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Water Quality Assessments of Selected Lakes within Washington State

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Water Quality Assessments of Selected Lakes within Washington State

1997

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Abstract

The objectives of the Washington State Department of Ecology (Ecology) Lake Water Quality Assessment Program are to identify lakes that are exhibiting water quality problems, to assess significant, publicly-owned lakes by estimating the trophic status of monitored lakes, and to promote public awareness of lake ecology and protection.

In 1997, Ecology staff collected data from 70 lakes. Water samples were collected in May and August 1997 from both the epilimnion and the hypolimnion of stratified lakes except those Thurston County lakes where the Thurston County Environmental Health were monitoring water quality. Samples were analyzed for total phosphorus, total nitrogen, and chlorophyll *a*. Because of budget shortfalls, chlorophyll samples were not collected in the spring. Samples for turbidity and fecal coliform bacteria were also collected from basin lakes and lakes with suspected or known sedimentation and/or bacterial contamination problems. To supplement data collected by Ecology staff, volunteers participating in Washington's Citizen Lake Monitoring Program measured Secchi disk transparency and surface water temperature in 52 of the 70 lakes. Volunteers monitored their lakes twice a month from May through October. Most volunteers also completed a questionnaire on lake and watershed uses.

Carlson's Trophic State Index (1977), tempered with professional judgement, was used to evaluate volunteer-collected Secchi depth data and Ecology-collected phosphorus and chlorophyll *a* data. Trophic state estimations were assigned to the lakes assessed using data collected by Ecology professionals, citizen volunteers, and data supplied by Sue Davis with the Thurston County Environmental Health.

Of the 70 lakes evaluated, 12 were oligotrophic, 24 were oligo-mesotrophic, 13 were mesotrophic, 9 were meso-eutrophic, and 12 were eutrophic.

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Introduction

The purpose of this report is to describe the 1997 Lake Water Quality Assessment (LWQA) Program, and to present data and individual lake assessments from 70 lakes which were monitored by volunteers and Ecology staff during 1997.

Program Objectives

The goals of the LWQA Program are to assess the current water quality of publicly-owned lakes in Washington, and to maintain a relationship with volunteers of monitored lakes for data exchange, education, and technical assistance. Specific objectives for the 1997 program were to:

1) determine the trophic status of monitored lakes,
2) assess water quality in chosen lakes not evaluated in the last five years,
3) promote public awareness of lake processes and lake protection measures and foster a conservation ethic, and
4) establish a data set for analysis and dissemination.

History of LWQA Program

Ecology's Lake Water Quality Assessment Program was established in 1989 to gather general water quality information from significant, publicly-owned lakes. Data collected from the program are used primarily to assess each monitored lake for the state's biennial Water Quality Assessment (305 (b)) Report. Lake water quality assessments are required under Section 314 (a)(2) of the Clean Water Act, as amended by the Water Quality Act of 1987. For the purposes of reporting water quality assessments, significant, publicly-owned lakes cover at least 20 acres, have a public access, and support or have the potential to support the fishable-swimmable goals of the Clean Water Act (Rector and Hallock, 1995).

The 1989 lake monitoring program was funded from a Federal 314 Water Quality Assessment grant. The program consisted of volunteer monitoring on 48 lakes, a supplemental water quality survey conducted by Ecology staff on 25 lakes (Brower and Kendra, 1990), and a toxics survey conducted by Ecology staff on fish tissues and sediments from 10 lakes (Johnson and Norton, 1990). Results from the 1989 program are discussed in Lake Water Quality Assessment Project, 1989 (Rector and Hallock, 1991).

In 1990, a Water Quality Management and Planning (205 (j)) grant funded the majority of the program. The volunteer monitoring program was expanded to include additional lakes (for a total of 73 lakes), and Ecology staff met with each of the volunteers during May and August to collect water samples and vertical profile data. A supplemental water quality survey was conducted on 15 lakes (Coots, 1991). Results of all data collected from 1990 are discussed in Lake Water Quality Assessment Project, 1990 (Rector and Hallock, 1993).

In 1991, the program was reduced because of insecure funding. A Federal 314 grant maintained the program through 1991. Volunteers collected data from 41 lakes, and Ecology staff collected one set of water samples and vertical profile data from each of the volunteer-monitored lakes. No supplemental surveys were conducted.

In 1992, additional 314 and 205(j) grants were obtained. Volunteers collected data from 41 lakes, and Ecology staff collected two sets of water samples and profile data from these lakes. Five lakes were surveyed for various contaminants in sediment and fish tissues, and five additional lakes were surveyed for copper in sediments (Serdar *et al.*, 1994). Results from the 1991 and 1992 monitoring years are discussed in Lake Water Quality Assessment Program, 1991-1992 (Rector, 1994).

In 1993, volunteers collected data from 65 lakes, and Ecology staff collected two sets of water samples and profile data from most of the volunteer-monitored lakes. Ecology staff collected water samples and profile data from 15 additional lakes, to support the monitoring phase of Ecology's watershed approach to water quality management. In 1993, watershed approach monitoring focused on the Kitsap, Lower Columbia, Upper Yakima, and Mid-Columbia basins. The program was funded largely through 314 grants and matching funds.

In 1994 volunteers monitored approximately 60 lakes. Ecology staff collected water samples and profile data from 73 lakes, which included six lakes which were sampled in support of the watershed approach to water quality management, as well as other lakes of interest to Ecology's regional permit writers and inspectors. In 1994, watershed approach monitoring focused on the Eastern Olympics, Cedar/Green, Spokane, and Lower Yakima basins. The program was funded largely through 314 grants and matching funds.

In 1995, funds allocated through the 314 grant process were rescinded by Congress and no longer available to states as of October 1995. This, however, did not impact the field season for 1995 and all went as planned for a normal sampling year. The watershed approach monitoring focused on the Skagit/Stillaguamish, Upper Columbia, Columbia Gorge and the Horseheaven/Klickitat basins.

In 1996 the LWQA Program received its first 319 grant which enabled the program to continue for an additional year. The EPA 319 Non-point program has fewer requirements than 314 and does not require matching funds. Conversely, the funding is only for a year with no guarantee of a grant award the following year. The watershed approach monitoring focused on South Puget Sound, Island/Snohomish, Esquatzel, Crab Creek and Okanogan basins.

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 that follows this "Methods" section.

Volunteer Recruitment and Lake Selection

All Washington lakes that cover at least 20 acres and have a public access are eligible for inclusion in the volunteer monitoring program. Approximately 1,000 lakes in Washington State meet these criteria, although the exact number is unknown (Rector and Hallock, 1995).

The main factor for selecting lakes was whether someone volunteered to monitor a lake for the program. In previous years volunteers were recruited through press releases or were referred to the program by Ecology staff, county offices, or from other volunteers. In 1997, most of the new volunteers were recruited to the program by referrals from other volunteers. Potential volunteers were accepted into the program if they indicated that they (1) wanted to monitor an eligible lake, (2) were willing and able to collect monitoring data for the six-month monitoring period, and (3) had access to a boat to use while collecting data.

Ecology coordinated lake selection with local volunteer lake monitoring programs in King County (coordinated by METRO) and Snohomish County (coordinated by Snohomish County Department of Public Works). The Snohomish County program was developed in 1993, so several volunteers who responded to Ecology's press release were referred to the new Snohomish County program. Some lakes were monitored by Ecology as well as King County's Small Lakes Program and Snohomish County's Volunteer Lake Monitoring Project. Data collected from these lakes may be compared in the future for QA/QC purposes.

In summary, each year of monitoring includes a group of lakes which have been monitored by volunteers over a long period (which allows for trend analysis), a group of lakes relatively new to the program, the volunteers for which may or may not continue over a long period, and a group of lakes monitored by Ecology staff for watershed-based permitting and planning purposes. The latter group of lakes are selected primarily because of a lack of data and geographical considerations.

Field Methods

There were two separate field data collection efforts for the program: (1) volunteers measured Secchi depth and surface water temperature on a relatively frequent basis (generally once every two weeks); and (2) Ecology staff collected water samples, profiles, and qualitative information on algae and macrophytes during two "onsite visits" with the volunteers.

Volunteer-Collected Data

All volunteers measured Secchi disk transparency and surface water temperature from one lake station (the deepest site). Data were collected between 10 a.m. and 2 p.m., approximately every two weeks from mid-May through mid-October 1997. Water clarity was measured by leaning over the shady side of a boat, lowering a 20 cm diameter limnological style Secchi disk until it was no longer visible, and then slowly raising the disk until it was just barely visible. This depth was then read from the line attached to the Secchi disk (which is marked at one-foot intervals) and recorded to the nearest 1/4 foot. The procedure was performed twice during each sampling trip. If the Secchi disk hit the lake bottom and was still visible, or was obscured by macrophyte growth, this was indicated on the data reporting card. The Secchi disks used by volunteers were made by Ecology staff, using methods described in Rector and Hallock (1991).

Surface water temperature was measured using red alcohol pocket thermometers. Two styles of pocket thermometers were used: a BCR model (range -40 to 50°C) and a model from Bacharach Instrument Company (range -35 to 120°F). Surface temperature was measured by holding the thermometer six to eight inches below the water surface until temperature equilibrated. The temperature was then quickly read, and recorded on the data card to the nearest 0.5 degree. Subjective assessments of weather conditions and water color were also reported on the data cards.

Each new volunteer was trained by Ecology staff at his or her monitoring site during the May surveys (see discussion below). New volunteers were provided with a summary of monitoring instructions, monitoring equipment (Secchi disk and thermometer), a bathymetric map showing the location of their monitoring site, and business-reply data cards for mailing in data. Each volunteer was also provided with a vial containing a small amount of Lugol's solution, to be used for collecting an algal sample. Collecting algal samples was optional, but having the vial readily available made it easier for volunteers to collect and preserve a sample from an algal bloom. Algae identification was provided by Ecology through the guidance of Dave Hallock.

In 1995, most volunteers were provided with viewing tubes, to help reduce the effect of glare and surface ripple. Earlier experience during the field visits with the volunteers showed that most volunteers could not see the Secchi disk as deep as Ecology staff (Rector and Hallock, 1993). This is partly due to differences in eyesight and experience with the Secchi disk. However, it was also apparent that while Ecology staff often measure Secchi depth while leaning over close to the water surface, this is not possible for all of the volunteers. To increase volunteers' readings closer to the range seen by Ecology staff, volunteers were provided with viewing tubes that were made by Ecology staff. Volunteers were asked to measure Secchi depth without the viewing tube, and then with the tube, on each of their regular monitoring days. Secchi depths measured with, and without, the tubes were also recorded during the onsite visits with Ecology staff so that a determination could be made whether the volunteers' "accuracy" improved using the viewing tube. Results of these evaluations are in the "Quality Assurance/Quality Control Evaluation and Results" section of this report.

All volunteers were mailed a questionnaire on lake and watershed uses near the end of each monitoring season. The purpose of these questionnaires was to gather additional information from the monitored lakes that may be used when assessing the lakes. Several questions required the volunteers to make additional observations around their lakes (e.g., counting the number of nearshore homes). Questionnaire results for each lake are presented with the individual lake assessments at the end of this report.

Data Collected by Ecology Staff

Ecology staff visited most of the volunteers twice in 1997; the first visit occurred during late May or early June, and the second occurred during late August or early September. The purpose of these visits was to (1) observe the volunteer's Secchi disk reading technique and compare to the Ecology staff reading, to determine whether the volunteer needed suggestions for improving his or her technique; (2) collect profile data and water samples from the volunteers' sampling sites; (3) collect macrophyte and/or algae samples for identification; and (4) answer questions or discuss lake issues with each of the volunteers.

During each field visit, the volunteer escorted Ecology personnel to their monitoring site, and anchored if possible. The volunteers and Ecology staff each measured Secchi depth. Temperature, pH, dissolved oxygen, and conductivity were profiled using a Hydrolab® Surveyor II or Sonde 3/Surveyor III. Temperature profile data were used to determine whether the lakes were stratified, and if they were, to determine depths within the epilimnion and hypolimnion 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 (indicated by a large increase in dissolved oxygen with no concurrent decrease in temperature), a sample was collected for later identification. Plant samples were either identified onsite, or collected for later identification. Algae and macrophyte samples were collected for qualitative purposes only, and results are not inclusive of all species present.

During each onsite visit, water samples for TP, total persulfate nitrogen (TN), and chlorophyll *a* were collected using a Kemmerer or Van Dorn style water sampler, and were composited from two to three equidistant depths within the strata (epilimnion or hypolimnion) sampled (Table 1). Samples for turbidity were collected from epilimnion of 16 lakes, at the same sites and sample depths as the nutrient samples. Most lakes sampled for turbidity were selected because in the previous year of sampling, they did not exhibit the expected relationship between Secchi depth, TP, and chlorophyll *a*. For some lakes, non-algal turbidity can interfere with these relationships.

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

Parameter	Strata Sampled[1]	Sample Preservation[2]	Analytical Method	Method Detection Limit	Holding Time	Analytical Lab[3]
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	0.010 mg/L	28 days	MEL
Chloro-phyll a4	epilimnion	$MgCO_3$	SM 10200H (2,B)	0.05 mg/L	28 days	MEL
Turbidity	epilimnion		SM 2540D,E	1 mg/L	7 days	MEL
Fecal Coliform Bacteria	nearshore grab samples (2 sites)		SM 9222D	1 colony/ 100 mL	30h	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 Manchester Environmental Laboratory (MEL)
4 Corrected for pheophytin.
5 Approximately 2 mL saturated $MgCO_3$ added with last of filtrate onto filter. Filters were iced, or frozen, until delivered to lab.

Fecal samples were collected approximately 20-35 feet from shore in areas which appeared (to the sampling staff) of having 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 $CaCO_3$ was added to the last of the filtrate to preserve the sample on the filter. Filters were placed in small plastic petri dishes, then wrapped in foil, and the lab number and volume of sample filtered were written on the foil. Packaged filters were bagged and stored in ice while in the field, and kept in a freezer until transported to the lab for analysis.

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 from 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), and Prescott (1980).

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 some professional judgment, were used to estimate the trophic status of the monitored lakes. In general, TSIs of 40 or less indicate oligotrophy, TSIs greater than 40 indicate mesotrophy, and TSIs greater than 50 indicate eutrophy (Carlson, 1979). To describe lakes which appeared to be between trophic states, the terms "oligo-mesotrophic" and "meso-eutrophic" were used.

TSI_{SD} values were calculated from a time-weighted mean Secchi depth calculated from all Secchi data collected between May and October 1997. The rationale for using a time-weighted TSI_{SD} is discussed in Rector (1994). A minimum of five Secchi depth measurements separated by at least two weeks were used to calculate the TSI_{SD} for each lake. Data invalidated by the QA/QC evaluation (below) were excluded from the TSI_{SD} calculations. TSI_{TP} and TSI_{CHL} values were calculated separately for each of the May and August results.

It is not legitimate 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." Therefore, a subjective assessment of all data collected during the monitoring season was used to determine which index to use for assigning trophic states. Then monitoring data, other available survey information (short-term lake surveys conducted by Ecology or universities, and consultant reports from Ecology-funded lake restoration activities), and information from the volunteers (e.g., information on aquatic herbicide use), were used to temper the trophic state assessment for most lakes. As a result, the 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 at the end of this report.

Quality Assurance/Quality Control Evaluation

All data collected for the Lake Water Quality Assessment (LWQA) Program were evaluated to determine whether data quality objectives for the program (Table 2) were met. Methods used for data quality evaluations are described in Lake Water Quality Assessment Program Quality Assurance Project Plan (Hallock, 1995). Laboratory QA/QC results for all parameters are discussed in Appendix B and listed in Appendix C. Hydrolab QC data are in Appendix D. The summary of QA/QC requirements is listed below in Table 2.

Table 2. Summary of data quality objectives for the LWQA Program.

Parameter	Detection Limit	Precision	Accuracy (Bias)
Secchi Depth	--	< 10% CV (daily pairs) < 5% CV (all pairs/lake)	< 10% CV (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 standard)
Profile parameters			
Temp.	--	--	± 0.5°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)	--
Solids	1 mg/L	± 1 mg/L (field splits)	--

Source of information: Hallock (1995)

Conclusions

A total of 70 publicly-owned lakes were sampled in 1997 by Ecology staff and volunteers. Total phosphorus, total nitrogen, and chlorophyll *a* were assessed for 63 of the lakes. Fecal coliform bacteria levels were evaluated for 20 of the lakes with known contamination problems and turbidity levels were evaluated for 18 of the lakes with known sedimentation problems; 452 surface temperature and Secchi depth readings were measured; 32 volunteer surveys regarding lake and watershed uses were completed. These and other factors, including Ecology staff observations and aquatic plant surveys, were combined to estimate the trophic states of each of the 70 lakes. Of those, twelve were oligotrophic, twenty-four were oligo-mesotrophic, thirteen were mesotrophic, nine were meso-eutrophic, and twelve were eutrophic.

Ecology's Lake Water Quality Assessment Program is the only lake management program statewide. It is effective in assessing the water quality of Washington's lakes and valuable for its promotion of public awareness of lake processes and lake protection measures. Because of its importance, the Program should be permanently funded.

Although quality control data indicated good quality data from the laboratories, more information is needed from the laboratories in order to determine whether data quality objectives for the program are met. Based on data quality review in 1997, the following recommendations were made for the 1998 program: The laboratory should report total phosphorus data to the nearest 0.1 µg/L so that variability in precision, accuracy, and detection limits can be calculated and the detection limit for total phosphorus can be computed independent of the lab. Additionally, because dissolved oxygen concentrations during Hydrolab® calibrations may be biased as field Winkler checks often do not meet QAPP standards, further research is needed to determine if there is a bias and how to correct the bias if it does exist.

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Appendix A

Individual Lake Assessments

The 70 individual lake assessments presented here were written primarily for the volunteers who participated in Washington's Citizen Lake Monitoring Project. As a result, layperson terms are used, and many basic limnological concepts are discussed or described.

Appendix B

Quality Assurance/Quality Control Results and Discussion for 1997

Volunteer-Collected Secchi Data

On each sampling date, volunteers measured the Secchi depth two times. The coefficient of variation (CV) was calculated for each pair of Secchi depth readings, to evaluate the volunteers' abilities to reproduce their measurements. Although this is summarized as "precision" in Table 2, it should be apparent that the two sets of readings cannot be collected independently of each other, so the estimation of precision may be biased. Pairs which exceeded the requirements in the data quality objectives were not used in calculations of trophic state indices (TSI_{SD}).

All CVs for each volunteer's data set for the year were pooled using the coefficient of variation (CV) to determine the overall variability in each volunteers' readings.

During at least one of the two field visits with the volunteers, Secchi depth was measured by both Ecology staff and the volunteers. The CV was calculated for Secchi depths measured during these field visits to evaluate the "accuracy" of the volunteers' measurements , assuming the Ecology staff reading was the "true" reading (Accuracy evaluation, Appendix C). Daily (Precision evaluation) and yearly (Median evaluation) precision assessments are also listed in Appendix C.

Overall, it was apparent that the majority of volunteers cannot see the disk as deep as Ecology staff. (This was also documented in 1990; Rector and Hallock, 1993.) In an attempt to improve Secchi depth readings collected by volunteers, viewing tubes were made by Ecology staff and distributed to volunteers in 1993. Using the tubes helps to reduce glare and surface ripple. Comparisons between volunteer-measured Secchi depths and Ecology staff-measured Secchi depths were made during the field visits. Based on improved "accuracy" using the viewing tubes volunteers with view tubes were asked to use a viewing tube for all their Secchi disk readings. Except for those volunteers who need to use the tube to increase "accuracy," most measurements made without tubes were used when both "with" and "without" readings were reported. This allows for readings collected before 1993 (including historical data) to be compared to readings collected for the current program. One exception is Lake Wenatchee, which is frequently choppy due to high winds in the area. The viewing tube has made it much easier for the volunteer to measure Secchi depth at this lake.

Profile Data

The Hydrolabs were pre- and postcalibrated daily for pH and dissolved oxygen. The manufacturer's instructions were followed for pH calibration, using pH 7 (low ionic strength) and pH 10 (regular, *i.e.,* high, ionic strength) standard buffer solutions. Postcalibration readings within 0.2 pH unit of the standard buffer values were considered acceptable. Dissolved oxygen concentrations from the Reporter unit were checked against the theoretical water-saturated air method as well as field samples collected at depth for Winkler titrations. Postcalibration results within 0.5 mg/L of the comparison method was considered acceptable. 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). Postcalibration values within 5 µmhos/cm of the standard value were considered acceptable. Temperature was also checked periodically against a National Bureau of Standards (NBS) mercury thermometer. Values within 0.5°C were considered acceptable. Pre and post-calibration results are listed in Appendix D.

Total Phosphorus Data

Laboratory QC

Results from all lab blanks were reported as 0 µg/L, although absorbances varied between individual blank samples. Based on the reported concentrations, the detection limit would be 0 µg/L. However, using the absorbances reported for each lab blank sample, the calculated detection limit was below 3 µg/L for 1997.

These detection limits were acceptable for the program, but also illustrate the need to have the lab report TP data to the nearest 0.1 µg/L (instead of the nearest whole µg/L) for QA/QC purposes. For the LWQA Program, all analytical results should be reported to one decimal place beyond the reporting limits, to allow for thorough (and easier) QA/QC evaluations.

Laboratory precision was calculated by pooling the coefficient for all pairs of lab splits. Results (Appendix C) were in the acceptable range specified in Table 2. Bias due to calibration error was estimated from the difference between the results for lab check standards and the true concentration. All spring data failed the QA requirements. The 40 µg/L standards failed for the summer survey. Interference effect (bias) due to the sample matrix was calculated as the percent recovery for matrix spikes. Bias due to matrix effects was considered acceptable if mean recoveries of matrix spikes were within 80-120%. Results from matrix spikes from both surveys were acceptable.

An additional check on laboratory quality control was to submit diluted standards as "blind" samples. However, because the standards had to be diluted considerably to be in the expected range of lake samples, the ranges of the extrapolated confidence intervals (calculated from equations provided with the standards) were extremely wide (e.g., 6.9 µg/L to 53.8 µg/L for a known TP concentration of 15 µg/L). Therefore, this QA test has been discontinued due to the relatively little value provided by the results.

Field Variability Evaluated from TP Field Duplicates

TP samples were collected at a second site from at least 10 lakes during each survey. These samples were collected to evaluate the representativeness of collecting epilimnetic data from a single lake station. The draft Quality Assurance Project Plan (QAPP) for the LWQA Program (Hallock, 1995) states that total precision of these field duplicates should be evaluated by pooling the CVs for each pair and if the median CV% exceeds 21% then collecting from a single lake station is not representative of epilimnetic phosphorous.

Results (Appendix C) show that the median CV% did not exceed 21%, therefore, sampling at one site is representative. As stated in the QAPP, to achieve spatial plus analytical variability within ± 3 TSI units using one sample per lake, the median CV% from at least 10 duplicate samples must be < 21%. Laboratory precision (CV%), which was calculated from results of field duplicate samples which were analyzed by the lab in duplicate, was 3.2% for the May survey, and 4.1% for the August survey. Both meet the criteria of less than 7.5%. Therefore results for total phosphorus meet the criteria set in the QAPP for representativeness and precision.

Other Water Chemistry Data

Hydrolab postcalibration data are compiled in Appendix D.

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.

Total Nitrogen

Results from field and laboratory duplicates were within acceptable ranges specified in Table 2.

Chlorophyll a

Total precision of chlorophyll *a* was reported as the median CV% of field duplicates. Results for the spring and summer were within the 10% limit (Appendix C).

Fecal Coliform Bacteria

It is not possible to conduct quality assurance calculations on fecal coliform data due to the wide variability in fecal concentrations detected in the field.

Turbidity

With one exception, all turbidity readings were within 0.5 NTUs (Appendix C).

Appendix C

Water Quality QA/QC Data from Lakes Monitored by Ecology Staff in 1997

Appendix C. Laboratory Quality Assurance/Quality Control Data for 1997

1997 TOTAL PHOSPHORUS DATA

May Lab Splits

Lake	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Long	34	34.2	34.1	0.1414214	0.414725
Palmer	33	29.4	31.2	2.5455844	8.158924
Roses	24.6	25.2	24.9	0.4242641	1.703872
Clear	59.6	56.2	57.9	2.4041631	4.152268
Clear	37.2	38.1	37.65	0.6363961	1.690295
Limerick	9.2	8.8	9	0.2828427	3.142697
Spanaway	8.8	9.8	9.3	0.7071068	7.603299
Newman	19.3	21.2	20.25	1.3435029	6.634582
Thomas	10.6	11.1	10.85	0.3535534	3.258557
Williams	12.8	11.2	12	1.1313708	9.42809
Tiger	3.9	4.1	4	0.1414214	3.535534
Mason	4.9	5.5	5.2	0.4242641	8.158924
Mason	3.9	3.8	3.85	0.0707107	1.836641
Padden	10.3	9.9	10.1	0.2828427	2.800423
Duck	53.7	52	52.85	1.2020815	2.274516
Horseshoe	12.7	12.9	12.8	0.1414214	1.104854
			Median CV%		3.200627

August Lab Splits

Lake	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Sylvia	12.6	11.7	12.15	0.6363961	5.237828
Tapps	25.1	26.2	25.65	0.7778175	3.032427
Palmer	14.8	17.1	15.95	1.6263456	10.19652
Slear	153	152	152.5	0.7071068	0.463677
Island	6.9	6.9	6.9	0	0
Long	36.5	44.5	40.5	5.6568542	13.96754
Loon	5.8	6.7	6.25	0.6363961	10.18234
Thomas	18.9	18.7	18.8	0.1414214	0.752241
Lacamas	25.7	24.7	25.2	0.7071068	2.805979
Martha Lake	5.6	6.4	6	0.5656854	9.42809
Samish	7.9	7.3	7.6	0.4242641	5.582422
Lake Martha	14.1	13.9	14	0.1414214	1.010153
Spanaway	14.4	14.6	14.5	0.1414214	0.97532
Toad	9.4	12.2	10.8	1.979899	18.3324
Bosworth	6.4	6.3	6.35	0.0707107	1.113554
Wooten	4	4.7	4.35	0.4949747	11.37873
			Median CV%		4.135127

All lab split median CV% are < 7.5 so the QAPP standard is met

Appendix C. Laboratory Quality Assurance/Quality Control Data for 1997

May Field Duplicates

Lake	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Long	27	34	30.50	4.9497475	16.22868
Palmer	33	30.6	31.8	1.6970563	5.336655
Phillips	7.9	7.6	7.75	0.212132	2.737188
Limerick	8.2	9.2	8.7	0.7071068	8.127664
Spanaway	10.4	8.8	9.6	1.1313708	11.78511
Newman	19.3	19.2	19.25	0.0707107	0.367328
Deep	20.1	10	15.05	7.1417785	47.45368
Tiger	4.4	3.9	4.15	0.3535534	8.519359
Mason	4	3.9	3.95	0.0707107	1.790144
Black	8.80	9.90	9.35	0.7778175	8.318903
			Median CV%		8.223284

August Field Duplicates

Lake	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Palmer	40.7	14.8	27.75	18.314066	65.99663
Silver	23.9	35	29.45	7.8488853	26.65156
Newman	33.3	31.5	32.4	1.2727922	3.928371
Black	8.8	7.8	8.3	0.7071068	8.519359
Sullivan	3.7	3.3	3.5	0.2828427	8.08122
Trails End	5.7	3.7	4.7	1.4142136	30.08965
Limerick	14.2	14.5	14.35	0.212132	1.478272
Lacamas	39	25.7	32.35	9.4045202	29.07116
Martha Lake	5.2	5.6	5.4	0.2828427	5.237828
Spanaway	13.70	14.40	14.05	0.4949747	3.522952
Bosworth	7.6	6.4	7	0.8485281	12.12183
			Median CV%		8.519359

All field duplicate CV% medians are < 21 so the QAPP standard is met

May Matrix Spikes

Date		% Recovery
5/19		102
5/28		94.2
5/30		89.5
6/05		92.4
6/10		122
6/19		82.5
	Mean	97.1
	Bias %	-2.9

August Matrix Spikes

Date		% Recovery
8/18		86.6
8/20		113
8/20		118
8/26		92.3
9/02		94.4
9/02		83.3
9/02		95.1
9/08		122
9/15		106
9/17		95.9
10/14		82.6
	Mean	99.01818
	Bias %	-0.981818

Appendix C. Laboratory Quality Assurance/Quality Control Data for 1997

May data

Total Phosphorous

check standards	**5ug/L**	**25ug/L**	**40ug/L**
	5		41.9
	4.6		
Total	9.6	0	41.9
mean	4.8	#DIV/0!	41.9
bias	-4	#DIV/0!	4.75

All >2.5% so fails QA requirements. Insufficient lab data.

Phosphorous LOD

blank 1	**blank 2**	**D**	**D^2**
-0.196	0.077	-0.273	0.074529
-0.93	-1.716	0.786	0.617796
-0.036	0.787	-0.823	0.677329
		sum of D^2=	1.369654

spring LOD = 1.12 *u*g/L

August data

check standards	**5ug/L**	**25ug/L**	**40ug/L**
	5.8	24.6	40.2
	5.4	24.8	39.2
	4.8	26.8	43.2
	4.6	26.3	39
	4.5		50
	4.5		
	4.9		
Total	34.5	102.5	211.6
mean	4.928571	25.625	42.32
bias	-1.428571	2.5	5.8

40 ug/L standard >2.5% so fails the requirements of the QAPP.

phosphorous LOD

blank 1	**blank 2**	**D**	**D^2**
-0.234	-0.96	0.726	0.527076
0.858	0.058	0.8	0.64
-0.422	-0.613	0.191	0.036481
0.866	0.99	-0.124	0.015376
-0.906	0.539	-1.445	2.088025
0.273	-0.068	0.341	0.116281
-0.011	0.793	-0.804	0.646416
0.204	0.725	-0.521	0.271441
		sum of D^2=	4.341096

fall LOD = 0.97 *u*g/L

LOD= (square root of sum of D squared/2*number of observations)*t distribution (alpha = 0.1)

Appendix C. Laboratory Quality Assurance/Quality Control Data for 1997

1997 Total Nitrogen Data

May Field Duplicates

Lake	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Long	0.431	0.463	0.447	0.0226274	5.062062
Palmer	0.266	0.269	0.2675	0.0021213	0.793017
Phillips	0.17	0.168	0.169	0.0014142	0.836813
Limerick	0.148	0.128	0.138	0.0141421	10.24792
Newman	0.406	0.325	0.3655	0.0572756	15.67049
Deep	0.172	0.111	0.1415	0.0431335	30.48305
Mason	0.102	0.029	0.0655	0.0516188	78.80732
			Median CV%		10.24792

August Field Duplicates

Lake	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Palmer	0.226	0.222	0.224	0.0028284	1.262691
Silver	0.815	0.785	0.8	0.0212132	2.65165
Black	0.189	0.164	0.1765	0.0176777	10.01568
Sullivan	0.03	0.031	0.0305	0.0007071	2.318383
Trails End	0.256	0.215	0.2355	0.0289914	12.31056
Limerick	0.226	0.231	0.2285	0.0035355	1.54728
Martha Lake	0.218	0.265	0.2415	0.033234	13.7615
Samish	0.192	0.233	0.2125	0.0289914	13.643
					6.333664

All median CV% of the field duplicate samples are < 30 so standards set by the QAPP are met

May lab duplicates

Lake	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Long (Kits)	0.463	0.475	0.469	0.0084853	1.809228
Palmer	0.266	0.268	0.267	0.0014142	0.529668
Silver (Sp)	1.44	1.43	1.435	0.0070711	0.492757
Phillips	0.17	0.173	0.1715	0.0021213	1.236921
Limmerick	0.128	0.124	0.126	0.0028284	2.244783
Lacamas	0.608	0.607	0.6075	0.0007071	0.116396
Loon	0.371	0.369	0.37	0.0014142	0.38222
Mason	0.029	0.034	0.0315	0.0035355	11.22392
			Median CV%		0.883295

August lab duplicates

Lake	#1 (ug/L)	#2 (ug/L)	Mean	S	CV%
Cascade	0.189	0.179	0.184	0.0070711	3.842972
Duck	0.274	0.278	0.276	0.0028284	1.024792
Wapato	0.477	0.484	0.4805	0.0049497	1.030124
Island	0.152	0.149	0.1505	0.0021213	1.409515
Long (Kits)	0.496	0.497	0.4965	0.0007071	0.142418
Deep (St)	0.13	0.124	0.127	0.0042426	3.340662
Sullivan	0.03	0.026	0.028	0.0028284	10.10153
Mason	0.075	0.069	0.072	0.0042426	5.892557
			Median CV%		2.375089

All median CV%<5 so standards set by the QAPP are met

Appendix C. Laboratory Quality Assurance/Quality Control Data for 1997

Chlorophyll *a* Data

No chlorophyll collected in the spring

August site duplicate

Lake	sample#1	sample#2	Mean	s	CV %
Palmer	3.7	4.2	3.95	0.3535534	8.950719
Silver (Sp)	4.7	4.9	4.8	0.1414214	2.946278
Newman	9.1	13.4	11.25	3.0405592	27.02719
Trails End	1.4	1.4	1.4	0	0
Samish	5.2	4.8	5	0.2828427	5.656854
Bosworth	4.3	3.9	4.1	0.2828427	6.898603
			Median CV%		6.277728

August field duplicates

Lake	Site # 1	Site # 2	Mean	s	CV %
Palmer	3.2	3.7	3.45	0.3535534	10.24792
Silver (Sp)	5.4	4.7	5.05	0.4949747	9.80148
Newman	9.2	9.1	9.15	0.0707107	0.772794
Trails End	0.99	1.4	1.195	0.2899138	24.26057
Samish	6.1	5.2	5.65	0.6363961	11.26365
Bosworth	4.8	4.3	4.55	0.3535534	7.770404
			Median CV%		10.0247

QAPP standards set for chlorophyll are met for 1997sampling

Turbidity

Lake	May sample	duplicate	difference
Tapps	3.4	3.3	0.1
Island	0.9	1	0.1
Conconully	13	13	0
Newman	2.1	2.2	0.1
Bay	4.3	4.2	0.1
Padden	1.5	1.3	0.2
Whatcom	0.9	0.9	0
Hummel	4.4	4.3	0.1

Lake	August sample	duplicate	difference
Sylvia	1.7	1.7	0
Roses	3	3.1	0.1
Mill Creek	45	45	0
Isabella	0.8	0.8	0
Black (Stev)	0.8	0.7	0.1
Wiser	16	15	1
Whatcom	0.9	0.8	0.1
Bay	3	3	0

All duplicates, except for Wiser Lake (fall), are within 0.5 NTUs so all but Wiser pass QA.

Appendix C. Accuracy Evaluation 1997

This list contains all QC Secchi pairs for 1997. Only records with 'QC = TRUE' were evaluated (i.e. volunteer/ecology pairs)

Lake	Sampler	Date	Secchi1	Secchi2	%CV
BAY (PIERCE)	PRAWITZ	97/06/05	3.5	4	9
BIG MEADOW (PEND ORE	HALLOCK	97/05/30	9.25	10.1	6
BIG MEADOW (PEND ORE	TERRY WILLIAMS	97/08/28	7.2	8	7
BOSWORTH (SNOHOMISH)	DICK MCFADDEN	97/06/03	16	17	4
CLEAR (SPOKANE)	HALLOCK/JOHNSON	97/05/22	19	18	4
CONCONULLY (OKANOGAN	HALLOCK/MOORE	97/05/19	17	18.5	6
CONCONULLY (OKANOGAN	LELAND MOORE	97/08/18	19	19	0
CRAWFISH (OKANOGAN)	DON PETERSON	97/08/17	13.6	15.6	10
CURLEW (FERRY)	HALLOCK/PERRY	97/05/18	15	16.5	7
CURLEW (FERRY)	DAVE HALLOCK	97/08/26	13.94	16.4	11
DEEP (STEVENS)	HALLOCK/HILL	97/05/30	6	7.3	14
DEEP (STEVENS)	STEPHEN HILL	97/08/26	13.5	12.5	5
DEEP (STEVENS)	HALLOCK/HILL	97/05/30	6	9.6	33
DUCK (GRAYS HARBOR)	ED MARCHBANK	97/08/21	7	8	9
GILLETTE (STEVENS)	RAY HAWK	97/05/29	8.75	8.83	1
GRAVELLY (PIERCE)	RAEMA HICKEY	97/06/19	14.67	15.17	2
HAVEN (MASON)	GENE MCTEE	97/06/05	19.5	19.5	0
HICKS (THURSTON)	DOLLY YATES	97/09/02	5.5	6	6
HORSESHOE (KITSAP)	SMITH	97/09/12	8.5	10.5	15
HORSESHOE (KITSAP)	KAREN CARLSEN	97/09/12	8.5	10.5	15
ISABELLA (MASON)	JEANETTE WEBB	97/06/04	11	9.75	9
ISLAND (MASON)	BILL YOUNG	97/05/21	16	16	0
KI (SNOHOMISH)	SMITH	97/06/04	26	27	3
LACAMAS (CLARK)	JUDY BALDWIN	97/09/02	6	6	0
LAVENDER (KITTITAS)	ANETTE PETERS	97/06/03	13.5	12.5	5
LELAND (JEFFERSON)	SMITH	97/05/22	5	5.25	3
LENORE (GRANT)	RAY NEFF	97/08/19	6.25	6.8	6
LIMERICK (MASON)	SMITH	97/05/27	11	11.5	3
LONG (THURSTON)	KATHEY WICOFF	97/08/28	5.5	5.83	4
LOOMIS (PACIFIC)	CHUCK BLIGHT	97/08/21	4	4.08	1
LOON (STEVENS)	ROD FEYK	97/08/25	22	22.5	2
MARTHA (LAKE MARTHA)	NANCY DEAN	97/09/04	16.5	16.34	1
MARTHA (MARTHA LAKE)	JOHN GUENTZ	97/06/09	19.4	19.4	0
MASON (MASON)	ALDEN BERNHARD	97/06/05	19	19	0
NAHWATZEL (MASON)	DAVE FOWBLE	97/08/25	19	20	4
NEWMAN (SPOKANE)	HALLOCK	97/05/28	8.9	8.9	0
NEWMAN (SPOKANE)	PUPO	97/05/28	8.9	8.9	0
NEWMAN (SPOKANE)	DAN PUPO	97/08/25	5	5.1	1
OSOYOOS (OKANOGAN)	ULLRICH	97/05/19	8.3	8.9	5
OSOYOOS (OKANOGAN)	WALTER R. ULLRI	97/08/18	13.75	16.6	13
PALMER (OKANOGAN)	CARLTON	97/05/17	3	3	0

Appendix C. Accuracy Evaluation 1997

Lake	Sampler	Date	Secchi1	Secchi2	%CV
PALMER (OKANOGAN)	JAMES CARLETON	97/08/18	14.5	16.1	7
PATTISON (NORTH ARM)	SMITH	97/05/27	3.75	3.5	5
PATTISON (NORTH ARM)	PAULA LOWE	97/08/28	9	7.67	11
PHILLIPS (MASON)	KIRK SMITH	97/09/01	12	13	6
ROESIGER (NORTH ARM)	ELSIE SORGENFRE	97/06/03	19	17	8
ROESIGER (SOUTH ARM)	SMITH	97/06/03	16	18	8
SAMISH (EAST ARM) (W	A. B. DAVIS	97/06/04	17	21	15
SAWYER (KING)	DOUG GEIGER	97/06/12	10.5	11.25	5
SILVER (SPOKANE)	HALLOCK	97/05/22	16.8	17.8	4
SPANAWAY (PIERCE)	SUE THOMPSON	97/09/05	12.5	12.5	0
ST. CLAIR (THURSTON)	M. E. CHRISTOPH	97/08/20	9.08	11.75	18
SULLIVAN (PEND OREIL	HALLOCK	97/05/29	17.1	17.9	3
SULLIVAN (PEND OREIL	STORY	97/05/29	19.5	17.5	8
SULLIVAN (PEND OREIL	ERIC STORY	97/08/28	42	43	2
SUMMIT (THURSTON)	LARRY DAVIS	97/08/28	25	26	3
TAPPS (PIERCE)	BRUCE COCHRAN	97/05/19	8	7.5	5
THOMAS (STEVENS)	RAY HAWK	97/05/29	10	10.7	5
TIGER (KITSAP/MASON)	KIRK SMITH	97/06/02	21.5	27	16
WARD (THURSTON)	KIT WEAVER	97/06/02	15	16.5	7
WENATCHEE (CHELAN)	HALLOCK	97/05/27	16.8	17.5	3
WILDCAT (KITSAP)	NATHAN SESSIONS	97/06/09	17	17	0

Appendix C. Median Evaluation 1997

This list contains the median CV for volunteer Secchi pairs for 1997.
Only records where both readings were taken either with or without a view tube were evaluated (I.e. w/tube1=wtube2). Entries with 'QC = TRUE' were not included. Pairs with CV > 10% were not included. N2 is the number of pairs that meet these criteria, n1 is the total number of pairs (should be >5).

Lake	Station	Median CV	n1	n2
ALICE (KING)	1	2.4	15	13
BAY (PIERCE)	1	N/A	2	0
BIG MEADOW (PEND OREILLE)	0	N/A	1	0
BIG MEADOW (PEND OREILLE)	1	0	12	11
BLACK (STEVENS)	1	4.9	1	1
BOSWORTH (SNOHOMISH)	1	0	11	9
CASCADE (SAN JUAN)	1	N/A	1	0
CLEAR (SPOKANE)	1	3.8	8	6
CLEAR (SPOKANE)	2	N/A	1	0
CONCONULLY (OKANOGAN)	0	N/A	1	0
CONCONULLY (OKANOGAN)	1	0	5	4
CRAWFISH (OKANOGAN)	1	3.3	9	5
CURLEW (FERRY)	0	N/A	1	0
CURLEW (FERRY)	1	N/A	10	0
DEEP (STEVENS)	1	N/A	10	0
DEEP (STEVENS)	2	N/A	1	0
DUCK (GRAYS HARBOR)	1	0	8	7
DUCK (GRAYS HARBOR)	2	4.2	6	6
DUCK (GRAYS HARBOR)	3	0	8	8
FISH (CHELAN)	1	N/A	2	0
GILLETTE (STEVENS)	1	0	8	7
GRAVELLY (PIERCE)	0	4.9	1	1
GRAVELLY (PIERCE)	1	4.9	4	3
HAVEN (MASON)	1	1.6	12	7
HICKS (THURSTON)	1	6.2	7	3
HORSESHOE (KITSAP)	0	N/A	1	0
HORSESHOE (KITSAP)	1	3.6	8	7
HUMMEL (SAN JUAN)	1	N/A	1	0
ISABELLA (MASON)	1	0	5	3
ISLAND (MASON)	1	2	9	8
KI (SNOHOMISH)	2	0	8	5
LACAMAS (CLARK)	1	2.4	7	5
LAVENDER (KITTITAS)	0	N/A	2	0
LAVENDER (KITTITAS)	1	N/A	4	0
LELAND (JEFFERSON)	1	0	10	5
LENORE (GRANT)	1	N/A	2	0
LIMERICK (MASON)	1	1.3	10	7
LIMERICK (MASON)	8	0	1	1
LONG (KITSAP)	1	N/A	1	0

Appendix C. Median Evaluation 1997

Lake	Station	Median CV	n1	n2
LONG (THURSTON)	1	1.4	14	10
LOOMIS (PACIFIC)	1	0	11	7
LOON (STEVENS)	0	N/A	2	0
LOON (STEVENS)	1	0	10	7
MARTHA (LAKE MARTHA) (SNOHO	1	0	12	11
MARTHA (MARTHA LAKE) (SNOHO	1	1.8	9	2
MASON (MASON)	2	3.1	9	9
MASON (MASON)	3	2.9	8	7
MASON (MASON)	4	0	11	10
MILL CREEK (WALLA WALLA)	1	N/A	1	0
MOUNTAIN (SAN JUAN)	1	N/A	1	0
NAHWATZEL (MASON)	1	0	6	5
NEWMAN (SPOKANE)	0	N/A	2	0
NEWMAN (SPOKANE)	1	0.6	7	4
OSOYOOS (OKANOGAN)	0	N/A	2	0
OSOYOOS (OKANOGAN)	1	0	10	8
PADDEN (WHATCOM)	1	N/A	1	0
PALMER (OKANOGAN)	0	N/A	2	0
PALMER (OKANOGAN)	1	2.6	7	6
PATTISON (NORTH ARM) (THURS	1	6.4	10	5
PHILLIPS (MASON)	1	0	8	7
ROCK (WHITMAN)	0	N/A	1	0
ROCK (WHITMAN)	1	N/A	1	0
ROESIGER (NORTH ARM) (SNOHO	1	4	6	4
ROESIGER (SOUTH ARM) (SNOHO	3	2	8	6
ROSES (ALKALI) (CHELAN)	1	N/A	2	0
SAMISH (EAST ARM) (WHATCOM)	1	2	8	5
SAMISH (WEST ARM) (WHATCOM)	2	0	8	7
SAWYER (KING)	1	N/A	5	0
SILVER (SPOKANE)	1	1.1	7	6
SPANAWAY (PIERCE)	1	0	13	2
SPORTSMAN (SAN JUAN)	1	N/A	1	0
ST. CLAIR (THURSTON)	1	2.5	14	13
SULLIVAN (PEND OREILLE)	0	5.4	4	2
SULLIVAN (PEND OREILLE)	1	2.6	3	1
SUMMIT (THURSTON)	1	0	7	6
SYLVIA (GRAYS HARBOR)	0	N/A	2	0
SYLVIA (GRAYS HARBOR)	1	N/A	1	0
TAPPS (PIERCE)	1	0	7	4
TAPPS (PIERCE)	2	N/A	2	0
TERRELL (WHATCOM)	1	N/A	1	0
THOMAS (STEVENS)	1	0	10	7
TIGER (KITSAP/MASON)	0	N/A	1	0
TIGER (KITSAP/MASON)	1	4.2	10	8
TOAD (EMERALD) (WHATCOM)	1	N/A	1	0

Appendix C. Median Evaluation 1997

Lake	Station	Median CV	n1	n2
TRAILS END (MASON)	1	N/A	2	0
WAPATO (CHELAN)	0	N/A	2	0
WAPATO (CHELAN)	1	N/A	1	0
WARD (THURSTON)	1	5.7	11	8
WENATCHEE (CHELAN)	1	0	10	9
WHATCOM (WHATCOM)	1	N/A	1	0
WILDCAT (KITSAP)	1	0	4	2
WILLIAMS (SPOKANE)	1	2.6	1	1
WILLIAMS (STEVENS)	1	N/A	1	0
WISER (WHATCOM)	1	3.9	1	1
WOOTEN (MASON)	1	2.8	12	9
WYE (KITSAP)	1	0	10	9

Appendix C. Precision Evaluation

This list contains Secchi pairs with CV > 10 percent for 1997.
Only records where both readings were taken either with or without a view tube were evaluated (i.e., wtube1=wtube2). Entries with 'QC=TRUE' were not included.

Lake	Sampler	Date	Secchi1	Secchi2	CV%
LONG (THURSTON)	KATHEY WICOFF	97/05/10	6	7	11
MASON (MASON)	JIM SCOTT	97/10/04	15	18	13
PATTISON (NORTH ARM)	LORAINE VAA	97/05/20	3	2.5	13
SAMISH (EAST ARM) (W	A. B. DAVIS	97/06/18	18	24	20
TAPPS (PIERCE)	BRUCE COCHRAN	97/08/17	0.25	0.34	22
TAPPS (PIERCE)	BRUCE COCHRAN	97/08/31	0.5	0.67	21

Appendix D

Hydrolab Postcalibration Data for 1997

Appendix D. Hydrolab Postcalibration Data for 1997

Date	Parameter	Comparison Value	Hydrolab Value	Postcalibration for the following Lakes	QA P/F
5/16/97	DO field check	10.10	9.80	Sylvia	P
	pH	6.97	6.83		P
	pH	9.16	9.16		P
	K (uS/cm)	100.90	110.50		
	DO calibration	8.01	7.87		P
5/18/97	DO field check	9.85	10.00	Curlew	P
	pH	7.01	7.07		P
	pH	9.25	9.25		P
	DO calibration	9.61	8.90		F
5/19/97	DO field check	9.50	8.87	Tapps, McIntosh	F
	pH	7.00	6.84		P
	pH	9.22	9.05		P
	DO calibration	8.59	8.59		P
	K	96.40	100.90		
	T (^{o}C)	22.70	22.12		P
	DO field check	9.75	9.80	Osoyoos, Palmer, Conconully	P
	pH	7.00	7.05		P
	pH	9.23	9.24		P
	DO calibration	9.73	9.75		P
5/20/97	pH	6.98	7.01	Wapato, Roses	P
	pH	9.27	9.25		P
	DO calibration	10.89	10.87		P
5/21/97	DO field check	9.60	9.54	Island, Isabella	P
	pH	7.00	6.94		P
	pH	9.24	9.18		P
	DO calibration	9.01	8.99		P
	DO field check	8.15	8.17	Lenore, Mill	P
	pH	7.00	7.01		P
	pH	9.25	9.25		P
	DO calibration	10.21	10.22		P
5/22/97	DO field check	9.54	9.24	Leland, Long (Kitsap)	P
	pH	9.31	9.24		P

Appendix D. Hydrolab Postcalibration Data for 1997

Date	Parameter	Comparison Value	Hydrolab Value	Postcalibration for the following Lakes	QA P/F
5/22/97	DO calibration	9.04	9.08		P
	DO field check	9.60	9.61	Silver, Clear	P
	pH	6.98	6.93		P
	pH	9.20	9.12		P
	DO calibration	9.23	9.13		P
5/26/97	DO field check	9.79	9.45	Wooten, Wye, Phillips	F
	pH	7.00	6.99		P
	pH	9.21	9.20		P
	DO calibration	9.75	9.82		P
5/27/97	DO field check	8.85	9.01	Limerick	P
	pH	6.99	7.00		P
	pH	9.20	9.20		P
	DO calibration	8.42	8.62		P
	DO field check	9.90	9.79	Wenatchee, Fish	P
	pH	6.99	7.01		P
	pH	9.20	9.22		P
	DO calibration	9.24	9.51		P
5/28/97	DO field check	9.85	9.17	Lacamas, Trails End, Spanaway	F
	pH	7.00	7.08		P
	pH	9.24	9.25		P
	DO calibration	9.86	10.10		P
	DO field check	10.15	9.96	Rock, Newman, Loon	P
	pH	6.99	6.95		P
	pH	9.20	9.20		P
	DO calibration	9.76	9.48		P
5/29/97	DO field check	9.15	9.90	Sullivan, Gillette, Thomas, Black	F
	pH	6.99	6.98		P
	pH	9.21	9.23		P
	DO calibration	9.40	9.50		P

Appendix D. Hydrolab Postcalibration Data for 1997

Date	Parameter	Comparison Value	Hydrolab Value	Postcalibration for the following Lakes	QA P/F
5/30/97	DO field check	9.40	9.31	Williams, Big Meadow, Deep	P
	pH	6.98	6.95		P
	pH	9.19	9.18		P
	DO calibration	8.70	8.74		P
6/2/97	DO field check	11.50	9.12	Tiger	F
	pH	6.99	6.90		P
	pH	9.17	9.21		P
	DO calibration	9.49	9.58		P
6/3/97	DO field check	10.50	9.56	Bosworth, Roesiger	F
	pH	6.99	7.01		P
	pH	9.24	9.23		P
	DO calibration	10.00	10.00		P
6/4/97	pH	7.00	7.05	Samish, Ki	P
	pH	9.24	9.26		P
	DO calibration	10.49	10.48		P
6/10/97	DO field check	10.18	10.31	Toad, Padden	P
	pH	6.98	6.98		P
	pH	9.19	9.19		P
	DO calibration	8.42	8.46		P
6/11/97	DO field check	11.15	9.82	Whatcom, Terrell,Wiser, Alice	F
	pH	6.99	6.98		P
	pH	9.23	9.42		P
	DO calibration	9.24	9.19		P
6/12/97	DO field check	9.29	9.37	Lake Martha	P
	pH	6.97	7.08		P
	pH	9.17	9.27		P
	DO calibration	8.66	8.78		P
6/16/97	DO field check	8.78	9.02	Duck, Nahwatzel	F
	pH	6.97	6.85		P
	pH	9.18	9.20		P
	DO calibration	9.08	9.10		P

Appendix D. Hydrolab Postcalibration Data for 1997

Date	Parameter	Comparison Value	Hydrolab Value	Postcalibration for the following Lakes	QA P/F
6/17/97	pH	7.00	7.02	Sportsman	P
	pH	9.23	9.25		P
	DO calibration	8.20	8.38		P
8/15/97	DO field check	7.37	8.01	Sylvia	F
	pH	6.96	6.86		P
	pH	9.14	9.11		P
8/17/97	DO field check	7.38	7.96	Crawfish	F
	pH	6.98	7.00		P
	pH	9.19	9.18		P
8/18/97	DO field check	8.87	9.20	Cascade, Mountain	F
	pH	6.98	7.05		P
	pH	9.18	9.33		P
	DO field check	8.28	8.67	Osoyoos, Conconully, Palmer	F
	pH	6.98	7.03		P
	pH	9.18	9.14		P
8/19/97	DO field check	3.45	3.60	Hummel, Sportsman	P
	pH	7.00	6.91		P
	DO field check	11.41	12.86	Wapato, Roses, Lenore	F
	pH	6.97	6.99		P
	pH	9.16	9.15		P
8/20/97	DO field check	8.63	8.42	Tapps	P
	pH	6.98	6.99		P
	pH	9.19	9.21		P
	DO field check	7.39	7.70	Mill, Clear	F
	pH	6.99	7.05		P
	pH	9.20	9.15		P

Appendix D. Hydrolab Postcalibration Data for 1997

Date	Parameter	Comparison Value	Hydrolab Value	Postcalibration for the following Lakes	QA P/F
8/21/97	DO field check	8.07	7.75	Duck, Loomis	F
	pH	6.98	6.97		P
	pH	9.19	9.21		P
8/24/97	DO field check	7.61	7.84	Lavender, Rock	P
	pH	6.99	7.02		P
	pH	9.23	9.22		P
8/25/97	DO field check	8.23	8.4	Island, Nahwatzel, Isabella	P
	pH	6.99	7.05		P
	pH	9.22	9.17		P
	DO field check	5.92	6.33	Loon, Newman	F
	pH	7.00	7.06		P
	pH	9.23	9.29		P
8/26/97	DO field check	7.99	8.25	Leland, Wildcat, Long	P
	pH	6.99	6.92		P
	pH	9.18	9.14		P
	DO field check	7.68	7.70	Curlew, Williams, Deep	P
	pH	6.98	6.93		P
	pH	9.18	9.15		P
8/27/97	DO field check	7.80	8.16	Thomas, Gillette, Black	F
	pH	6.99	7.04		P
	pH	9.23	9.23		P
8/28/97	DO field check	8.17	8.16	Sullivan, Big Meadow	P
	pH	6.99	7.00		P
	pH	9.22	9.21		P
8/29/97	DO field check	7.79	8.06	Wenatchee, Fish	P
	pH	6.97	6.86		P
	pH	9.18	9.12		P

Appendix D. Hydrolab Postcalibration Data for 1997

Date	Parameter	Comparison Value	Hydrolab Value	Postcalibration for the following Lakes	QA P/F
9/1/97	DO field check	8.03	8.48	Trails End, Phillips, Limerick, Mason	F
	pH	6.99	6.95		P
	pH	9.21	9.12		P
9/2/97	DO field check	10.69	11.38	Lacamas	F
	pH	6.97	7.07		P
	pH	9.17	9.30		P
9/3/97	DO field check	8.22	8.81	Alice, Martha Lake	F
	pH	6.98	6.92		P
	pH	9.18	9.13		P
9/4/97	DO field check	9.01	9.61	Samish, Lake Martha	F
	pH	6.97	7.04		P
	pH	9.18	9.14		P
9/5/97	DO field check	11.51	12.19	Spanaway, Gravelly	F
	pH	6.97	6.99		P
	pH	9.15	9.15		P
9/8/97	DO field check	8.80	8.89	Toad, Terrell, Wiser	P
	pH	6.97	7.12		P
	pH	9.20	9.18		P
9/10/97	DO field check	8.64	8.65	Whatcom, Padden	P
	pH	6.97	6.89		P
	pH	9.16	9.10		P
9/11/97	DO field check	8.15	9.00	Roesiger, Bosworth	F
	pH	6.98	6.99		P
	pH	9.19	9.19		P
9/12/97	DO field check	7.51	8.05	Horseshoe, Bay, Wye	F
	pH	6.97	7.00		P
	pH	9.18	9.15		P

Appendix D. Hydrolab Postcalibration Data for 1997

Date	Parameter	Comparison Value	Hydrolab Value	Postcalibration for the following Lakes	QA P/F
9/16/97	pH	7.00	7.01	Tiger, Woten, Haven	P
	pH	9.23	9.23		P