8/4/1999			2.62	7	0	2	1	3	2	0	65	0	0
	Sampler:	SMITH		Remarks:	Water very green this month. Small clumps of algae about the size of a pencil eraser.								
9/12/1999			4.1	8	0			4	2	0	300	0	0
	Sampler:	SMITH		Remarks:	Water is extremely turbid at 4 meters but clearer at 5 meters. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.								

STARVATION

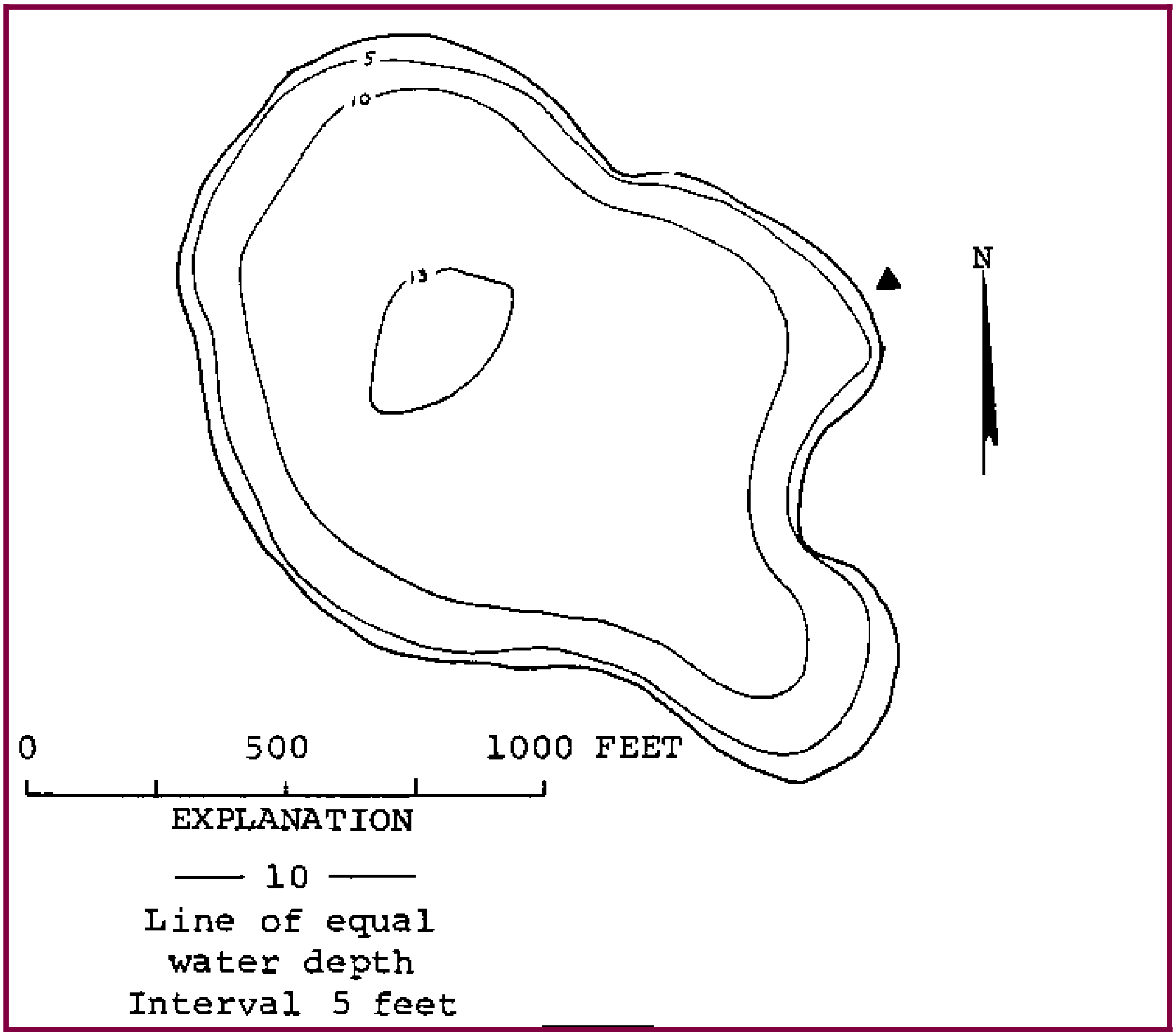
STEVENS County

Lake ID: STAST1

Ecoregion: 8

Starvation Lake is located eight miles southeast of Colville in the Colville National Forest. It is fed by a small creek and has no outlet.

Area (acres)	***Maximum Depth (ft)***	***Mean Depth (ft)***	***Drainage (sq mi)***	
30	14	8	3	
Volume (ac-ft)	***Shoreline (miles)***	***Altitude (ft abv msl)***	***Latitude***	***Longitude***
233	0.88	2375	48 29 24.	117 42 27.



Station Information

STAST1

Primary Station	Station # 1	latitude: 48 29 17.0	longitude: 117 42 45.0
	Description: Deep part of lake: just northwest of center.		

Trophic State Assessment for 1999

STARVATION

Analyst: Sarah O'Neal

TSI_Secchi: [a]	44	BN
TSI_Phos:	65	
TSI_Chl:	58	
Narrative TSI: [b]	E	

Starvation Lake is a small, shallow, highly productive lake located in the Colville National Forest. About twelve people lived around the lake in five homes, several of which appeared to use fertilizers. Varying numbers of cattle grazed in a pasture on the north shore. They occasionally grazed very close to the water. High numbers of both geese and ducks also used the lake as habitat. A wetland surrounded much of the southeastern shore. There were no apparent best management practices in use to prevent watershed activities from impacting the water quality of the lake. The lake lacked buffer zones. A cattle exclusion fence along the inlet stream is needed. High nutrient levels in the lake indicate eutrophy. Some internal nutrient loading probably resulted from apparent hypolimnetic anoxia. Weak or intermittent stratification allowed these nutrients to be periodically cycled into the epilimnion. This resulted in dense plant and algae growth. The macrophyte community was dense, and dominated by one submerged plant, and one floating-leaved plant. The lake experienced tremendous algae blooms for three years prior to sampling, the first of which caused a major summer die off of rainbow trout. Algae decreased toward the end of summer, causing steadily increasing Secchi readings. Total phosphorus concentrations were quite a bit higher than they were during a 1990 survey.

WDFW managed the lake primarily for rainbow trout. About 18,000 were planted each spring. Characteristic of a productive lake, the zooplankton community exhibited a large average size that decreased somewhat toward the end of summer, indicating utilization by planktivores and a possibly ineffective number of piscivores to balance planktivore numbers. Starvation was an extremely popular trout fishing lake with a short take season that lasted from opening day until the end of May. Uses changed to mostly camping and some fly fishing after the first of June. Only two surveys were completed; one respondent also indicated watching wildlife as a primary activity. Many coots, other ducks, turtles, and osprey lived in and around the lake. Questionnaires indicated poor water clarity and aquatic plants as main detractors from the lake, while views, Canada geese, good coldwater fishing, and restricted watercraft were assets.

While surrounding watershed activities clearly impacted the lake, primary uses were largely supported by the eutrophic state of this productive lake. There was evidence of degradation of water quality. Pending a more thorough study, including a nutrient budget analysis, we recommend a tentative total phosphorus criterion of 90.0 ug/L (mean 68.4 ug/L plus standard deviation of 21.6 ug/L). Future studies will likely recommend lowering this criterion. In the meantime, best management practices should be implemented in the watershed.

Mean Secchi = 3.1m (BN); Mean TP = 68.4 ug/L; Mean Chl = 16.1 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

Chemistry Data

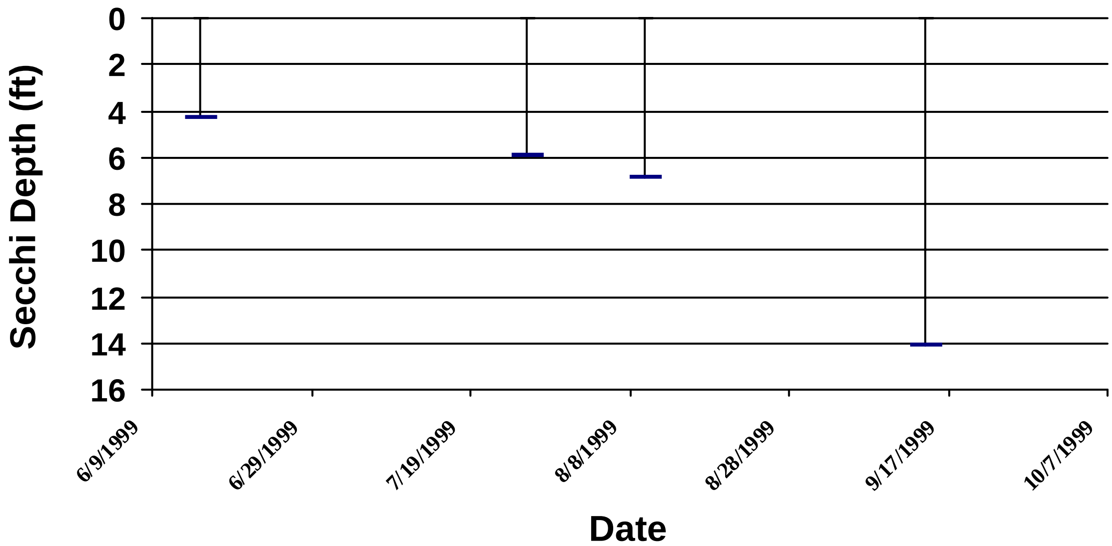
STARVATION

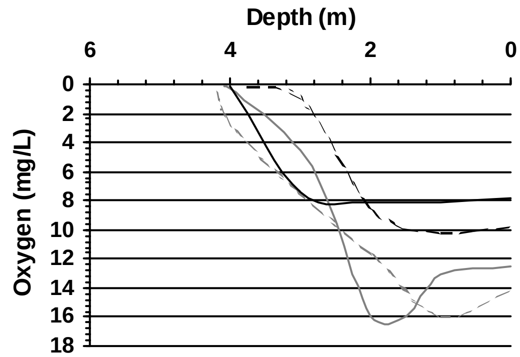
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 0										
6/15/1999		L					1			
7/13/1999		L					4			
8/10/1999		L					1			
9/14/1999		L					1			
Station 1										
6/15/1999		E	60.3	.998	17	28		164	46700	4.6
		H	57	.625	11					
7/13/1999		E	43	1.03	24	13.2				2.7
		H	66.9	1.19	18					
8/10/1999		E	39.9	1.19	30	20.5				2.1
		H	49.5	1.18	24					
9/14/1999		E	109	1.14	10	3.8				.8

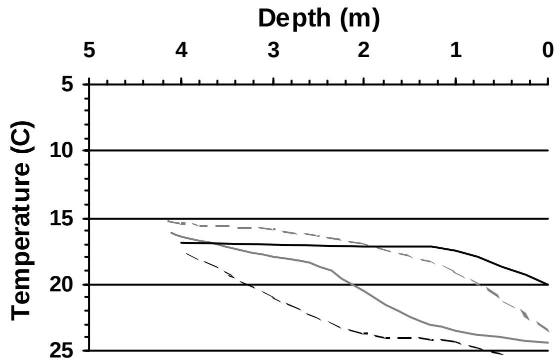
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

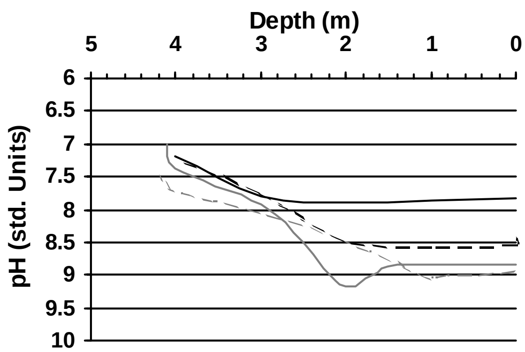
Secchi Depth and Profile Graphics

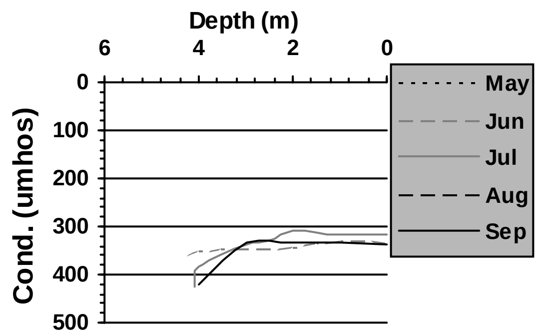
Station: 1 STAST1











Secchi Data and Field Observations

STARVATION

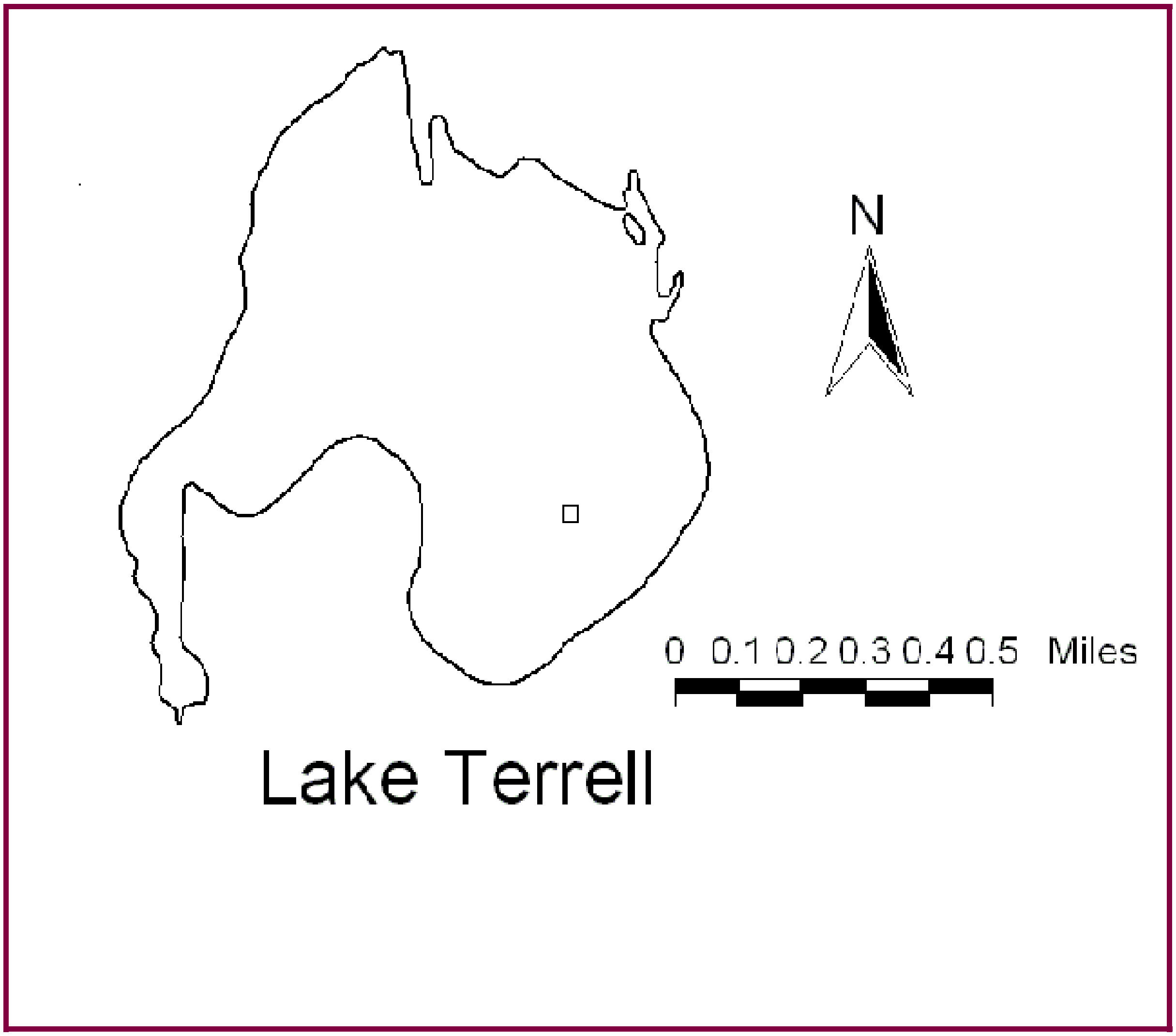
Date	Time	Temperature (F)	Secchi (ft)	Color (1-greens, 11-browns	Brightness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/15/1999			4.3	7	5	2	1	2	1	7	40		
	Sampler: HALLOCK			Remarks:	Bottom: 4.2M. ~20 cattle but not w/in 100ft of lake. 1M oxygen high--off scale. Other waterfowl mostly coots. All fecal coliform samples from this lake were collected from end of pier the day after collecting other samples. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.								
7/13/1999					0	2	1	2	1	12	45		
	Sampler: HALLOCK			Remarks:	bottom: 4.2M. No Secchi reading! 1.5-2.5M oxygen off scale (probably entered coontail mat). Curt Vail (DFW) says ~12 people live on the lake in 5 houses. ~30 cattle. Lots of algae, lots of turtles. Waterfowl are mostly coots, 1 osprey. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.								
7/26/1999			5.91										
	Sampler: Parsons			Remarks:									
8/10/1999			6.9	6	5	2	1	2	1	0	45		
	Sampler: HALLOCK			Remarks:	Bottom 3.9M. Stevens Co. Cons. Dist. will be continuing to study the lake next year. Starvation is very popular for fishing early in the season and has excellent opening day catch statistics. Dissolved oxygen measurement qualified as an estimate due to calibration failing QA/QC requirements.								
9/14/1999			14.11 B	6	1	1	1	2	1	14	40		
	Sampler: HALLOCK			Remarks:	Bottom: 4.0M. Secchi visible on bottom. Still plenty of Anabaena or Microcystis (?) clumps but water is much clearer than previously. Bottom sediments very soft. Not stratified.								

TERRELL WHATCOM County *Lake ID:* TERWH1

Ecoregion: 2

Lake Terrell is a shallow lake surrounded mostly by a wildlife refuge. There is also access for livestock along the west shore. Some of the habitat has been altered to favor Canada goose reproduction and to attrack other waterfowl. It is located five miles west of the city of Ferndale, north of Bellingham. It is fed by an intermittent, unnamed tributary and drains via Terrell Creek to Birch Bay.

Area (acres)	Maximum Depth (ft)	Mean Depth (ft)	Drainage (sq mi)	
435	10	7	3	
Volume (ac-ft)	**Shoreline (miles)**	**Altitude (ft abv msl)**	**Latitude**	**Longitude**
2950	3.84	212	48 52 10.	122 41 19.



Station Information

TERWH1

Primary Station	Station # 1	latitude: 48 51 44.0	longitude: 122 41 02.8
	Description: Located approximately 1500 feet northeast of boat launch.		

Trophic State Assessment for 1999

TERRELL

Analyst: Sarah O'Neal

TSI_Secchi: [a]	53	WB
TSI_Phos:	55	
TSI_Chl:	56	
Narrative TSI: [b]	E	

Terrell Lake is a mid-sized, extremely shallow, productive lake surrounded by a wildlife refuge. Land uses in the watershed were primarily agriculture, with some natural land provided for wildlife. Cattle grazed on agricultural land, and used the lake for watering since there was no fencing to limit access. The lake may be naturally eutrophic. Nutrient levels were not exceptionally high and the lake did not stratify, so there was no evident internal nutrient loading or hypolimnetic anoxia. Dense vegetation surrounded the shoreline, which lacked significant human influence. Cattle grazing and alteration of habitat to favor Canada geese and other waterfowl likely impacted the lake, however. Plants and algae grew densely in the lake. There was an extremely diverse macrophyte community, with no dominant species. The invasive wetland plant, purple loosestrife (Lythrum salicaria), grew around the lake, but not in excess. Frequent floating mats of algae and blue green scum reduced water clarity. Questionnaire respondents indicated a desire for less algae.

The lake was used primarily for hunting and fishing. Questionnaire respondents indicated a desire for good warmwater fishing and public access. The lack of primary contact uses made water clarity and nutrient loading less important as in other lakes. A secondary use of the lake was livestock watering. Since the lake was not used for primary contact recreation, allowing livestock a small watering access to the lake may not present a threat to the beneficial uses. The lake and its surroundings provided an abundance of natural habitat for fish and wildlife. WDFW planted the lake annually with channel catfish. Resident cutthroat trout were also occasionally planted in the lake. No anadromous fish used the lake due to a water-regulating dam at the outlet. According to WDFW officials, it is highly probable that sea-run cutthroat trout formerly used the lake to access its intermittent tributaries for spawning. It is unknown whether or not coho salmon may have used the lake in the past. Warmwater fish species included largemouth bass, brown bullhead, perch, channel catfish and bluegill. The small average zooplankton size indicated a possible overabundance of prey species relative to predators. Fishing was open year round on the lake, though it received only about 50 anglers on opening day in 1999.

Beneficial uses appeared to be largely supported. Since the lake was not generally used for primary contact recreation, dense plants and algae did not appear to hinder uses. Consequently, we recommend a total phosphorus criterion of 41.0 ug/L (mean 34.5 ug/L plus standard deviation of 6.5 ug/L).

Mean Secchi = 1.6m WB; Mean TP = 34.5 ug/L; Mean Chl = 13.1 ug/L

[a] TSI Qualifiers: B or W-Secchi Disk hit bottow or entered weeds; J-Estimate; N-Fewer than the required number of samples

[b] E=eutrophic, ME=mesoeutrophic, M=mesotrophic, OM=oligomesotrophic, O=oligotrophic

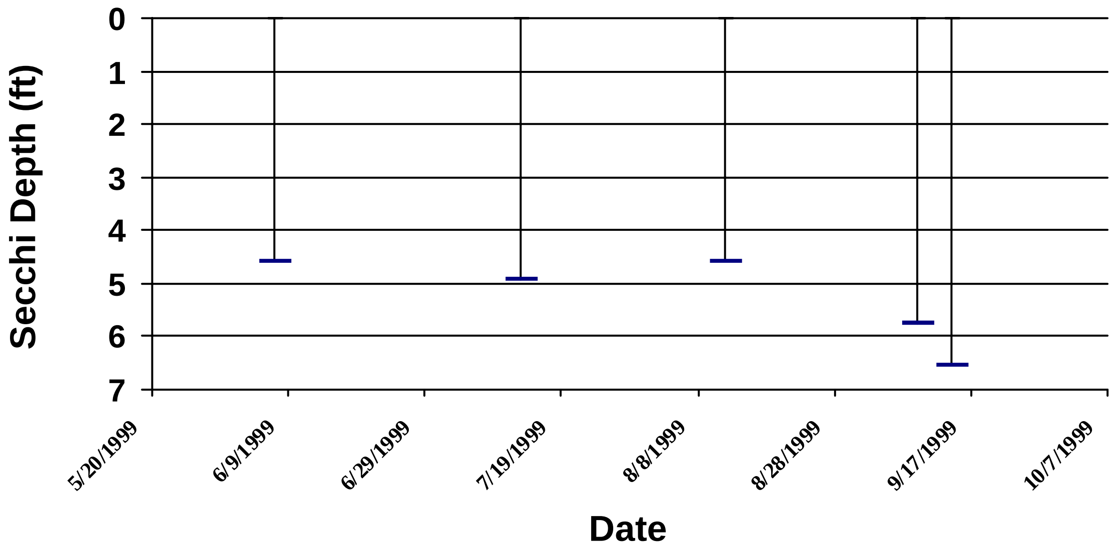
Chemistry Data

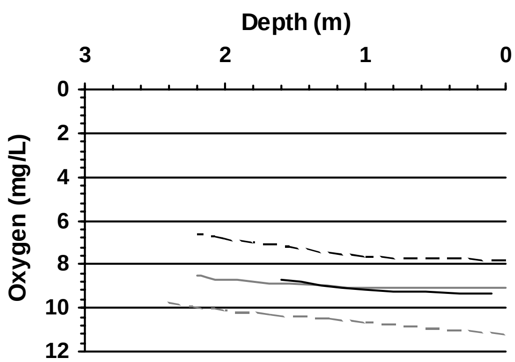
TERRELL

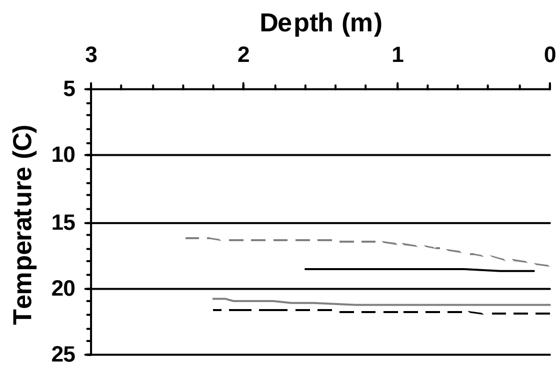
Date	Time	Strata	Tot P (ug/L	Tot N (mg/L)	TN:TP	Chloro-phyll (ug/L)	Fecal Col. Bacteria (#/100mL)	Hardness (mg/L)	Calcium (ug/L)	Turbidity (NTU)
Station 1										
6/7/1999		E	28.9	.933	32	16.8		32.4	6820	
7/13/1999	1209	E	32.2	.828	26	12.6				2.3
8/12/1999		E	45.8	.878	19	12.4				
9/9/1999	1100	E	34.1	.732	21	10.7				3

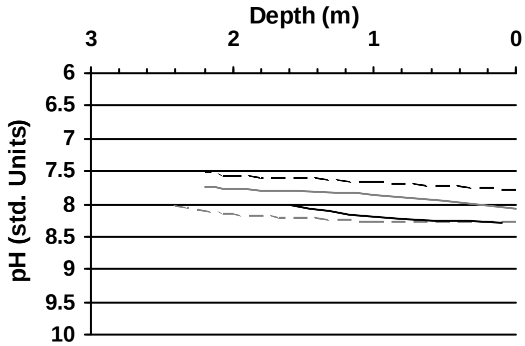
Strata: L=lake surface, E=epilimnion, H=hypolimnion; Qualifier: J=Estimate, U=Less than, G=Greater than.

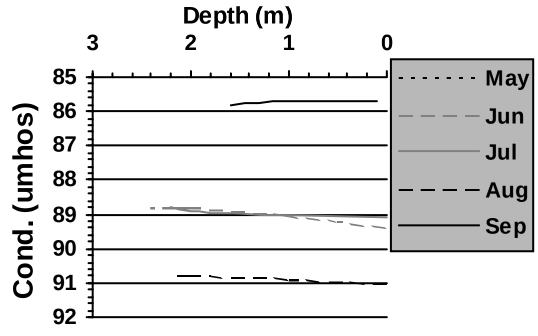
Secchi Depth and Profile Graphics **Station:** 1 TERWH1











Secchi Data and Field Observations

TERRELL

Date	Time	Temp-erature (F)	Secchi (ft)	Color (1-greens, 11-browns	Bright-ness (pct)	Wind (1-none, 5-gusty)	Rainfall (0-none, 5-heavy)	Aesthetics (1-bad, 5-good)	Swimming (1-poor, 5-good)	Geese (#)	Waterfowl (besides geese #)	Boats-Fishing (#)	Boats-Skiing (#)
Station 1													
6/7/1999			4.59	6	0			5	3	200	0	3	0
	Sampler: SMITH			Remarks: Many swallows flying above water.									
7/13/1999			4.92 W	7	0	3		5	1	46		3	0
	Sampler: SMITH			Remarks: Geese are raised by wildlife refuge so actual population may not reflect a natural state.									
8/12/1999			4.59	9	80			5	1	2	0	1	0
	Sampler: SMITH			Remarks: Plants starting to senesce.									
9/9/1999			5.74	8	100			5	2	130	35	2	0
	Sampler: SMITH			Remarks: Olive-green algal bloom. Livestock all along west shoreline in the lake. No fencing to limit access. Milfoil spotted on east shore. Huge algal mats in water. Large Bryozoans.									
9/14/1999			6.56 B										
	Sampler: Parsons			Remarks:									

Appendix C

Quality Assurance/Quality Control Results for 1999

For details on procedures for evaluating QC data see Ecology's *Lake Water Quality Assessment Project Quality Assurance Project Plan* (in draft) (Hallock, 1995). This appendix is an evaluation of laboratory data in accordance with the quality assurance project plan.

Appendix C - Quality Assurance/Quality Control Results for 1999

1999 TOTAL PHOSPHOROUS DATA

TOTAL PHOSPHOROUS LAB SPLITS

Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%	Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Harts	6/1/1998	93.8	93.1	93.45	0.49	0.53	Duck	7/5/1999	36.3	36.4	36.4	0.07	0.19
Sacajawea	6/3/1999	68.0	72.0	70.00	2.83	4.04	Harts	7/10/1999	54.7	54.6	54.7	0.07	0.13
Duck	6/5/1999	60.0	60.1	60.05	0.07	0.12	Desire	7/12/1999	20.2	21.9	21.1	1.20	5.71
Potholes	6/13/1999	17.5	19.9	18.70	1.70	9.08	Long	7/12/1999	21.0	24.4	22.7	2.40	10.59
Long	6/14/1999	21.5	21.6	21.55	0.07	0.33	Gillette	7/14/1999	22.3	21.6	22.0	0.49	2.26
				Median CV %		**0.53**	Big	7/15/1999	14.1	12.1	13.1	1.41	10.80
							Curlew	7/15/1999	15.7	14.5	15.1	0.85	5.62
											Median CV %		**5.62**
Sacajawea	8/4/1999	71.9	70.1	71.0	1.27	1.79	Rowland	9/5/1999	45.7	47.0	46.4	0.92	1.98
Deer	8/9/1999	21.7	23.2	22.5	1.06	4.72	Terrel	9/9/1999	34.1	35.2	34.7	0.78	2.24
Starvation	8/10/1999	39.9	44.6	42.3	3.32	7.87	Martha	9/10/1999	8.45	8.06	8.26	0.28	3.34
Martha	8/11/1999	11.1	9.46	10.28	1.16	11.28	Potholes	9/12/1999	44.3	41.8	43.1	1.77	4.11
Curlew	8/12/1999	14.4	16.2	15.3	1.27	8.32	Duck	9/15/1999	41.7	42.6	42.2	0.64	1.51
Desire	8/13/1999	28.2	26.8	27.5	0.99	3.60	Gillette	9/15/1999	22.8	22.8	22.8	0.00	0.00
				Median CV %		**6.30**	Desire	9/16/1999	31.3	31.8	31.6	0.35	1.12
											Median CV %		**1.98**

All total phosphorous lab splits fall within the acceptable limit of median CV less than 7.5%.

TOTAL PHOSPHOROUS NONSEQUENTIAL DUPLICATES

Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%	Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Duck	6/5/1999	66.5	60	63.25	4.60	7.3	Duck	7/5/1999	35.0	36.3	35.65	0.92	2.6
Martha	6/10/1999	11.9	13.1	12.5	0.85	6.8	Potholes	7/11/1999	28.8	45.1	36.95	11.53	31.2
Potholes	6/13/1999	18.9	16.1	17.5	1.98	11.3	Desire	7/12/1999	21.4	20.2	20.8	0.85	4.1
Gillette	6/16/1999	23.2	24.5	23.85	0.92	3.9	Gillette	7/14/1999	22.3	22.9	22.6	0.42	1.9
Curlew	6/17/1999	22.9	23.5	23.2	0.42	1.8	Curlew	7/15/1999	13.0	15.7	14.35	1.91	13.3
Desire	6/21/1999	22.3	24.0	23.15	1.20	5.2	Martha	7/16/1999	11.1	15.6	13.35	3.18	23.8
				Median CV %		**5.99**					**Median CV %**		**8.69**

Appendix C - Quality Assurance/Quality Control Results for 1999

TOTAL PHOSPHOROUS NONSEQUENTIAL DUPLICATES (continued)													
Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%	Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Potholes	8/8/1999	32.1	31.1	31.6	0.71	2.2	Martha	9/10/1999	8.45	12.1	10.275	2.58	25.1
Gillette	8/11/1999	23.5	22.7	23.1	0.57	2.4	Potholes	9/12/1999	44.3	46.0	45.15	1.20	2.7
Martha	8/11/1999	11.1	14.2	12.65	2.19	17.3	Duck	9/15/1999	41.7	42.0	41.85	0.21	0.5
Curlew	8/12/1999	14.4	15.7	15.05	0.92	6.1	Gillette	9/15/1999	22.8	23.4	23.1	0.42	1.8
Desire	8/13/1999	28.2	26.9	27.55	0.92	3.3	Curlew	9/16/1999	22.0	21.8	21.9	0.14	0.6
				Median CV %		**3.34**	Desire	9/16/1999	31.3	36.0	33.65	3.32	9.9
											Median CV %		**2.25**

All total phosphorous nonsequential duplicates fall within the acceptable limit of median CV less than 21%.

TOTAL PHOSPHOROUS SEQUENTIAL DUPLICATES													
Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%	Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Duck	6/5/1999	66.5	47.2	56.85	13.647	24.01	Duck	7/5/1999	45.6	35.0	40.3	7.50	18.6
Martha	6/10/1999	15.1	11.9	13.5	2.2627	16.76	Potholes	7/11/1999	32.5	28.8	30.65	2.62	8.5
Potholes	6/13/1999	17.5	18.9	18.2	0.9899	5.44	Desire	7/12/1999	21.2	21.4	21.3	0.14	0.7
Long	6/14/1999	21.5	21.6	21.55	0.0707	0.33	Long	7/12/1999	21.0	20.0	20.5	0.71	3.4
Curlew	6/17/1999	23.7	22.9	23.3	0.5657	2.43	Gillette	7/14/1999	23.1	22.3	22.7	0.57	2.5
Desire	6/21/1999	21.6	22.3	21.95	0.495	2.26	Curlew	7/15/1999	10.5	13.0	11.75	1.77	15.0
				Median CV %		**3.93**	Martha	7/16/1999	12.4	11.1	11.75	0.92	7.8
											Median CV %		**7.82**
Potholes	8/8/1999	28.8	32.1	30.45	2.3335	7.66	Martha	9/10/1999	11.1	8.45	9.775	1.87	19.2
Long	8/9/1999	12.4	14.0	13.2	1.1314	8.57	Potholes	9/12/1999	44.8	44.3	44.55	0.35	0.8
Long	8/9/1999	23.2	30.8	27	5.374	19.90	Long	9/13/1999	19.1	24.9	22	4.10	18.6
Gillette	8/11/1999	22.4	23.5	22.95	0.7778	3.39	Long	9/13/1999	43.2	27.2	35.2	11.31	32.1
Martha	8/11/1999	11.2	11.1	11.15	0.0707	0.63	Duck	9/15/1999	32.5	41.7	37.1	6.51	17.5
Curlew	8/12/1999	16.3	14.4	15.35	1.3435	8.75	Gillette	9/15/1999	22.1	22.8	22.45	0.49	2.2
Desire	8/13/1999	27.5	28.2	27.85	0.495	1.78	Curlew	9/16/1999	22.2	22.0	22.1	0.14	0.6
				Median CV %		**7.66**	Desire	9/16/1999	26.7	31.3	29	3.25	11.2
											Median CV %		**14.38**

There is no QAPP standard for total phosphorous sequential duplicates.

Appendix C - Quality Assurance/Quality Control Results for 1999

1999 TOTAL NITROGEN DATA

TOTAL NITROGEN LAB SPLITS

Lake	Date	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%	Lake	Date	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%
Harts	6/1/1999	1.140	1.130	1.135	0.007	0.6	Duck	7/5/1999	0.507	0.497	0.502	0.007	1.4
Terrel	6/7/1999	0.933	0.947	0.940	0.010	1.1	Duck	7/5/1999	0.645	0.623	0.634	0.016	2.5
Rowland	6/19/1999	0.214	0.214	0.214	0.000	0.0	Potholes	7/11/1999	1.21	1.28	1.245	0.049	4.0
Deer	6/14/1999	0.250	0.254	0.252	0.003	1.1	Desire	7/12/1999	0.468	0.468	0.468	0.000	0.0
				Median CV %		**0.84**	Starvation	7/13/1999	1.03	1.00	1.015	0.021	2.1
							Gillette	7/14/1999	0.209	0.207	0.208	0.001	0.7
							Curlew	7/15/1999	0.375	0.379	0.377	0.003	0.8
							Martha	7/16/1999	0.571	0.661	0.616	0.064	10.3
											Median CV %		**1.75**
Long	8/9/1999	1.27	1.28	1.275	0.007	0.6	Rowland	9/5/1999	0.306	0.312	0.309	0.004	1.4
Gillette	8/11/1999	0.206	0.216	0.211	0.007	3.4	Martha	9/10/1999	0.415	0.413	0.414	0.001	0.3
Gillette	8/11/1999	3.05	3.07	3.060	0.014	0.5	Potholes	9/12/1999	1.09	1.06	1.075	0.021	2.0
Martha	8/11/1999	0.652	0.647	0.650	0.004	0.5	Desire	9/16/1999	0.716	0.711	0.714	0.004	0.5
Terrel	8/12/1999	0.878	0.870	0.874	0.006	0.6					**Median CV %**		**0.93**
Desire	8/13/1999	0.496	0.487	0.492	0.006	1.3							
				Median CV %		**0.60**							

All total nitrogen lab splits fall within the acceptable limit of CV less than 5%.

TOTAL NITROGEN NONSEQUENTIAL DUPLICATES

Lake	Date	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%	Lake	Date	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%
							Duck	7/5/1999	0.600	0.645	0.6225	0.032	5.11
											Median CV %		**5.11**

All total nitrogen nonsequential duplicates fall within the acceptable limit of CV less than 30%

Appendix C - Quality Assurance/Quality Control Results for 1999

TOTAL NITROGEN SEQUENTIAL DUPLICATES													
Lake	Date	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%	Lake	Date	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%
Duck	6/5/1999	0.505	0.611	0.558	0.07	13.4	Duck	7/5/1999	0.507	0.600	0.5535	0.07	11.9
Martha	6/10/1999	0.455	0.448	0.4515	0.00	1.1	Potholes	7/11/1999	1.21	0.856	1.033	0.25	24.2
Potholes	6/13/1999	0.886	0.924	0.905	0.03	3.0	Desire	7/12/1999	0.468	0.489	0.4785	0.01	3.1
Long	6/14/1999	0.273	0.298	0.2855	0.02	6.2	Long	7/12/1999	0.372	0.726	0.549	0.25	45.6
Curlew	6/17/1999	0.35	0.326	0.338	0.02	5.0	Gillette	7/14/1999	0.216	0.209	0.2125	0.00	2.3
Desire	6/21/1999	0.372	0.419	0.3955	0.03	8.4	Curlew	7/15/1999	0.369	0.375	0.372	0.00	1.1
				Median CV %		**5.61**	Martha	7/16/1999	0.584	0.571	0.5775	0.01	1.6
											Median CV %		**3.10**
Potholes	8/8/1999	0.854	0.885	0.8695	0.02	2.5	Martha	9/10/1999	0.416	0.415	0.4155	0.00	0.2
Long	8/9/1999	0.519	0.577	0.548	0.04	7.5	Potholes	9/12/1999	1.19	1.09	1.14	0.07	6.2
Long	8/9/1999	1.16	1.27	1.215	0.08	6.4	Long	9/13/1999	0.873	0.770	0.8215	0.07	8.9
Gillette	8/11/1999	0.206	0.208	0.207	0.00	0.7	Long	9/13/1999	1.30	1.090	1.195	0.15	12.4
Martha	8/11/1999	0.637	0.652	0.6445	0.01	1.6	Gillette	9/15/1999	0.193	0.192	0.1925	0.00	0.4
Curlew	8/12/1999	0.392	0.372	0.382	0.01	3.7	Curlew	9/16/1999	0.358	0.397	0.3775	0.03	7.3
Desire	8/13/1999	0.475	0.496	0.4855	0.01	3.1	Desire	9/16/1999	0.601	0.716	0.6585	0.08	12.3
				Median CV %		**3.06**					**Median CV %**		**7.31**

There is no QAPP standard for total nitrogen sequential duplicates.

Appendix C - Quality Assurance/Quality Control Results for 1999

1999 CHLOROPHYLL A DATA

CHLOROPHYLL A LAB SPLITS

Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%	Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Starvation	6/15/1999	28.0	27.7	27.9	0.21	0.8	Duck	7/5/1999	28.6	29.1	28.9	0.35	1.2
				Median CV %		**0.8**					**Median CV %**		**1.2**
							Potholes	9/12/1999	36.0	34.1	35.1	1.34	3.8
							Desire	9/16/1999	37.6	37.8	37.7	0.14	0.4
											Median CV %		**0.3**

All chlorophyll a lab splits fall within the acceptable limit of CV less than 10%.

CHLOROPHYLL A NONSEQUENTIAL DUPLICATES

Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%	Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Potholes	6/13/1999	4.6	4.6	4.6	0	0.0	Duck	7/5/1999	27.8	28.6	28.2	0.566	2.0
Gillette	6/16/1999	1.2	1.2	1.2	0	0.0	Potholes	7/11/1999	32.1	34.0	33.05	1.344	4.1
Curlew	6/17/1999	3.7	3.4	3.55	0.21213	6.0	Desire	7/12/1999	9.91	11.6	10.755	1.195	11.1
Desire	6/21/1999	10.9	10.8	10.85	0.07071	0.7	Gillette	7/14/1999	1.57	1.65	1.61	0.057	3.5
				Median CV %		**0.33**	Martha	7/16/1999	11.6	11.3	11.45	0.212	1.9
											Median CV %		**3.51**
Potholes	8/8/1999	32.1	25.0	28.6	5.02046	17.6	Potholes	9/12/1999	36.0	37.9	36.95	1.344	3.6
Gillette	8/11/1999	1.4	1.5	1.45	0.07071	4.9	Gillette	9/15/1999	1.8	1.8	1.8	0	0.0
Curlew	8/12/1999	2.5	2.5	2.5	0	0.0	Curlew	9/16/1999	3.1	3.1	3.1	0	0.0
				Median CV %		**4.88**					**Median CV %**		**0.00**

There is no QAPP standard for chlorophyll a nonsequential duplicates.

Appendix C - Quality Assurance/Quality Control Results for 1999

CHLOROPHYLL A SEQUENTIAL DUPLICATES													
Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%	Lake	Date	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Duck	6/5/1999	15.7	19.9	17.8	2.970	16.7	Duck	7/5/1999	45.3	27.8	36.55	12.374	33.9
Martha	6/10/1999	8.1	8.2	8.15	0.071	0.9	Potholes	7/11/1999	65.4	32.1	48.75	23.547	48.3
Potholes	6/13/1999	4.6	4.6	4.6	0.000	0.0	Desire	7/12/1999	10.7	9.91	10.305	0.559	5.4
Long	6/14/1999	5.8	3.9	4.85	1.344	27.7	Long	7/12/1999	2.68	5.71	4.195	2.143	51.1
Curlew	6/17/1999	3.5	3.7	3.6	0.141	3.9	Gillette	7/14/1999	1.81	1.57	1.69	0.170	10.0
Desire	6/21/1999	7.9	10.9	9.4	2.121	22.6	Curlew	7/15/1999	1.93	2.13	2.03	0.141	7.0
				Median CV %		**10.31**	Martha	7/16/1999	10.5	11.6	11.05	0.778	7.0
											Median CV %		**10.04**
Potholes	8/8/1999	24.5	32.1	28.3	5.374	19.0	Martha	9/10/1999	3.2	3.0	3.1	0.141	4.6
Long	8/9/1999	1.9	6.7	4.3	3.394	78.9	Potholes	9/12/1999	35.5	36.0	35.75	0.354	1.0
Gillette	8/11/1999	1.4	1.4	1.4	0.000	0.0	Long	9/13/1999	14.6	4.5	9.55	7.142	74.8
Martha	8/11/1999	11.2	11.6	11.4	0.283	2.5	Duck	9/15/1999	15.7	9.6	12.65	4.313	34.1
Curlew	8/12/1999	2.5	2.5	2.5	0.000	0.0	Gillette	9/15/1999	1.7	1.8	1.75	0.071	4.0
Desire	8/13/1999	22.5	17.6	20.1	3.465	17.3	Curlew	9/16/1999	2.9	3.1	3	0.141	4.7
				Median CV %		**9.88**	Desire	9/16/1999	25.7	37.6	31.65	8.415	26.6
											Median CV %		**4.71**

All chlorophyll a sequential duplicates are within the acceptable limit of 10% median CV.

Appendix C - Quality Assurance/Quality Control Results for 1999

1999 TURBIDITY DATA

TURBIDITY LAB SPLITS

Lake	Date	#1 (NTU)	#2 (NTU)	Difference	Lake	Date	#1 (NTU)	#2 (NTU)	Difference
Harts	6/1/1999	2.6	2.7	0.1	Desire	7/12/1999	1.5	1.7	0.2
Sacajawea	6/3/1999	2.5	2.4	0.1	Big	7/15/1999	1.2	1.3	0.1
Loomis	6/4/1999	4.1	4.1	0.0	Long	7/12/1999	2.3	2.3	0.0
Campbell	6/8/1999	8.3	8.4	0.1	Potholes	7/16/1998	5.5	5.4	0.1
McMurray	6/9/1999	0.7	0.7	0.0			**Maximum difference =**		**0.2**
Martha	6/10/1999	0.8	0.9	0.1					
Potholes	6/13/1999	1.2	1.2	0.0					
N.Skookum	6/15/1999	0.9	1.0	0.1					
Curlew	6/17/1998	0.6	0.6	0.0					
Desire	6/21/1999	1.3	1.2	0.1					
		Maximum difference =		**0.1**					
Sacajawea	8/4/1999	6.2	6.2	0.0	Rowland	9/5/1999	2.5	2.5	0.0
Rowland	8/5/1999	1.6	1.5	0.1	Terrel	9/9/1999	3.0	3.1	0.1
Long	8/9/1999	1.5	1.6	0.1	Potholes	9/12/1999	3.5	3.5	0.0
Desire	8/13/1999	1.4	1.5	0.1	Curlew	9/16/1999	0.6	0.5	0.1
		Maximum difference =		**0.1**			**Maximum difference =**		**0.1**

All turbidity splits are within 0.5 NTU and are considered acceptable.

TURBIDITY NONSEQUENTIAL DUPLICATES

Lake	Date	#1 (NTU)	#2 (NTU)	Difference	Mean	S	CV%
Long	6/14/1999	2.3	2.9	0.6	2.6	0.4	16.32
						Median CV %	**16.32**
Long	7/12/1999	1.1	2.3	1.2	1.7	0.8	49.91
						Median CV %	**49.91**
Potholes	8/8/1999	6.7	5.8	0.9	6.25	0.6	10.18
Long	8/9/1999	0.6	1.5	0.9	1.05	0.6	60.61
						Median CV %	**35.40**
Long	9/13/1999	0.8	1.5	0.7	1.15	0.5	43.04
						Median CV %	**43.04**

There are no QAPP requirements for turbidity nonsequential duplicates.

Appendix D

Hydrolab® Quality Assurance/Quality Control Results for 1999

For details on procedures for evaluating Hydrolab® QC data see Ecology's *Lake Water Quality Assessment Project Quality Assurance Project Plan* (in draft) (Hallock, 1995) or see the Hydrolab® post-calibration results of any prior Ecology lake water quality assessment program annual report.

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

DO NONSEQUENTIAL DUPLICATES

Lake	Depth	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%
Desire	0	9.49	9.08	9.285	0.289914	3.12
6/21/1999	1	9.34	9.07	9.205	0.190919	2.07
	2	9.67	9.48	9.575	0.13435	1.40
	3	10.3	9.92	10.11	0.268701	2.66
	4	0.7	0.43	0.565	0.190919	33.79
	4.5	0.46	0.4	0.43	0.042426	9.87
				Median CV%		**2.89**
Potholes	0.1	10.24	10.26	10.25	0.014142	0.14
8/8/1999	1	10.38	10.61	10.495	0.162635	1.55
	2	9.76	9.99	9.875	0.162635	1.65
	3	8.85	9.14	8.995	0.205061	2.28
	4	8.13	8.26	8.195	0.091924	1.12
	5	7.98	7.93	7.955	0.035355	0.44
	6	6.09	4.92	5.505	0.827315	15.03
	7	1.58	1.73	1.655	0.106066	6.41
	7.2	1.29	1.1	1.195	0.13435	11.24
Long	0	9.48	8.98	9.23	0.353553	3.83
8/9/1999	1	8.76	8.61	8.685	0.106066	1.22
	2	8.08	9.91	8.995	1.294005	14.39
Desire	0	8.8	8.5	8.65	0.212132	2.45
8/13/1999	1	8.53	8.3	8.415	0.162635	1.93
	2	7.96	7.74	7.85	0.155563	1.98
	3	0.39	0.84	0.615	0.318198	51.74
	4	0.44	0.21	0.325	0.162635	50.04
	4.4	0.18	0.14	0.16	0.028284	17.68
				Median CV%		**2.37**

Lake	Depth	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%
Potholes	0.1	10.99	11.33	11.16	0.240416	2.15
7/11/1999	1	11	11.24	11.12	0.169706	1.53
	3	8.98	8.97	8.975	0.007071	0.08
	4	8.58	8.7	8.64	0.084853	0.98
	5	8.03	8.05	8.04	0.014142	0.18
	6	7.61	7.58	7.595	0.021213	0.28
	8	6.29	6.06	6.175	0.162635	2.63
Desire	0	8.22	7.81	8.015	0.289914	3.62
7/12/1999	1	8.31	8.31	8.31	0	0.00
	2	9.3	9.1	9.2	0.141421	1.54
	3	5.03	3.92	4.475	0.784889	17.54
	4	2.74	2.08	2.41	0.46669	19.36
	4.4	2.1	2.07	2.085	0.021213	1.02
				Median CV%		**1.53**
Martha	0	9.14	8.83	8.985	0.219203	2.44
9/10/1999	1	9.1	9.19	9.145	0.06364	0.70
	2	9.01	9.36	9.185	0.247487	2.69
	3	8.95	8.86	8.905	0.06364	0.71
	4	7.84	8.43	8.135	0.417193	5.13
	6	1.52	1.22	1.37	0.212132	15.48
	7	2.24	2.07	2.155	0.120208	5.58
	8	4.11	3.17	3.64	0.66468	18.26
	10	3.31	3.14	3.225	0.120208	3.73
	11	3.1	2.9	3	0.141421	4.71
Potholes	0	10.52	10.46	10.49	0.042426	0.40
9/12/1999	1	10.16	10.33	10.245	0.120208	1.17
	2	9.41	9.46	9.435	0.035355	0.37
	3	8.57	8.52	8.545	0.035355	0.41
	4	7.71	7.7	7.705	0.007071	0.09
	4.7	7.48	7.45	7.465	0.021213	0.28
Desire	0	11.21	10.89	11.05	0.226274	2.05
9/16/1999	1	10.96	10.85	10.905	0.077782	0.71
	2	10.99	10.81	10.9	0.127279	1.17
	3	10.11	10.62	10.365	0.360624	3.48
	4	0.26	0.25	0.255	0.007071	2.77
	4.3	0.19	0.17	0.18	0.014142	7.86
				Median CV%		**2.24**

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

DO SEQUENTIAL DUPLICATES

Lake	Depth	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%	Lake	Depth	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%
Duck	0	8.04	9	8.52	0.678823	7.97	Gillette	0	10.61	10.63	10.620	0.014142	0.13
6/5/1999	1	8.68	12.05	10.365	2.38295	22.99	6/16/1999	1	10.62	10.37	10.495	0.176777	1.68
	2	9.78	12.12	10.95	1.65463	15.11		2	11.75	11.64	11.695	0.077782	0.67
Martha	0	10.4	10.43	10.415	0.021213	0.20		3	13.56	13.82	13.690	0.183848	1.34
6/10/1999	1	10.47	10.5	10.485	0.021213	0.20		4	11.76	12.03	11.895	0.190919	1.61
	2	10.47	10.7	10.585	0.162635	1.54		5	7.15	7.01	7.080	0.098995	1.40
	3	10.37	10.07	10.22	0.212132	2.08		6	0.78	0.98	0.880	0.141421	16.07
	4	7.81	7.36	7.585	0.318198	4.20		8	0.6	0.56	0.580	0.028284	4.88
	5	5.96	6.2	6.08	0.169706	2.79		10	0.43	0.49	0.460	0.042426	9.22
	6	6.69	6.26	6.475	0.304056	4.70		12	0.31	0.43	0.370	0.084853	22.93
	8	8.02	8.21	8.115	0.13435	1.66		14	0.29	0.39	0.340	0.070711	20.80
	10	7.32	7.21	7.265	0.077782	1.07		16	0.29	0.33	0.310	0.028284	9.12
Potholes	0	9.99	10.17	10.08	0.127279	1.26		18	0.25	0.31	0.280	0.042426	15.15
6/13/1999	1	10.02	10.15	10.085	0.091924	0.91		20	0.23	0.27	0.250	0.028284	11.31
	2	10.02	10.18	10.1	0.113137	1.12	Curlew	0	9.97	10.01	9.990	0.028284	0.28
	4	10.15	10.4	10.275	0.176777	1.72	6/17/1999	1	9.99	10.06	10.025	0.049497	0.49
	6	10.66	10.25	10.455	0.289914	2.77		2	9.97	10.09	10.030	0.084853	0.85
	8	8.89	8.6	8.745	0.205061	2.34		3	10.59	10.92	10.755	0.233345	2.17
	10	7.7	7.47	7.585	0.162635	2.14		4	10.19	10.47	10.330	0.19799	1.92
	12	6.7	5.94	6.320	0.537401	8.50		6	8.48	8.29	8.385	0.13435	1.60
Long	0	11.06	10.77	10.915	0.205061	1.88		8	6.66	6.79	6.725	0.091924	1.37
6/14/1999	1	11.29	11	11.145	0.205061	1.84		10	6.25	5.76	6.005	0.346482	5.77
	2	11.63	11.05	11.340	0.410122	3.62		12	5.29	5.07	5.180	0.155563	3.00
	3	11.79	11.05	11.420	0.523259	4.58		14	5.07	4.84	4.955	0.162635	3.28
	4	11.67	10.95	11.310	0.509117	4.50		16	4.7	4.57	4.635	0.091924	1.98
	6	11.41	10.84	11.125	0.403051	3.62		18	4.61	4.57	4.590	0.028284	0.62
	8	10.69	10.83	10.760	0.098995	0.92		20	4.63	4.15	4.390	0.339411	7.73
	10	10.91	10.8	10.855	0.077782	0.72		25	3.17	2.17	2.670	0.707107	26.48
	12	11.04	10.79	10.915	0.176777	1.62		30	0.84	1.02	0.930	0.127279	13.69
	14	10.97	10.75	10.860	0.155563	1.43	Desire	0	9.08	9.49	9.285	0.289914	3.12
							6/21/1999	1	9.06	9.34	9.200	0.19799	2.15
								2	9.01	9.67	9.340	0.46669	5.00
								3	9.17	10.3	9.735	0.799031	8.21
								4	0.79	0.7	0.745	0.06364	8.54
											Median CV%		**2.16**

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

DO SEQUENTIAL DUPLICATES (CONT'D)													
Lake	Depth	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%	Lake	Depth	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%
Potholes	0	12.75	10.99	11.870	1.244508	10.48	Gillette	0	9.93	9.68	9.805	0.176777	1.80
7/11/1999	1	16.03	11	13.515	3.556747	26.32	7/14/1999	1	9.88	9.7	9.790	0.127279	1.30
	3	13.22	8.98	11.100	2.998133	27.01		2	11.15	11.13	11.140	0.014142	0.13
	5	9.94	8.03	8.985	1.350574	15.03		3	14.45	14.24	14.345	0.148492	1.04
	6	8.12	7.61	7.865	0.360624	4.59		4	16.03	16.27	16.150	0.169706	1.05
	8	8.06	6.29	7.175	1.251579	17.44		5	5.2	6.15	5.675	0.671751	11.84
Desire	0	8.77	8.22	8.495	0.388909	4.58		6	0.58	0.58	0.580	0	0.00
7/12/1999	1	8.72	8.31	8.515	0.289914	3.40		8	0.19	0.27	0.230	0.056569	24.60
	2	9.59	9.3	9.445	0.205061	2.17		10	0.18	0.2	0.190	0.014142	7.44
	3	7.75	5.03	6.390	1.92333	30.10		15	0.16	0.18	0.170	0.014142	8.32
	4	0.34	2.74	1.540	1.697056	110.20		20	0.16	0.16	0.160	0	0.00
Long	0	9.66	9.81	9.735	0.106066	1.09	Curlew	0	8.87	8.77	8.820	0.070711	0.80
7/12/1999	1	9.93	9.96	9.945	0.021213	0.21	7/15/1999	1	8.8	8.7	8.750	0.070711	0.81
	2	10.08	10.12	10.100	0.028284	0.28		2	8.79	8.73	8.760	0.042426	0.48
	4	11.81	11.48	11.645	0.233345	2.00		3	8.7	8.73	8.715	0.021213	0.24
	5	11.24	10.81	11.025	0.304056	2.76		4	8.82	8.9	8.860	0.056569	0.64
	6	10.42	9.79	10.105	0.445477	4.41		6	6.88	7.04	6.960	0.113137	1.63
	8	9.8	9.4	9.600	0.282843	2.95		8	4.83	4.68	4.755	0.106066	2.23
	10	9.38	9.05	9.215	0.233345	2.53		10	3.76	3.75	3.755	0.007071	0.19
	12	9.02	8.82	8.920	0.141421	1.59		20	3.12	2.69	2.905	0.304056	10.47
	14	8.79	8.44	8.615	0.247487	2.87		25	0.26	0.29	0.275	0.021213	7.71
								30	0.15	0.16	0.155	0.007071	4.56
											Median CV%		**2.53**

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

DO SEQUENTIAL DUPLICATES (CONT'D)

Lake	Depth	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%
Potholes	0	9.75	10.24	9.995	0.346482	3.47
8/8/1999	1	9.61	10.38	9.995	0.544472	5.45
	2	8.55	9.76	9.155	0.855599	9.35
	3	8.3	8.85	8.575	0.388909	4.54
	4	8.21	8.13	8.17	0.056569	0.69
	5	7.9	7.98	7.94	0.056569	0.71
	6	6.8	6.09	6.445	0.502046	7.79
	7	3.96	1.58	2.77	1.682914	60.76
Long	1	8.6	9.07	8.835	0.33234	3.76
8/9/1999	2	8.46	8.84	8.65	0.268701	3.11
	4	8.87	9.84	9.355	0.685894	7.33
	6	9.45	8.17	8.81	0.905097	10.27
	8	8.02	7.13	7.575	0.629325	8.31
	10	7.37	7.22	7.295	0.106066	1.45
	12	6.69	7	6.845	0.219203	3.20
	14	6.69	6.45	6.57	0.169706	2.58
	16	6.42	5.99	6.205	0.304056	4.90
Gillette	0	8.71	8.5	8.605	0.148492	1.73
8/11/1999	1	8.71	8.45	8.58	0.183848	2.14
	2	8.68	8.55	8.615	0.091924	1.07
	3	13.33	12.65	12.99	0.480833	3.70
	4	16.11	14.94	15.525	0.827315	5.33
	5	13.32	13.69	13.505	0.26163	1.94
	6	0.87	1.18	1.025	0.219203	21.39
	8	0.47	0.45	0.46	0.014142	3.07
	10	0.36	0.34	0.35	0.014142	4.04
	15	0.38	0.28	0.33	0.070711	21.43
	20	0.31	0.26	0.285	0.035355	12.41

Lake	Depth	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%
Curlew	0	7.76	7.85	7.805	0.06364	0.82
8/12/1999	1	8.23	8.01	8.12	0.155563	1.92
	2	8.21	8.05	8.13	0.113137	1.39
	3	8.15	7.79	7.97	0.254558	3.19
	4	8.1	7.82	7.96	0.19799	2.49
	5	8.34	7.49	7.915	0.601041	7.59
	6	8.4	6.55	7.475	1.308148	17.50
	8	4.25	3.59	3.92	0.46669	11.91
	10	2.75	2.19	2.47	0.39598	16.03
	15	0.98	1.08	1.03	0.070711	6.87
	20	0.71	0.69	0.7	0.014142	2.02
	25	0.19	0.17	0.18	0.014142	7.86
Desire	0	8.71	8.8	8.755	0.06364	0.73
8/13/1999	1	8.65	8.53	8.59	0.084853	0.99
	2	7.08	7.96	7.52	0.622254	8.27
	3	0.34	0.39	0.365	0.035355	9.69
	4	0.43	0.44	0.435	0.007071	1.63
				Median CV%		**3.76**

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

DO SEQUENTIAL DUPLICATES (CONT'D)

Lake	Depth	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%
Martha	0	9.13	9.14	9.135	0.007071	0.08
9/10/1999	1	9.13	9.1	9.115	0.021213	0.23
	2	9.05	9.01	9.03	0.028284	0.31
	3	9.05	8.95	9	0.070711	0.79
	4	8.13	7.84	7.985	0.205061	2.57
	6	1.16	1.52	1.34	0.254558	19.00
	7	3.08	2.24	2.66	0.59397	22.33
	8	3.35	4.11	3.73	0.537401	14.41
	10	3.75	3.31	3.53	0.311127	8.81
	11	3.02	3.1	3.06	0.056569	1.85
Potholes	0	9.1	10.52	9.81	1.004092	10.24
9/12/1999	1	9.25	10.16	9.705	0.643467	6.63
	2	9.5	9.41	9.455	0.06364	0.67
	3	9.03	8.57	8.8	0.325269	3.70
	4	8.44	7.71	8.075	0.516188	6.39
	5	8.12	7.48	7.8	0.452548	5.80
Long	0	8.87	8.89	8.88	0.014142	0.16
9/13/1999	1	8.82	8.84	8.83	0.014142	0.16
	2	8.81	8.72	8.765	0.06364	0.73
	4	8.78	8.6	8.69	0.127279	1.46
	6	8.64	8.27	8.455	0.26163	3.09
	8	7.58	7.78	7.68	0.141421	1.84
	10	5.27	7.69	6.48	1.711198	26.41
	12	4.94	8.2	6.57	2.305168	35.09
	14	5.18	8.85	7.015	2.595082	36.99
	16	5.55	8.92	7.235	2.38295	32.94

Lake	Depth	#1 (mg/L)	#2 (mg/L)	Mean	S	CV%
Gillette	0	9.25	9.24	9.245	0.007071	0.08
9/15/1999	1	9.23	9.22	9.225	0.007071	0.08
	2	9.21	9.16	9.185	0.035355	0.38
	4	9.32	9.22	9.27	0.070711	0.76
	5	10.25	9.55	9.9	0.494975	5.00
	6	1.12	0.96	1.04	0.113137	10.88
	8	0.21	0.21	0.21	0	0.00
	10	0.17	0.2	0.185	0.021213	11.47
	15	0.15	0.15	0.15	0	0.00
Curlew	0	9.28	9.38	9.33	0.070711	0.76
9/16/1999	2	9.22	9.23	9.225	0.007071	0.08
	4	9.21	9.17	9.19	0.028284	0.31
	6	8.58	8.83	8.705	0.176777	2.03
	8	1.44	0.7	1.07	0.523259	48.90
	10	0.25	0.23	0.24	0.014142	5.89
	20	0.12	0.15	0.135	0.021213	15.71
	25	0.11	0.13	0.12	0.014142	11.79
	30	0.11	0.13	0.12	0.014142	11.79
Desire	0	11.32	11.21	11.265	0.077782	0.69
9/16/1999	1	11.22	10.96	11.09	0.183848	1.66
	2	7.79	10.99	9.39	2.262742	24.10
	3	4.47	10.11	7.29	3.988082	54.71
	4	0.33	0.26	0.295	0.049497	16.78

Median CV% **3.09**

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

PH NONSEQUENTIAL DUPLICATES

Lake	Depth	#1	#2	Mean	S	CV%
Desire	0	7.15	7.06	7.105	0.06364	0.90
6/21/1999	1	7.16	7.1	7.13	0.042426	0.60
	2	7.18	7.14	7.16	0.028284	0.40
	3	7.18	7.11	7.145	0.049497	0.69
	4	6.49	6.36	6.425	0.091924	1.43
	4.5	6.43	6.32	6.375	0.077782	1.22
				Median CV%		**0.79**
Potholes	0.1	9.08	9.12	9.1	0.028284	0.31
8/8/1999	1	9.11	9.15	9.13	0.028284	0.31
	2	9.1	9.1	9.1	0	0.00
	3	9	9.05	9.025	0.035355	0.39
	4	8.93	8.95	8.94	0.014142	0.16
	5	8.9	8.89	8.895	0.007071	0.08
	6	8.75	8.54	8.645	0.148492	1.72
	7	8.24	8.15	8.195	0.06364	0.78
	7.2	8.12	8.05	8.085	0.049497	0.61
Long	0	8.44	8.51	8.475	0.049497	0.58
8/9/1999	1	8.31	8.05	8.18	0.183848	2.25
	2	8.47	8.17	8.32	0.212132	2.55
Desire	0	7.46	7.09	7.275	0.26163	3.60
8/13/1999	1	7.42	7.15	7.285	0.190919	2.62
	2	7.36	7.14	7.25	0.155563	2.15
	3	6.86	6.8	6.83	0.042426	0.62
	4	6.75	6.68	6.715	0.049497	0.74
	4.4	6.7	6.66	6.68	0.028284	0.42
				Median CV%		**0.62**

Lake	Depth	#1	#2	Mean	S	CV%
Potholes	0.1	8.91	8.93	8.92	0.014142	0.16
7/11/1999	1	8.91	8.93	8.92	0.014142	0.16
	3	8.76	8.79	8.775	0.021213	0.24
	4	8.73	8.75	8.74	0.014142	0.16
	5	8.67	8.69	8.68	0.014142	0.16
	6	8.62	8.63	8.625	0.007071	0.08
	8	8.44	8.41	8.425	0.021213	0.25
Desire	0	7.66	7.45	7.555	0.148492	1.97
7/12/1999	1	7.61	7.47	7.54	0.098995	1.31
	2	7.62	7.55	7.585	0.049497	0.65
	3	7.23	7.17	7.2	0.042426	0.59
	4	6.92	6.91	6.915	0.007071	0.10
	4.4	6.83	6.83	6.83	0	0.00
				Median CV%		**0.16**
Martha	0	7.58	7.26	7.42	0.226274	3.05
9/10/1999	1	7.61	7.32	7.465	0.205061	2.75
	2	7.61	7.36	7.485	0.176777	2.36
	3	7.63	7.42	7.525	0.148492	1.97
	4	7.53	7.4	7.465	0.091924	1.23
	6	7.42	7.07	7.245	0.247487	3.42
	7	7.11	6.99	7.05	0.084853	1.20
	8	6.85	6.96	6.905	0.077782	1.13
	10	6.77	6.87	6.82	0.070711	1.04
	11	7.05	6.84	6.945	0.148492	2.14
Potholes	0	8.82	8.85	8.835	0.021213	0.24
9/12/1999	1	8.81	8.86	8.835	0.035355	0.40
	2	8.74	8.78	8.76	0.028284	0.32
	3	8.66	8.67	8.665	0.007071	0.08
	4	8.55	8.57	8.56	0.014142	0.17
	4.7	8.53	8.54	8.535	0.007071	0.08
Desire	0	8.71	8.29	8.5	0.296985	3.49
9/16/1999	1	8.71	8.44	8.575	0.190919	2.23
	2	8.73	8.52	8.625	0.148492	1.72
	3	8.56	8.57	8.565	0.007071	0.08
	4	7.53	7.42	7.475	0.077782	1.04
	4.3	7.19	7.09	7.14	0.070711	0.99
				Median CV%		**1.17**

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

PH SEQUENTIAL DUPLICATES

Lake	Depth	#1	#2	Mean	S	CV%	Lake	Depth	#1	#2	Mean	S	CV%
Duck	0	8	8.81	8.405	0.572756	6.81	Gillette	0	7.35	7.47	7.410	0.084853	1.15
6/5/1999	1	7.9	8.8	8.35	0.636396	7.62	6/16/1999	1	7.37	7.4	7.385	0.021213	0.29
	2	7.86	8.78	8.32	0.650538	7.82		2	7.41	7.45	7.430	0.028284	0.38
Martha	0	8.19	8.31	8.25	0.084853	1.03		3	7.47	7.44	7.455	0.021213	0.28
6/10/1999	1	8.14	8.22	8.18	0.056569	0.69		4	7.2	7.26	7.230	0.042426	0.59
	2	8.08	8.17	8.125	0.06364	0.78		5	6.91	6.9	6.905	0.007071	0.10
	3	7.98	7.81	7.895	0.120208	1.52		6	6.52	6.55	6.535	0.021213	0.32
	4	7.5	7.3	7.4	0.141421	1.91		8	6.46	6.47	6.465	0.007071	0.11
	5	7.25	7.09	7.17	0.113137	1.58		10	6.42	6.42	6.420	0	0.00
	6	7.15	7.01	7.08	0.098995	1.40		12	6.41	6.42	6.415	0.007071	0.11
	8	7.12	7.3	7.21	0.127279	1.77		14	6.45	6.46	6.455	0.007071	0.11
	10	7.04	7.07	7.055	0.021213	0.30		16	6.48	6.5	6.490	0.014142	0.22
Potholes	0	8.58	8.79	8.685	0.148492	1.71		18	6.51	6.53	6.520	0.014142	0.22
6/13/1999	1	8.59	8.81	8.7	0.155563	1.79		20	6.54	6.54	6.540	0	0.00
	2	8.61	8.81	8.71	0.141421	1.62	Curlew	0	8.68	8.75	8.715	0.049497	0.57
	4	8.64	8.82	8.73	0.127279	1.46	6/17/1999	1	8.73	8.81	8.770	0.056569	0.65
	6	8.66	8.75	8.705	0.06364	0.73		2	8.74	8.8	8.770	0.042426	0.48
	8	8.43	8.52	8.475	0.06364	0.75		3	8.75	8.81	8.780	0.042426	0.48
	10	8.28	8.38	8.330	0.070711	0.85		4	8.67	8.75	8.710	0.056569	0.65
	12	8.16	8.18	8.170	0.014142	0.17		6	8.3	8.29	8.295	0.007071	0.09
Long	0	7.54	7.83	7.685	0.205061	2.67		8	7.86	7.99	7.925	0.091924	1.16
6/14/1999	1	7.61	7.86	7.735	0.176777	2.29		10	7.79	7.82	7.805	0.021213	0.27
	2	7.63	7.92	7.775	0.205061	2.64		12	7.68	7.7	7.690	0.014142	0.18
	3	7.63	7.95	7.790	0.226274	2.90		14	7.63	7.64	7.635	0.007071	0.09
	4	7.62	7.89	7.755	0.190919	2.46		16	7.59	7.59	7.590	0	0.00
	6	7.59	7.8	7.695	0.148492	1.93		18	7.57	7.56	7.565	0.007071	0.09
	8	7.58	7.68	7.630	0.070711	0.93		20	7.55	7.54	7.545	0.007071	0.09
	10	7.57	7.58	7.575	0.007071	0.09		25	7.48	7.45	7.465	0.021213	0.28
	12	7.56	7.54	7.550	0.014142	0.19		30	7.38	7.39	7.385	0.007071	0.10
	14	7.55	7.51	7.530	0.028284	0.38	Desire	0	7.08	7.15	7.115	0.049497	0.70
							6/21/1999	1	7.1	7.16	7.130	0.042426	0.60
								2	7.1	7.18	7.140	0.056569	0.79
								3	7.06	7.18	7.120	0.084853	1.19
								4	6.52	6.49	6.505	0.021213	0.33
											Median CV%		**0.62**

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

PH SEQUENTIAL DUPLICATES (CONT'D)													
Lake	Depth	#1	#2	Mean	S	CV%	Lake	Depth	#1	#2	Mean	S	CV%
Potholes	0	8.56	8.91	8.735	0.247487	2.83	Gillette	0	7.48	7.57	7.525	0.06364	0.85
7/11/1999	1	8.99	8.91	8.950	0.056569	0.63	7/14/1999	1	7.49	7.53	7.510	0.028284	0.38
	3	8.93	8.76	8.845	0.120208	1.36		2	7.6	7.67	7.635	0.049497	0.65
	5	8.74	8.67	8.705	0.049497	0.57		3	7.74	7.75	7.745	0.007071	0.09
	6	8.59	8.62	8.605	0.021213	0.25		4	7.79	7.79	7.790	0	0.00
	8	8.58	8.44	8.510	0.098995	1.16		5	7.24	7.03	7.135	0.148492	2.08
Desire	0	7.6	7.66	7.630	0.042426	0.56		6	6.69	6.73	6.710	0.028284	0.42
7/12/1999	1	7.57	7.61	7.590	0.028284	0.37		8	6.54	6.57	6.555	0.021213	0.32
	2	7.66	7.62	7.640	0.028284	0.37		10	6.43	6.5	6.465	0.049497	0.77
	3	7.53	7.23	7.380	0.212132	2.87		15	6.49	6.56	6.525	0.049497	0.76
	4	7.04	6.92	6.980	0.084853	1.22		20	6.52	6.57	6.545	0.035355	0.54
Long	0	8.28	8.37	8.325	0.06364	0.76	Curlew	0	8.83	8.84	8.835	0.007071	0.08
7/12/1999	1	8.37	8.45	8.410	0.056569	0.67	7/15/1999	1	8.87	8.87	8.870	0	0.00
	2	8.46	8.5	8.480	0.028284	0.33		2	8.87	8.87	8.870	0	0.00
	4	8.87	8.69	8.780	0.127279	1.45		3	8.87	8.88	8.875	0.007071	0.08
	5	8.73	8.55	8.640	0.127279	1.47		4	8.8	8.85	8.825	0.035355	0.40
	6	8.51	8.16	8.335	0.247487	2.97		6	8.19	8.33	8.260	0.098995	1.20
	8	8.24	8.05	8.145	0.13435	1.65		8	7.79	7.86	7.825	0.049497	0.63
	10	8.01	7.93	7.970	0.056569	0.71		10	7.63	7.7	7.665	0.049497	0.65
	12	7.87	7.86	7.865	0.007071	0.09		20	7.45	7.55	7.500	0.070711	0.94
	14	7.75	7.79	7.770	0.028284	0.36		25	7.35	7.51	7.430	0.113137	1.52
								30	7.32	7.39	7.355	0.049497	0.67
										7.36			
											Median CV%		**0.65**

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

PH SEQUENTIAL DUPLICATES (CONT'D)

Lake	Depth	#1	#2	Mean	S	CV%
Potholes	0	9.04	9.08	9.06	0.028284	0.31
8/8/1999	1	9.06	9.11	9.085	0.035355	0.39
	2	8.99	9.1	9.045	0.077782	0.86
	3	8.96	9	8.98	0.028284	0.31
	4	8.95	8.93	8.94	0.014142	0.16
	5	8.89	8.9	8.895	0.007071	0.08
	6	8.74	8.75	8.745	0.007071	0.08
	7	8.36	8.24	8.3	0.084853	1.02
Long	1	8.54	8.66	8.66	0.084853	0.98
8/9/1999	2	8.57	8.7	8.7	0.091924	1.06
	4	8.61	8.74	8.74	0.091924	1.05
	6	8.52	8.43	8.43	0.06364	0.75
	8	8.23	8.05	8.05	0.127279	1.58
	10	8.07	8.03	8.03	0.028284	0.35
	12	7.91	8.01	8.01	0.070711	0.88
	14	7.86	7.95	7.95	0.06364	0.80
	16	7.81	7.85	7.85	0.028284	0.36
Gillette	0	7.53	7.55	7.54	0.014142	0.19
8/11/1999	1	7.48	7.53	7.505	0.035355	0.47
	2	7.44	7.49	7.465	0.035355	0.47
	3	7.51	7.55	7.53	0.028284	0.38
	4	7.88	7.75	7.815	0.091924	1.18
	5	7.89	7.83	7.86	0.042426	0.54
	6	7.24	7.28	7.26	0.028284	0.39
	8	7.03	6.91	6.97	0.084853	1.22
	10	6.77	6.64	6.705	0.091924	1.37
	15	6.6	6.52	6.56	0.056569	0.86
	20	6.61	6.56	6.585	0.035355	0.54

Lake	Depth	#1	#2	Mean	S	CV%
Curlew	0	8.84	8.82	8.83	0.014142	0.16
8/12/1999	1	8.84	8.85	8.845	0.007071	0.08
	2	8.84	8.87	8.855	0.021213	0.24
	3	8.84	8.87	8.855	0.021213	0.24
	4	8.84	8.87	8.855	0.021213	0.24
	5	8.72	8.82	8.77	0.070711	0.81
	6	8.61	8.47	8.54	0.098995	1.16
	8	8.15	8.1	8.125	0.035355	0.44
	10	8.03	7.98	8.005	0.035355	0.44
	15	7.8	7.85	7.825	0.035355	0.45
	20	7.75	7.79	7.77	0.028284	0.36
	25	7.66	7.68	7.67	0.014142	0.18
Desire	0	7.23	7.46	7.345	0.162635	2.21
8/13/1999	1	7.28	7.42	7.35	0.098995	1.35
	2	7.2	7.36	7.28	0.113137	1.55
	3	6.77	6.86	6.815	0.06364	0.93
	4	6.69	6.75	6.72	0.042426	0.63
				Median CV%		**0.47**

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

PH SEQUENTIAL DUPLICATES (CONT'D)													
Lake	Depth	#1	#2	Mean	S	CV%	Lake	Depth	#1	#2	Mean	S	CV%
Martha	0	8.86	7.58	8.22	0.905097	11.01	Gillette	0	7.64	7.69	7.665	0.035355	0.46
9/10/1999	1	8.66	7.61	8.135	0.742462	9.13	9/15/1999	1	7.66	7.69	7.675	0.021213	0.28
	2	8.46	7.61	8.035	0.601041	7.48		2	7.69	7.69	7.69	0	0.00
	3	8.36	7.63	7.995	0.516188	6.46		4	7.62	7.65	7.635	0.021213	0.28
	4	8.18	7.53	7.855	0.459619	5.85		5	7.37	7.23	7.3	0.098995	1.36
	6	7.7	7.42	7.56	0.19799	2.62		6	6.83	6.67	6.75	0.113137	1.68
	7	7.6	7.11	7.355	0.346482	4.71		8	6.48	6.49	6.485	0.007071	0.11
	8	7.53	6.85	7.19	0.480833	6.69		10	6.39	6.45	6.42	0.042426	0.66
	10	7.42	7.14	7.28	0.19799	2.72		15	6.49	6.48	6.485	0.007071	0.11
	11	7.31	7.05	7.18	0.183848	2.56	Curlew	0	8.87	8.81	8.84	0.042426	0.48
Potholes	0	8.66	8.82	8.74	0.113137	1.29	9/16/1999	2	8.92	8.92	8.92	0	0.00
9/12/1999	1	8.71	8.81	8.76	0.070711	0.81		4	8.92	8.91	8.915	0.007071	0.08
	2	8.76	8.74	8.75	0.014142	0.16		6	8.85	8.89	8.87	0.028284	0.32
	3	8.72	8.66	8.69	0.042426	0.49		8	7.85	8.01	7.93	0.113137	1.43
	4	8.65	8.55	8.6	0.070711	0.82		10	7.64	7.75	7.695	0.077782	1.01
	5	8.61	8.53	8.57	0.056569	0.66		20	7.47	7.53	7.5	0.042426	0.57
Long	0	8.16	8.14	8.15	0.014142	0.17		25	7.41	7.46	7.435	0.035355	0.48
9/13/1999	1	8.18	8.16	8.17	0.014142	0.17		30	7.33	7.37	7.35	0.028284	0.38
	2	8.19	8.16	8.175	0.021213	0.26	Desire	0	8.89	8.71	8.8	0.127279	1.45
	4	8.19	8.12	8.155	0.049497	0.61	9/16/1999	1	8.89	8.71	8.8	0.127279	1.45
	6	8.17	8.04	8.105	0.091924	1.13		2	8.3	8.73	8.515	0.304056	3.57
	8	7.95	7.92	7.935	0.021213	0.27		3	7.85	8.56	8.205	0.502046	6.12
	10	7.63	7.87	7.75	0.169706	2.19		4	7.37	7.53	7.45	0.113137	1.52
	12	7.55	7.95	7.75	0.282843	3.65							
	14	7.53	8.1	7.815	0.403051	5.16							
	16	7.55	8.11	7.83	0.39598	5.06							
											Median CV%		**1.01**

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

TEMPERATURE NONSEQUENTIAL DUPLICATES

Lake	Depth	#1 (C)	#2 (C)	Mean	S	CV%
Desire	0	19	18.93	18.965	0.049497	0.26
6/21/1999	1	18.97	18.98	18.975	0.007071	0.04
	2	18.79	18.69	18.74	0.070711	0.38
	3	16.2	16.35	16.275	0.106066	0.65
	4	13.6	13.65	13.625	0.035355	0.26
	4.5	12.2	12.1	12.15	0.070711	0.58
				Median CV%		**0.32**
Potholes	0.1	24.31	24.48	24.395	0.120208	0.49
8/8/1999	1	23.89	23.71	23.8	0.127279	0.53
	2	23.44	23.29	23.365	0.106066	0.45
	3	23.04	23.16	23.1	0.084853	0.37
	4	22.91	22.88	22.895	0.021213	0.09
	5	22.73	22.7	22.715	0.021213	0.09
	6	22.34	22.19	22.265	0.106066	0.48
	7	21.31	21.36	21.335	0.035355	0.17
	7.2	21.25	21.2	21.225	0.035355	0.17
Long	0	24.59	24.22	24.405	0.26163	1.07
8/9/1999	1	21.36	21.96	21.66	0.424264	1.96
	2	19.27	20.13	19.7	0.608112	3.09
Desire	0	21.3	21.3	21.3	0	0.00
8/13/1999	1	21.12	21.11	21.115	0.007071	0.03
	2	20.98	20.91	20.945	0.049497	0.24
	3	19.94	19.49	19.715	0.318198	1.61
	4	14.75	14.7	14.725	0.035355	0.24
	4.4	13.82	13.85	13.835	0.021213	0.15
				Median CV%		**0.30**

Lake	Depth	#1 (C)	#2 (C)	Mean	S	CV%
Potholes	0.1	23.72	24.62	24.17	0.636396	2.63
7/11/1999	1	22.79	22.64	22.715	0.106066	0.47
	3	18.82	18.87	18.845	0.035355	0.19
	4	18.59	18.62	18.605	0.021213	0.11
	5	18.48	18.47	18.475	0.007071	0.04
	6	18.4	18.38	18.39	0.014142	0.08
	8	17.99	17.96	17.975	0.021213	0.12
Desire	0	24.02	24.08	24.05	0.042426	0.18
7/12/1999	1	23.71	24.04	23.875	0.233345	0.98
	2	19.68	19.8	19.74	0.084853	0.43
	3	16.27	16.57	16.42	0.212132	1.29
	4	13.91	14.09	14	0.127279	0.91
	4.4	13.19	13.16	13.175	0.021213	0.16
				Median CV%		**0.19**
Martha	0	18.77	18.76	18.765	0.007071	0.04
9/10/1999	1	18.76	18.77	18.765	0.007071	0.04
	2	18.67	18.65	18.66	0.014142	0.08
	3	18.57	18.55	18.56	0.014142	0.08
	4	18.19	18.19	18.19	0	0.00
	6	11.29	11.25	11.27	0.028284	0.25
	7	10.09	9.93	10.01	0.113137	1.13
	8	8.19	8.09	8.14	0.070711	0.87
	10	6.99	6.92	6.955	0.049497	0.71
	11	6.61	6.62	6.615	0.007071	0.11
Potholes	0	19.23	19.21	19.22	0.014142	0.07
9/12/1999	1	18.87	19.02	18.945	0.106066	0.56
	2	18.52	18.49	18.505	0.021213	0.11
	3	18.27	18.28	18.275	0.007071	0.04
	4	18.18	18.18	18.18	0	0.00
	4.7	18.16	18.15	18.155	0.007071	0.04
Desire	0	18.79	18.77	18.78	0.014142	0.08
9/16/1999	1	18.58	18.62	18.6	0.028284	0.15
	2	18.54	18.55	18.545	0.007071	0.04
	3	18.45	18.48	18.465	0.021213	0.11
	4	16.32	16.15	16.235	0.120208	0.74
	4.3	15.35	15.12	15.235	0.162635	1.07
				Median CV%		**0.09**

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

TEMPERATURE SEQUENTIAL DUPLICATES

Lake	Depth	#1 (C)	#2 (C)	Mean	S	CV%
Duck	0	15.72	16.69	16.205	0.685894	4.23
6/5/1999	1	15.65	16.55	16.1	0.636396	3.95
	2	15.66	16.22	15.94	0.39598	2.48
Martha	0	18	18.26	18.13	0.183848	1.01
6/10/1999	1	17.85	17.8	17.825	0.035355	0.20
	2	17.21	16.78	16.995	0.304056	1.79
	3	16.23	15.66	15.945	0.403051	2.53
	4	13.37	12.72	13.045	0.459619	3.52
	5	10.59	10.38	10.485	0.148492	1.42
	6	9.48	9.56	9.52	0.056569	0.59
	8	8.05	7.75	7.9	0.212132	2.69
	10	6.78	6.57	6.675	0.148492	2.22
Potholes	0	19.46	19.67	19.565	0.148492	0.76
6/13/1999	1	19.38	19.53	19.455	0.106066	0.55
	2	19.43	19.39	19.41	0.028284	0.15
	4	18.81	19.1	18.955	0.205061	1.08
	6	17.38	16.89	17.135	0.346482	2.02
	8	16.3	15.99	16.145	0.219203	1.36
	10	15.61	15.46	15.535	0.106066	0.68
	12	15.01	15.01	15.010	0	0.00
Long	0	18.18	17.48	17.480	0.494975	2.83
6/14/1999	1	16.6	15.53	15.530	0.756604	4.87
	2	15.38	15.21	15.210	0.120208	0.79
	3	15.14	15.19	15.190	0.035355	0.23
	4	14.68	14.88	14.880	0.141421	0.95
	6	14.34	14.76	14.760	0.296985	2.01
	8	14.01	14.76	14.760	0.53033	3.59
	10	13.8	14.74	14.740	0.66468	4.51
	12	13.73	14.68	14.680	0.671751	4.58
	14	13.73	14.63	14.630	0.636396	4.35
Gillette	0	19.31	19.5	19.405	0.13435	0.69
6/16/1999	1	19.25	18.69	18.970	0.39598	2.09
	2	16.2	15.68	15.940	0.367696	2.31
	3	12.76	12.38	12.570	0.268701	2.14
	4	8.62	8.79	8.705	0.120208	1.38
	5	7	7	7.000	0	0.00
	6	5.6	5.66	5.630	0.042426	0.75
	8	4.89	4.8	4.845	0.06364	1.31
	10	4.6	4.6	4.600	0	0.00
	12	4.59	4.62	4.605	0.021213	0.46
	14	4.62	4.63	4.625	0.007071	0.15
	16	4.65	4.68	4.665	0.021213	0.45
	18	4.7	4.69	4.695	0.007071	0.15
	20	4.7	4.72	4.710	0.014142	0.30
Curlew	0	20.75	21.08	20.915	0.233345	1.12
6/17/1999	1	20.54	20.29	20.415	0.176777	0.87
	2	20.38	20.19	20.285	0.13435	0.66
	3	17	17.07	17.035	0.049497	0.29
	4	15.53	15.89	15.710	0.254558	1.62
	6	12.77	11.84	12.305	0.657609	5.34
	8	8.46	8.32	8.390	0.098995	1.18
	10	7.51	7.26	7.385	0.176777	2.39
	12	6.83	6.57	6.700	0.183848	2.74
	14	6.49	6.41	6.450	0.056569	0.88
	16	6.23	6.24	6.235	0.007071	0.11
	18	6.16	6.16	6.160	0	0.00
	20	6.03	6.03	6.030	0	0.00
	25	5.63	5.65	5.640	0.014142	0.25
	30	5.45	5.58	5.515	0.091924	1.67
Desire	0	19.08	19	19.040	0.056569	0.30
6/21/1999	1	19.08	18.97	19.025	0.077782	0.41
	2	19.1	18.79	18.945	0.219203	1.16
	3	15.88	16.2	16.040	0.226274	1.41
	4	13.38	13.6	13.490	0.155563	1.15
				Median CV%		**1.13**

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

TEMPERATURE SEQUENTIAL DUPLICATES (CONT'D)													
Lake	Depth	#1 (C)	#2 (C)	Mean	S	CV%	Lake	Depth	#1 (C)	#2 (C)	Mean	S	CV%
Potholes	0	23.75	23.72	23.735	0.021213	0.09	Gillette	0	21.07	20.98	21.025	0.06364	0.30
7/11/1999	1	21.72	22.79	22.255	0.756604	3.40	7/14/1999	1	21.09	20.98	21.035	0.077782	0.37
	3	19.78	18.82	19.300	0.678823	3.52		2	19.28	19.04	19.160	0.169706	0.89
	5	18.56	18.48	18.520	0.056569	0.31		3	15.43	15.39	15.410	0.028284	0.18
	6	18.27	18.4	18.335	0.091924	0.50		4	12.12	12.12	12.120	0	0.00
	8	18.15	17.99	18.070	0.113137	0.63		5	8.21	8.61	8.410	0.282843	3.36
Desire	0	23.46	24.02	23.740	0.39598	1.67		6	6.64	6.62	6.630	0.014142	0.21
7/12/1999	1	23.21	23.71	23.460	0.353553	1.51		8	5.22	5.13	5.175	0.06364	1.23
	2	19.42	19.68	19.550	0.183848	0.94		10	4.72	4.78	4.750	0.042426	0.89
	3	16.81	16.27	16.540	0.381838	2.31		15	4.67	4.67	4.670	0	0.00
	4	14.54	13.91	14.225	0.445477	3.13		20	4.7	4.7	4.700	0	0.00
Long	0	23.04	23.15	23.095	0.077782	0.34	Curlew	0	20.72	20.76	20.740	0.028284	0.14
7/12/1999	1	21.86	21.59	21.725	0.190919	0.88	7/15/1999	1	20.63	20.76	20.695	0.091924	0.44
	2	21.72	21.28	21.500	0.311127	1.45		2	20.58	20.6	20.590	0.014142	0.07
	4	19.45	18	18.725	1.025305	5.48		3	20.46	20.49	20.475	0.021213	0.10
	5	18.45	17.53	17.990	0.650538	3.62		4	18.1	18.93	18.515	0.586899	3.17
	6	17.72	17.09	17.405	0.445477	2.56		6	13.34	13.04	13.190	0.212132	1.61
	8	17.21	16.89	17.050	0.226274	1.33		8	8.84	8.9	8.870	0.042426	0.48
	10	16.99	16.72	16.855	0.190919	1.13		10	7.39	7.49	7.440	0.070711	0.95
	12	16.71	16.5	16.605	0.148492	0.89		20	6.24	6.34	6.290	0.070711	1.12
	14	16.15	16.25	16.200	0.070711	0.44		25	5.84	5.96	5.900	0.084853	1.44
								30	5.63	5.76	5.695	0.091924	1.61
											Median CV%		**0.89**

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

TEMPERATURE SEQUENTIAL DUPLICATES (CONT'D)													
Lake	Depth	#1 (C)	#2 (C)	Mean	S	CV%	Lake	Depth	#1 (C)	#2 (C)	Mean	S	CV%
Potholes	0	23.6	24.31	23.955	0.502046	2.10	Curlew	0	22.64	22.69	22.665	0.035355	0.16
8/8/1999	1	23.16	23.89	23.525	0.516188	2.19	8/12/1999	1	22.69	22.61	22.65	0.056569	0.25
	2	22.73	23.44	23.085	0.502046	2.17		2	22.69	22.56	22.625	0.091924	0.41
	3	22.62	23.04	22.83	0.296985	1.30		3	22.69	22.51	22.6	0.127279	0.56
	4	22.61	22.91	22.76	0.212132	0.93		4	22.66	22.49	22.575	0.120208	0.53
	5	22.36	22.73	22.545	0.26163	1.16		5	20.33	22.01	21.17	1.187939	5.61
	6	22.14	22.34	22.24	0.141421	0.64		6	16.35	13.8	15.075	1.803122	11.96
	7	21.13	21.31	21.22	0.127279	0.60		8	9.88	10.08	9.98	0.141421	1.42
Long	1	23.68	23.63	23.655	0.035355	0.15		10	7.85	7.99	7.92	0.098995	1.25
8/9/1999	2	23.32	23.44	23.38	0.084853	0.36		15	6.87	6.74	6.805	0.091924	1.35
	4	23.07	23.25	23.16	0.127279	0.55		20	6.54	6.44	6.49	0.070711	1.09
	6	20.8	20.85	20.825	0.035355	0.17		25	5.86	6.23	6.045	0.26163	4.33
	8	18.34	18.89	18.615	0.388909	2.09	Desire	0	21.44	21.3	21.37	0.098995	0.46
	10	18.24	18.54	18.39	0.212132	1.15	8/13/1999	1	21.28	21.12	21.2	0.113137	0.53
	12	18.1	18.18	18.14	0.056569	0.31		2	21.09	20.98	21.035	0.077782	0.37
	14	17.91	17.92	17.915	0.007071	0.04		3	19.31	19.94	19.625	0.445477	2.27
	16	17.72	17.66	17.69	0.042426	0.24		4	15.82	14.75	15.285	0.756604	4.95
Gillette	0	22.26	22.38	22.32	0.084853	0.38							
8/11/1999	1	22.27	22.36	22.315	0.06364	0.29							
	2	22.29	22.2	22.245	0.06364	0.29					**Median CV%**		**0.55**
	3	20.05	19.86	19.955	0.13435	0.67							
	4	14.37	14.4	14.385	0.021213	0.15							
	5	10.72	10.6	10.66	0.084853	0.80							
	6	7.81	7.86	7.835	0.035355	0.45							
	8	5.58	5.58	5.58	0	0.00							
	10	4.87	4.9	4.885	0.021213	0.43							
	15	4.72	4.72	4.72	0	0.00							
	20	4.77	4.75	4.76	0.014142	0.30							

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

TEMPERATURE SEQUENTIAL DUPLICATES (CONT'D)													
Lake	Depth	#1 (C)	#2 (C)	Mean	S	CV%	Lake	Depth	#1 (C)	#2 (C)	Mean	S	CV%
Martha	0	18.69	18.77	18.73	0.056569	0.30	Gillette	0	15.88	15.93	15.905	0.035355	0.22
9/10/1999	1	18.69	18.76	18.725	0.049497	0.26	9/15/1999	1	15.88	15.9	15.89	0.014142	0.09
	2	18.69	18.67	18.68	0.014142	0.08		2	15.88	15.88	15.88	0	0.00
	3	18.63	18.57	18.6	0.042426	0.23		4	15.2	15.23	15.215	0.021213	0.14
	4	18.29	18.19	18.24	0.070711	0.39		5	13.29	12.77	13.03	0.367696	2.82
	6	11.34	11.29	11.315	0.035355	0.31		6	8.95	9.66	9.305	0.502046	5.40
	7	9.4	10.09	9.745	0.487904	5.01		8	5.98	5.75	5.865	0.162635	2.77
	8	8.44	8.19	8.315	0.176777	2.13		10	5.12	5.25	5.185	0.091924	1.77
	10	7	6.92	6.96	0.056569	0.81		15	4.67	4.69	4.68	0.014142	0.30
	11	6.67	6.61	6.64	0.042426	0.64	Curlew	0	17.25	16.99	17.12	0.183848	1.07
Potholes	0	18.88	19.23	19.055	0.247487	1.30	9/16/1999	2	17.26	16.97	17.115	0.205061	1.20
9/12/1999	1	18.71	18.87	18.79	0.113137	0.60		4	17.23	16.94	17.085	0.205061	1.20
	2	18.42	18.52	18.47	0.070711	0.38		6	16.37	16.63	16.5	0.183848	1.11
	3	18.27	18.27	18.27	0	0.00		8	10.72	10.74	10.73	0.014142	0.13
	4	18.2	18.18	18.19	0.014142	0.08		10	8.11	8.3	8.205	0.13435	1.64
	5	18.18	18.16	18.17	0.014142	0.08		20	6.74	6.8	6.77	0.042426	0.63
Long	0	19.64	18.76	19.2	0.622254	3.24		25	6.11	6.26	6.185	0.106066	1.71
9/13/1999	1	18.8	18.71	18.755	0.06364	0.34		30	5.76	6.09	5.925	0.233345	3.94
	2	18.69	18.52	18.605	0.120208	0.65	Desire	0	18.91	18.79	18.85	0.084853	0.45
	4	18.54	18.32	18.43	0.155563	0.84	9/16/1999	1	18.7	18.58	18.64	0.084853	0.46
	6	18.49	18.23	18.36	0.183848	1.00		2	18.53	18.54	18.535	0.007071	0.04
	8	18.27	17.94	18.105	0.233345	1.29		3	18.01	18.45	18.23	0.311127	1.71
	10	17.59	17.65	17.62	0.042426	0.24		4	16.49	16.32	16.405	0.120208	0.73
	12	17.28	17.26	17.27	0.014142	0.08							
	14	17.08	15.53	16.305	1.096016	6.72							
	16	16.88	14.75	15.815	1.506137	9.52							
											Median CV%		**0.64**

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

CONDUCTIVITY NONSEQUENTIAL DUPLICATES

Lake	Depth	#1 (uS/cm)	#2 (uS/cm)	Mean	S	CV%
Desire	0	61.5	61.5	61.5	0	0.00
6/21/1999	1	61.4	61.5	61.45	0.070711	0.12
	2	61.3	61.4	61.35	0.070711	0.12
	3	60.8	60.6	60.7	0.141421	0.23
	4	65.9	65.7	65.8	0.141421	0.21
	4.5	85.9	85.7	85.8	0.141421	0.16
				Median CV%		**0.14**
Potholes	0.1	29.3	29.4	29.35	0.070711	0.24
8/8/1999	1	29.2	29.4	29.3	0.141421	0.48
	2	29.6	29.4	29.5	0.141421	0.48
	3	29.7	29.4	29.55	0.212132	0.72
	4	29.7	30	29.85	0.212132	0.71
	5	29.9	30.1	30	0.141421	0.47
	6	30.4	31	30.7	0.424264	1.38
	7	31.8	32.1	31.95	0.212132	0.66
	7.2	31.7	31.9	31.8	0.141421	0.44
Long	0	15.2	15.6	15.4	0.282843	1.84
8/9/1999	1	16.3	17.2	16.75	0.636396	3.80
	2	16.8	17.4	17.1	0.424264	2.48
Desire	0	65	65	65	0	0.00
8/13/1999	1	65	64.9	64.95	0.070711	0.11
	2	64.9	64.9	64.9	0	0.00
	3	65.6	66.3	65.95	0.494975	0.75
	4	78	82.3	80.15	3.040559	3.79
	4.4	106	113.3	109.65	5.16188	4.71
				Median CV%		**0.69**

Lake	Depth	#1 (uS/cm)	#2 (uS/cm)	Mean	S	CV%
Potholes	0.1	379	380	379.5	0.707107	0.19
7/11/1999	1	378	378	378	0	0.00
	3	357	356	356.5	0.707107	0.20
	4	358	357	357.5	0.707107	0.20
	5	358	358	358	0	0.00
	6	357	357	357	0	0.00
	8	361	362	361.5	0.707107	0.20
Desire	0	63.1	63	63.05	0.070711	0.11
7/12/1999	1	63.1	63	63.05	0.070711	0.11
	2	61.6	61.5	61.55	0.070711	0.11
	3	62.6	62.4	62.5	0.141421	0.23
	4	71.6	70.8	71.2	0.565685	0.79
	4.4	78	81.8	79.9	2.687006	3.36
				Median CV%		**0.19**
Martha	0	87.2	87.1	87.15	0.070711	0.08
9/10/1999	1	87.2	87.2	87.2	0	0.00
	2	87	87	87	0	0.00
	3	87.2	87.4	87.3	0.141421	0.16
	4	87.2	87	87.1	0.141421	0.16
	6	86.7	87	86.85	0.212132	0.24
	7	86.4	86.2	86.3	0.141421	0.16
	8	85.4	84.6	85	0.565685	0.67
	10	84.9	84.6	84.75	0.212132	0.25
	11	85.9	84.5	85.2	0.989949	1.16
Potholes	0	360	361	360.5	0.707107	0.20
9/12/1999	1	360	361	360.5	0.707107	0.20
	2	357	356	356.5	0.707107	0.20
	3	357	356	356.5	0.707107	0.20
	4	357	358	357.5	0.707107	0.20
	4.7	358	357	357.5	0.707107	0.20
Desire	0	65.1	64.8	64.95	0.212132	0.33
9/16/1999	1	64.8	64.7	64.75	0.070711	0.11
	2	64.7	64.9	64.8	0.141421	0.22
	3	64.8	64.7	64.75	0.070711	0.11
	4	85.7	89.6	87.65	2.757716	3.15
	4.3	119.7	127.8	123.75	5.727565	4.63
				Median CV%		**0.20**

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

CONDUCTIVITY SEQUENTIAL DUPLICATES													
Lake	Depth	#1 (uS/cm)	#2 (uS/cm)	Mean	S	CV%	Lake	Depth	#1 (uS/cm)	#2 (uS/cm)	Mean	S	CV%
Duck	0	145.8	133.2	139.5	8.909545	6.39	Gillette	0	27.5	45	36.250	12.37437	34.14
6/5/1999	1	145.7	133.1	139.4	8.909545	6.39	6/16/1999	1	44.5	45.9	45.200	0.989949	2.19
	2	145.8	133.1	139.45	8.980256	6.44		2	45.5	45.4	45.450	0.070711	0.16
Martha	0	89.4	89.2	89.3	0.141421	0.16		3	46.5	48.3	47.400	1.272792	2.69
6/10/1999	1	89.2	89.1	89.15	0.070711	0.08		4	52.1	51.2	51.650	0.636396	1.23
	2	88.9	88.6	88.75	0.212132	0.24		5	56.3	55.5	55.900	0.565685	1.01
	3	88.4	88.5	88.45	0.070711	0.08		6	60.8	60.6	60.700	0.141421	0.23
	4	89.4	89.5	89.45	0.070711	0.08		8	72.7	77.7	75.200	3.535534	4.70
	5	89.9	89.7	89.8	0.141421	0.16		10	93.8	99.8	96.800	4.242641	4.38
	6	89.5	89.5	89.5	0	0.00		12	142.9	137.9	140.400	3.535534	2.52
	8	88.8	88.7	88.75	0.070711	0.08		14	165	157	161.000	5.656854	3.51
	10	89	88.7	88.85	0.212132	0.24		16	173	177	175.000	2.828427	1.62
Potholes	0	333	363	348	21.2132	6.10		18	179	182	180.500	2.12132	1.18
6/13/1999	1	365	367	366	1.414214	0.39		20	184	186	185.000	1.414214	0.76
	2	365	368	366.5	2.12132	0.58	Curlew	0	236	236	236.000	0	0.00
	4	366	368	367	1.414214	0.39	6/17/1999	1	236	234	235.000	1.414214	0.60
	6	363	363	363	0	0.00		2	236	234	235.000	1.414214	0.60
	8	364	362	363	1.414214	0.39		3	236	235	235.500	0.707107	0.30
	10	364	363	363.500	0.707107	0.19		4	237	235	236.000	1.414214	0.60
	12	364	364	364.000	0	0.00		6	240	241	240.500	0.707107	0.29
Long	0	70.1	73.4	73.400	2.333452	3.18		8	250	250	250.000	0	0.00
6/14/1999	1	70.7	72.9	72.900	1.555635	2.13		10	253	253	253.000	0	0.00
	2	71.1	72.8	72.800	1.202082	1.65		12	254	256	255.000	1.414214	0.55
	3	70.8	72.8	72.800	1.414214	1.94		14	256	256	256.000	0	0.00
	4	70.6	72.8	72.800	1.555635	2.14		16	257	256	256.500	0.707107	0.28
	6	69.5	73.2	73.200	2.616295	3.57		18	257	257	257.000	0	0.00
	8	69.5	73.1	73.100	2.545584	3.48		20	258	259	258.500	0.707107	0.27
	10	69.2	73.1	73.100	2.757716	3.77		25	260	260	260.000	0	0.00
	12	68.9	73.3	73.300	3.11127	4.24		30	263	264	263.500	0.707107	0.27
	14	68.8	73.3	73.300	3.181981	4.34	Desire	0	61.5	61.5	61.500	0	0.00
							6/21/1999	1	61.5	61.4	61.450	0.070711	0.12
								2	61.5	61.3	61.400	0.141421	0.23
								3	61.2	60.8	61.000	0.282843	0.46
								4	67.4	65.9	66.650	1.06066	1.59
											Median CV%		**0.51**

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

CONDUCTIVITY SEQUENTIAL DUPLICATES (CONT'D)														
Lake	Depth	#1 (uS/cm)	#2 (uS/cm)	Mean	S	CV%		Lake	Depth	#1 (uS/cm)	#2 (uS/cm)	Mean	S	CV%
Potholes	1	331	378	354.500	33.23402	9.37		Gillette	0	47.5	47.6	47.550	0.070711	0.15
7/11/1999	3	347	357	352.000	7.071068	2.01		7/14/1999	1	47.6	47.7	47.650	0.070711	0.15
	5	351	358	354.500	4.949747	1.40			2	47.5	47.6	47.550	0.070711	0.15
	6	355	357	356.000	1.414214	0.40			3	53.7	55.1	54.400	0.989949	1.82
	8	356	361	358.500	3.535534	0.99			4	54	54	54.000	0	0.00
Desire	0	63	63.1	63.050	0.070711	0.11			5	57.3	56.9	57.100	0.282843	0.50
7/12/1999	1	62.9	63.1	63.000	0.141421	0.22			6	59.5	60.3	59.900	0.565685	0.94
	2	61.6	61.6	61.600	0	0.00			8	68.9	78.7	73.800	6.929646	9.39
	3	61.9	62.6	62.250	0.494975	0.80			10	107.3	95.6	101.450	8.273149	8.15
	4	67.8	71.6	69.700	2.687006	3.86			15	164	167	165.500	2.12132	1.28
Long	0	103.9	87.6	95.750	11.52584	12.04			20	177	177	177.000	0	0.00
7/12/1999	1	105.2	89.1	97.150	11.38442	11.72		Curlew	0	225	225	225.000	0	0.00
	2	106.2	88.7	97.450	12.37437	12.70		7/15/1999	1	226	225	225.500	0.707107	0.31
	4	132.8	89.7	111.250	30.4763	27.39			2	226	225	225.500	0.707107	0.31
	5	141.8	89.6	115.700	36.91097	31.90			3	226	225	225.500	0.707107	0.31
	6	145.6	92.5	119.050	37.54737	31.54			4	228	226	227.000	1.414214	0.62
	8	146	94.8	120.400	36.20387	30.07			6	239	240	239.500	0.707107	0.30
	10	147.8	98.7	123.250	34.71894	28.17			8	244	246	245.000	1.414214	0.58
	12	148.4	116.9	132.650	22.27386	16.79			10	248	247	247.500	0.707107	0.29
	14	149.8	123.4	136.600	18.66762	13.67			20	250	250	250.000	0	0.00
									25	254	253	253.500	0.707107	0.28
									30	258	264	261.000	4.242641	1.63
												Median CV%		**0.87**

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

CONDUCTIVITY SEQUENTIAL DUPLICATES (CONT'D)

Lake	Depth	#1 (uS/cm)	#2 (uS/cm)	Mean	S	CV%	Lake	Depth	#1 (uS/cm)	#2 (uS/cm)	Mean	S	CV%
Potholes	0	29.2	29.3	29.25	0.070711	0.24	Curlew	0	20.1	20.2	20.15	0.070711	0.35
8/8/1999	1	29	29.2	29.1	0.141421	0.49	8/12/1999	1	20.2	20.2	20.2	0	0.00
	2	29	29.6	29.3	0.424264	1.45		2	20.2	20.3	20.25	0.070711	0.35
	3	29	29.7	29.35	0.494975	1.69		3	20.1	20.5	20.3	0.282843	1.39
	4	28.8	29.7	29.25	0.636396	2.18		4	20.1	20.4	20.25	0.212132	1.05
	5	30.3	29.9	30.1	0.282843	0.94		5	20.7	20.4	20.55	0.212132	1.03
	6	30.6	30.4	30.5	0.141421	0.46		6	21.8	21.4	21.6	0.282843	1.31
	7	31	31.8	31.4	0.565685	1.80		8	22.3	21.9	22.1	0.282843	1.28
Long	1	13.5	12.3	12.9	0.848528	6.58		10	22.2	22.5	22.35	0.212132	0.95
8/9/1999	2	13.2	12.4	12.8	0.565685	4.42		15	21.5	22.2	21.85	0.494975	2.27
	4	13.8	12.3	13.05	1.06066	8.13		20	21.7	23.9	22.8	1.555635	6.82
	6	17.3	14.3	15.8	2.12132	13.43		25	23.3	24.8	24.05	1.06066	4.41
	8	18.5	18.1	18.3	0.282843	1.55	Desire	0	65	65	65	0	0.00
	10	18.5	18	18.25	0.353553	1.94	8/13/1999	1	65	65	65	0	0.00
	12	18.3	18.4	18.35	0.070711	0.39		2	65.2	64.9	65.05	0.212132	0.33
	14	20.2	18.6	19.4	1.131371	5.83		3	66.5	65.6	66.05	0.636396	0.96
	16	18.6	18	18.3	0.424264	2.32		4	74.5	78	76.25	2.474874	3.25
Gillette	0	2	5.2	3.6	2.262742	62.85							
8/11/1999	1	5.2	5.2	5.2	0	0.00							
	2	5.2	5.3	5.25	0.070711	1.35					**Median CV%**		**1.45**
	3	5.5	5.7	5.6	0.141421	2.53							
	4	5.9	5.8	5.85	0.070711	1.21							
	5	5.5	5.9	5.7	0.282843	4.96							
	6	5.5	6.1	5.8	0.424264	7.31							
	8	7.4	7.6	7.5	0.141421	1.89							
	10	8.7	10	9.35	0.919239	9.83							
	15	14.1	15.2	14.65	0.777817	5.31							
	20	16.3	16.1	16.2	0.141421	0.87							

Appendix D - Hydrolab Quality Assurance/Quality Control Results for 1999

CONDUCTIVITY SEQUENTIAL DUPLICATES (CONT'D)

Lake	Depth	#1 (uS/cm)	#2 (uS/cm)	Mean	S	CV%	Lake	Depth	#1 (uS/cm)	#2 (uS/cm)	Mean	S	CV%
Martha	0	87.3	87.2	87.25	0.070711	0.08	Gillette	0	55.7	55.8	55.75	0.070711	0.13
9/10/1999	1	87.2	87.2	87.2	0	0.00	9/15/1999	1	55.8	55.8	55.8	0	0.00
	2	87.4	87	87.2	0.282843	0.32		2	55.8	55.8	55.8	0	0.00
	3	87.1	87.2	87.15	0.070711	0.08		4	55.8	56.5	56.15	0.494975	0.88
	4	87.2	87.2	87.2	0	0.00		5	58.2	58.5	58.35	0.212132	0.36
	6	86.7	86.7	86.7	0	0.00		6	61.4	60.4	60.9	0.707107	1.16
	7	85.4	86.4	85.9	0.707107	0.82		8	67.6	80.1	73.85	8.838835	11.97
	8	85.2	85.4	85.3	0.141421	0.17		10	95.6	94.5	95.05	0.777817	0.82
	10	84.6	84.5	84.55	0.070711	0.08		15	159	157	158	1.414214	0.90
	11	84.5	85.9	85.2	0.989949	1.16	Curlew	0	222	221	221.5	0.707107	0.32
Potholes	0	350	360	355	7.071068	1.99	9/16/1999	2	222	221	221.5	0.707107	0.32
9/12/1999	1	349	360	354.5	7.778175	2.19		4	222	221	221.5	0.707107	0.32
	2	348	357	352.5	6.363961	1.81		6	223	221	222	1.414214	0.64
	3	347	357	352	7.071068	2.01		8	245	247	246	1.414214	0.57
	4	349	357	353	5.656854	1.60		10	245	247	246	1.414214	0.57
	5	350	358	354	5.656854	1.60		20	244	246	245	1.414214	0.58
Long	0	177	178	177.5	0.707107	0.40		25	250	251	250.5	0.707107	0.28
9/13/1999	1	176	178	177	1.414214	0.80		30	256	255	255.5	0.707107	0.28
	2	177	178	177.5	0.707107	0.40	Desire	0	65.3	65.1	65.2	0.141421	0.22
	4	177	178	177.5	0.707107	0.40	9/16/1999	1	65.3	64.8	65.05	0.353553	0.54
	6	177	178	177.5	0.707107	0.40		2	64.8	64.7	64.75	0.070711	0.11
	8	182	186	184	2.828427	1.54		3	65.8	64.8	65.3	0.707107	1.08
	10	196	194	195	1.414214	0.73		4	79.9	85.7	82.8	4.101219	4.95
	12	204	200	202	2.828427	1.40							
	14	220	233	226.5	9.192388	4.06							
	16	229	247	238	12.72792	5.35							
											Median CV%		**0.57**