WATER QUALITY STATUS REPORT NO. 105

Idaho Lake Water Quality Assessment Report

Idaho Department of Health and Welfare

Division of Environmental Quality
North Idaho Regional Office
March, 1993

Water Quality Status Report No. 105

Idaho Lake Water Quality Assessment Report

Prepared by
Jere Mossier, Ph.D.

2110 Ironwood Parkway
Coeur d'Alene, ID 83814

(208) 667-3524

Idaho Department Of Health and Welfare
Division of Environmental Quality
North Idaho Regional Office
March, 1993

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ACKNOWLEDGEMENTS

Appreciation is extended to those individuals from the Idaho Division of Environmental Quality (DEQ) who participated in the Lake Water Quality Assessment (LWQA) Study from its inception to this final report. Appreciation is also extended to the citizens who volunteered their time and efforts to participate in the Citizen Volunteer Monitoring Program (CVMP). This LWQA Study was funded by a Lake Water Quality Assessment (Clean Lakes) grant from the Environmental Protection Agency (EPA) and matching grant funds from the Idaho Division of Environmental Quality.

I thank Ed Tulloch, Carla Fromm, Glen Rothrock and Bill Clark for their guidance and suggestions in completing the Lake Water Quality Assessment Study and Final Report. I thank Mike Hartz, DEQ aquatic biologist for his exceptional assistance in field sampling and report preparation in 1991 and 1992. Gratitude is also extended to Scott McQuarrie and Mike Beckwith, both formerly of Idaho DEQ for their LWQA field sampling and data collection in 1990. I also extend my appreciation to the staff at the Idaho Health and Welfare Analytical Laboratories in Coeur d'Alene and Boise, Idaho, for their analysis of water and biological samples.

EXECUTIVE SUMMARY

A Lake Water Quality Assessment Study (LWQA) and Citizen's Volunteer Monitoring Program (CVMP) was conducted in northern Idaho during 1990 and 1991. The LWQA Study was designed to assess the trophic status and water quality of selected lakes in Idaho and make recommendations to maintain the beneficial uses of these lakes and prevent further eutrophication. The LWQA also was designed to evaluate the CVMP and determine the most effective and efficient means and parameters to monitor and evaluate lake water quality.

The LWQA Study demonstrated that secchi depth, chlorophyll "a" and total phosphorus can be used in conjunction with dissolved oxygen and temperature (August) profiles and the number of prevalent species of submergent macrophytes to determine water quality and trophic status of lakes. The maximum water depth that submergent macrophytes grow as related to secchi depth and lake trophic status was also found to be an important parameter.

The cost and reliability of water quality and biological parameters used in citizen volunteer lake monitoring programs was a major concern that was evaluated in this LWQA Study. Based on the results of this Study and other information, the following recommendations can be made for implementing a citizen's volunteer lake monitoring program and future LWQA Study efforts:

* Measure those parameters in citizen volunteer monitoring programs which provide meaningful, cost-effective information for use in determining lake water quality and trophic status:

    1) dissolved oxygen/temperature profiles in August,
    2) secchi depth,
    3) number of prevalent submergent macrophyte species,
    4) chlorophyll "a", and
    5) total phosphorus.

* Nitrogen water chemistry provided limited utility, reliability and poor precision, relative to the cost and time expended.
* Diatoms, flagellates and green algal groups were not a reliable measure of water quality and lake trophic status. Only the blue-green algal group was found to be a reliable lake trophic status indicator. Phytoplankton analysis should be a low priority parameter in volunteer lake monitoring programs, based on the cost, time and limited utility of this information.

INTRODUCTION

Lake Water Quality Assessment Objectives

Section 314(a)(2) of the Clean Water Act, as amended by the Water Quality Act of 1987, requires the States to submit a biennial assessment of their lake water quality as part of their 305(b) report. The specific elements of the assessment, as outlined in Section 314(a)(1), constitute the minimal requirements for approval and for subsequent requests for federal assistance as required by Section 314(a)(4).

The purpose of the Lake Water Quality Assessment (LWQA) project was to increase our knowledge and understanding of lake water quality conditions and sources of pollution in selected lakes in northern and central Idaho. The information compiled through this project allows the Idaho Division of Environmental Quality (DEQ) to:

* Confirm or dispel the public perception of declining lake water quality in the selected lakes of high public value.
* Determine trophic status for the selected lakes.
* Determine trends in lake conditions over time where possible.
* Determine nutrients of concern for the selected lakes.
* Determine beneficial use support status for the selected lakes.
* Identify potential sources of pollution.
* Recommend appropriate management actions.
* Provide QA/AC data for the Citizen Lake Monitoring Program.
* Update the Idaho Lake Inventory.
* Provide a list of significant public-owned lakes examined in the Study and classify according to trophic condition.
* Provide a prioritized list of lakes and their acreage that are known to have threatened or impaired uses.
* For each threatened or impaired lake studied, provide the following:
    a) A summary of chemical and biological data demonstrating the present water quality.
    b) General lake characteristics.
    c) General watershed description.
    d) Major point and nonpoint sources of pollution and any controls in place.
    e) Ongoing NonPoint Source program activity in the associated watersheds.

The primary goal of the LWQA was to assess the water quality and trophic status of 17 Idaho lakes and make management recommendations to prevent further lake eutrophication and water quality degradation of these lakes.

The 17 lakes studied were: Winchester, Mann, Rose, Waha, Soldier Meadow, Granite, Round, Hauser, Cocolalla, Upper Twin, Kelso, Fernan, Lower Twin, Upper Priest, Spirit, Hayden and Priest. Data and information for all of these seventeen lakes were evaluated with the objectives outlined above.

Background and Overview

Idaho has over 2,800 named freshwater lakes covering a total of more than 700,000 surface acres (IDFG, 1988). The types and distribution of lakes range from large, mainstem river reservoirs in southern Idaho, to alpine lakes in the high mountain areas of central Idaho, to developed recreational lakes in the northern panhandle area.

Lake conditions vary from pristine to overproductive. Most of the reservoirs in Idaho were created to provide agricultural irrigation water. Many are experiencing eutrophication problems due to excessive nutrient and sediment loading from irrigation return flows and agricultural runoff. High alpine lakes are pristine and generally not impacted by human activities. Signs of deteriorating water quality are most notable in the panhandle area lakes. Although few of these lakes are classified as eutrophic, there is a strong public perception of deteriorating water quality. Sources of impact to these are varied. Shoreline development results in impacts from construction, urban runoff and subsurface sewage disposal. Watershed sources of impact include mining, agriculture and forest practices.

Most of the information on the condition of Idaho lakes has come from two major lake eutrophication studies. A lake classification study was completed by the University of Idaho in 1983 and included an inventory of Idaho lakes and trophic status assessments on a subset of 85 lakes (Milligan, et. al., 1983). This assessment was based on one-time sampling during peak productivity. A trophic status index was developed using a linear weighted sum of eleven variables. The second study, the National Eutrophication Survey, completed by the U.S. Environmental Protection Agency in 1977, looked at conditions in 13 Idaho lakes (EPA, 1977). Lake trophic status, nutrient loading and sources of impact were all examined.

A third source of recent lake water quality information is the Citizen Volunteer Monitoring Program (CVMP). The importance of ongoing lake monitoring has been recognized by DEQ, however, the State has not had the resources to support a statewide program. Because citizen interest in lake protection is so high in Idaho, DEQ designed and implemented a Citizen Lake Monitoring Program in 1987.

The objectives of the Citizen Lake Monitoring Program are to obtain information to determine trends, collect baseline information on lakes not previously studied and increase public awareness of lake protection needs. Lakes included in this program are: Priest, Hayden, Spirit, Twin, Cocolalla, Hauser, Rose, Pend Oreille, Cascade Reservoir, Henry's Lake and the Spokane River. The Idaho Division of Environmental Quality is committed to continuing this program and hopes to increase the number of participating lakes. This program has provided the most recent information on conditions for selected lakes (Bellatty, 1989).

Idaho Lake Monitoring Programs

The Lake Water Quality Assessment Study has enhanced and expanded ongoing lake management activities in the State. Idaho's Lake Management Program is currently focused on six major areas:

* Providing technical assistance to local lake protection groups and promoting grass-roots lake management ethics.
* Conducting information and educational activities to increase public awareness and understanding of lake water quality.
* Conducting and expanding the Citizen Volunteer Monitoring Program.
* Managing Federal Clean Lakes Program projects and State-funded clean lakes projects.
* Integrating Clean Lake activities with other State water pollution control programs such as the Agricultural Water Quality Program, the Nonpoint Source Management Program, the Municipal Facilities Construction Program, the Nutrient Management Act Plans, and the Clean Lakes Act.
* Working with local and State leaders to obtain funding for continued Clean Lakes activities.

The LWQA Study is particularly important to lake-related activities mandated by the Idaho Nutrient Management Act and the Clean Lakes Act. The Nutrient Management Act requires that a State nutrient management plan be developed on a hydrological basin unit basis with a lake system emphasis. The plans will characterize water quality and watershed conditions, identify and quantify nutrient sources, and identify appropriate nutrient management levels and control alternatives for restoring or protecting water quality. The technical information acquired, and progress made toward nutrient management through the LWQA Study will serve as direct input to the development of a Statewide Nutrient Management Plan.

The Clean Lakes Act authorized a pilot program in the five northern counties and the formation of a Clean Lakes Coordinating Council (CLCC). The Council's duties include coordinating lake related activities, prioritizing lakes for study, completing baseline studies, developing lake management plans, promoting public awareness, providing technical assistance and reporting progress to the public. DEQ and the Panhandle Health District are responsible for assisting the Council in carrying out its duties. By virtue of these roles and responsibilities, the LWQA Study has been closely coordinated through the Council.

The fundamental goal of the Clean Lakes Act and the Nutrient Management Act is to protect Idaho lakes from cultural eutrophication. The LWQA Study provides essential background information to help achieve this common goal.

METHODS

Lake Water Quality Assessment (LWQA) Overview

The Idaho Division of Environmental Quality (DEQ) conducted a two-year study of 17 lakes to determine the present water quality and trophic status of important public lakes in Idaho and determine any pollution that may be threatening or impairing the designated beneficial uses of these lakes. The following lakes were studied: Priest, Upper Priest, Hayden, Spirit, Twin, Fernan, Kelso, Cocolalla, Hauser, Round, Granite, Soldiers Meadow, Waha, Rose, Mann and Winchester Lakes (Tables 1 and 2). Parameters sampled included: chlorophyll "a", secchi depth, total phosphorus, ortho phosphate, total kjeldahl nitrogen, nitrate and nitrite nitrogen, total ammonia, total hardness, total alkalinity, pH, specific conductivity, dissolved oxygen/temperature profiles, phytoplankton (identification and % frequency) and submergent aquatic macrophytes. These parameters and data were used to ascertain lake water quality and trophic status. Lakes were chosen to represent a broad spectrum from oligotrophic to hyper-eutrophic.

Based on the results from this LWQA Study a more practical and cost-effective list of parameters are suggested for future LWQA Studies (Table 5).

Data Use, Transfer and Storage

Data collected during the LWQA will be added to the Idaho Department of Fish and Game lakes database, STORET and the EPA Waterbody Tracking System. Cooperation between the IDFG and DEQ has been initiated with a preliminary review of the database structure. Efforts are underway to modify the database to better suit the needs of both agencies. Final review will be requested of EPA prior to data entry.

The Waterbody Tracking System will be updated, along with STORET, with the assistance of EPA technical staff. STORET station numbers have been assigned. Data entry is imminent.

Determination of Lake Trophic Classification

The trophic status of any lake is best delineated by the use of a number of water quality and biological parameters. Since the beginning of limnology, there have been numerous approaches used to determine lake trophic status. One of the primary goals in this Lake Water Quality Assessment Study was to determine the parameters that provided the most useful water quality and biological information to determine the trophic status of lakes. Another goal was to determine the most cost-effective means to ascertain the lake trophic status.

Citizen Volunteer Monitoring Program (CVMP) Overview

As part of DEQ's ongoing education and water quality monitoring efforts, a Citizen's Volunteer Monitoring Program (CVMP) for North Idaho Lakes is coordinated through the DEQ North Idaho Regional Office. Volunteers supply their own boats to take water samples and water clarity readings from Priest, Hayden, Spirit, Twin, Cocolalla, Hauser, Pend Oreille and Rose Lakes, and the Spokane River. DEQ added Fernan Lake to the CVMP in 1992. Cascade Reservoir and Henry's Lake monitoring efforts are overseen by the Southwest Idaho Regional Office and Eastern Idaho Regional Office, respectively. Results of these efforts are not provided in this report.

There are approximately two dozen volunteers in the CVMP. The CVMP has been in existence for four years. Volunteers sample their lakes five times per year beginning in May and continue through the fall. DEQ pays for the lab analyses of the water samples. Monitoring groups purchased their own water quality sampling equipment.

For the two years evaluated in this report, water quality samples were taken at specific open-water locations, usually at the deepest point of the lake or river. These water samples were placed in cubitainers and transported to the Idaho Bureau of Laboratories, a State Department of Health and Welfare Laboratory (LAB) facility, where samples were analyzed for nutrient and chlorophyll "a". Nutrients analyzed were: total phosphorus, ortho-phosphate, total nitrite and nitrate nitrogen, total Kjeldahl nitrogen, and total ammonia. Samples were collected at six week intervals from April through October. In addition, volunteers determined maximum depth, secchi depth, and dissolved oxygen and temperature while on the lake.

The primary goal of the CVMP program is public education concerning lake water quality, while establishing good relationships with DEQ. Other goals include: assessing water quality conditions, monitoring changes over time, and determining the need for more intensive study and action. Information collected through the CVMP is included in this LWQA Report.

DEQ has worked with citizen volunteers to develop monitoring strategies tailored to the level of interest, commitment, and financial resources of each volunteer group. Monitoring programs vary in complexity from obtaining water clarity measurements using a secchi disk, to collecting water quality samples using a Kemmerer sampling bottle and use of sampling probes and dissolved oxygen kits (Bellatty and Meitl, 1991).

LWQA and CVMP Data Collection and Analysis:

Discussion of the number, frequency and dates in which lake samples were taken are discussed in individual lake sections.

Secchi Depth

In 1990 and 1991, secchi depth was determined by lowering a secchi disk until it dissappeared and then recording the depth at which it reappeared after pulling the disk back up towards the lake surface. Secchi depth was recorded in meters. Two measurements were taken twice by two individuals in the field to help ensure precision in determining the secchi depth readings. Attempts were made to note the light conditions, algal blooms and suspended matter, wave action and shading from the boat. All of these factors are known to influence secchi depth readings.

Chlorophyll "a"

In 1990 and 1991, the LWQA Study determined chlorophyll "a" from a composite sample comprised of five water samples taken from equally distant depths. These depths were determined by multiplying the secchi depth by 2.4 to obtain the approximate lower reach of the trophogenic zone, then dividing by five. Water samples from these five depth intervals were mixed in a polyeurethane mixer in the boat and filtered using a Standard Millipore Filter Apparatus. The filters were placed in petri dishes, wrapped in aluminum foil and iced, while being transported back to the laboratory in the dark, inside an insulated cooler.

The CVMP volunteers obtained chlorophyll "a" from secchi depth only, rather than a composite sample. The samples were not filtered in the field and were transported back to the Lab for processing and analysis. The cubitainers were transported on ice inside an insulated cooler.

Phytoplankton

In 1991, phytoplankton samples were taken as a composite of five integrated water depths in the trophogenic zone for the LWQA Study. The taxonomic identification and enumeration of phytoplankton genera and species was performed by the Lab. The per cent frequency for major genera or species was determined from numerical counts of blue-green algae, diatoms and flagellates. The per cent frequency for each genera/species was grouped and a mean per cent frequency was calculated for each group. The per cent frequency of these groups was related to chlorophyll "a" and trophic condition of the lake where possible. This was done for the LWQA Project only; samples were not collected for phytoplankton identification for the CVMP.

Dissolved Oxygen/Temperature Profiles

The dissolved oxygen, temperature, pH and specific conductivity were determined at one meter intervals in 1990 and 1991 for each of the seventeen LWQA lakes. A HydroLab Surveyor II was used for determination of these parameters. Dissolved oxygen/temperature profiles were determined by CVMP monitors using a YSI dissolved oxygen/temperature meter on Spirit, Hayden and Twin Lakes. Calibration of instruments was performed in the Lab and field, prior to each sampling event, according to the instrument and procedure manuals.

Submergent Macrophytes

The distribution and identification (Fassett, 1966) of submergent aquatic macrophytes in the 17 LWQA lakes was determined in the late summer of 1991. A modified, weighted rake with an attached line was used to sample submergent macrophytes on both sides of the boat running along a line which was perpendicular to the lakeshore. Bays and other shoreline areas with representative submergent plant communities were sampled to the maximum depth at which the submergent macrophytes were found. The number of prevalent species was determined, whereby, prevalent species equals those species found in 25 per cent or more of the submergent stands of aquatic plants sampled in the lake. No submergent macrophytes were sampled in the CVMP. However, the delineation of the submergent aquatic plant community in CVMP lakes will be incorporated in the citizen field monitoring efforts beginning in August of 1992.

Lake Water Quality Assessment:

Water Quality Parameters and Quality Assurance

Water samples taken for the LWQA were taken at deep water stations on each of the 17 lakes in 1990. Samples were taken with a Kemmerer water bottle at secchi depth and one meter off the lake bottom. Total phosphorus, total nitrite and nitrate, TKN, total ammonia, dissolved ortho-phosphate, total hardness and total alkalinity were analyzed by the Lab according to Standard Methods for the Examination of Waste and Wastewater (Taras, 1992).

The Quality Assurance for water chemistry samples relied upon the estimate of precision that was determined for samples taken by CVMP citizens, and between DEQ staff and CVMP individuals. No duplicate samples were taken for precision by DEQ in 1990 and no water chemistry samples were taken in 1991. No funds or time was permitted for water chemistry precision or quality assurance work during the spring of 1991. DEQ will make certain that the proper quality assurance work is performed for the proposed LWQA Study for 1992 and 1993. The Quality Control of Laboratory analytical accuracy was conducted by the Department of Health and Welfare Laboratory, according to Standard Methods. Accuracy is defined in this Study with reference to spiked nutrient samples analyzed by the Lab, and is expressed as per cent recovery.

Citizen Volunteer Monitoring Program:

Quality Assurance

A major challenge for any citizen volunteer water quality monitoring program is convincing water quality managers that volunteers are collecting high quality, reproducible water quality data and information. In response to this need, a series of quality assurance (QA) procedures were developed to determine the precision of the data and address other quality assurance concerns. Quality assurance steps taken included: an annual volunteer water quality monitoring training session and review meeting, a DEQ field audit, duplicate sampling and laboratory quality controls.

Training

Citizen volunteers begin each year by attending an annual water quality training session conducted by the Idaho Division of Environmental Quality. This annual meeting provides volunteers with an opportunity to learn proper water quality sampling techniques and equipment use. Data is reviewed and analyzed at these meetings. The training session is designed to provide a forum for presenting the water quality sampling procedures and data results from previous monitoring seasons and discuss lake trophic conditions and water quality trends.

Field Audit

Each volunteer group has a field audit with the DEQ staff during the monitoring season. The purpose of this DEQ audit is to provide an opportunity for both the citizens and DEQ staff to evaluate sampling procedures and to provide positive, constructive comments for improving water quality sampling techniques.

The field audits include an informal evaluation of the volunteer's organizational capabilities, their preparation and labeling procedures, paperwork, consistency, instrument calibration techniques, and their ability to preserve and transport water quality samples to the Lab in a timely manner. Volunteers generally are conscientious about their water quality sampling techniques and procedures.

Replicate and Duplicate Sampling

The volunteers are required to collect one set of replicate water quality samples on at least one occasion during the sampling season. These replicate samples enable DEQ to estimate the level of sampling precision or the amount of reproducibility among individual measurements of the same parameter (Bauer, 1986).

Duplicate sampling was incorporated into the Lake Water Quality Assessment Study for estimating levels of volunteer monitoring accuracy. Accuracy refers to the agreement or disparity between quantities measured and the amount actually present (Bauer, 1986). DEQ staff coordinated sampling efforts with the volunteers to collect this comparative water quality data.

Laboratory Quality Controls

Volunteers collected, preserved and transported their water quality samples to the Idaho Bureau of Laboratories for the appropriate chemical and biological analyses in accordance with methods described in Standard Methods (Taras, 1992). Analyses were conducted in accordance with the Environmental Protection Agency and the American Public Health Association Standards, and were tested for estimates of analytical accuracy and laboratory precision.

We feel that a combination of these several quality assurance/quality control (QA/QC) procedures provides adequate data precision and accuracy to meet our program goals and objectives.

RESULTS AND DISCUSSION

Trophic Status and Water Quality Trends of Lakes

The 17 Idaho lakes studied in the 1990 and 1991 LWQA Project illustrated the extremes and trends found in lakes ranging in trophic status (Tables 1 and 2) from eutrophic to mesotrophic to oligotrophic.

Trophic status and water quality trends in lakes are inherently interrelated. The further development and evolution of more refined analytical techniques, common sense and practical approaches to classifying lakes according to trophic status requires both science and art.

DEQ found that the most useful and reliable parameters used to assess the biological productivity in lakes and determine the overall lake water quality include: secchi depth, dissolved oxygen/temperature profiles, and the number of prevalent submergent macrophytes. These parameters are also cost-effective in ascertaining the trophic status of lakes.

Recommended Trophic Status Methods for CVMP

DEQ has determined that some of the more traditional and more expensive lake study procedures used in citizen volunteer lake monitoring programs can be improved upon. While data from the analysis of lake water quality parameters traditionally have value and usefulness, budgetary constraints on lake water quality agencies and lack of funding sources for lake studies strongly suggest there is a need to look for other options in ascertaining the trophic status of lakes. In order to maintain citizen and governmental lake water quality monitoring programs, and provide meaningful and quality baseline information of lakes, it is becoming increasingly necessary to prioritize what parameters are used to economize the way we study and assess lakes.

Secchi depth has historically been proven to be an inexpensive parameter to measure the trophic status of lakes. DEQ found that dissolved oxygen and temperature profiles taken during the month of peak cumulative biological productivity (August) provided excellent and easily-understood synopsis of the oxygen and thermal characteristics from the lake surface to the lake bottom. The number of prevalent submergent macrophytes, measured in August, was also found to be extremely useful and cost-effective. Secchi depth was also obtained in August. Conceivably, if there was an absolute need to reduce costs and field work to one month a year in order to monitor a lake and determine the trophic status, August would be the month to concentrate your efforts.

Another advantage of measuring secchi depth, dissolved oxygen temperature profiles and submergent macrophytes was the opportunity for citizens to visualize this information more easily than traditional water chemistry data. The meaning of water clarity (transparency) is inherently obvious to most people. A graphical illustration of the dissolved oxygen and temperature profiles can be readily understood, providing the data is presented in a simplified manner. The number of prevalent submergent macrophytes is also easily visualized, both in the field with hands-on experience and when data and information are summarized and graphically presented. These parameters or measurements provide volunteer monitors with a more easily-comprehended understanding of lake water quality.

Trophic Status Determined by LWQA Methods

The trophic status of freshwater lakes is best determined by using both water quality and biological indices as measurements of lake productivity. Secchi depth, chlorophyll "a" and total phosphorus are traditionally used as the primary parameters in evaluating lake trophic status. Total phosphorus, as measured in 1990 (LWQA) and secchi depth and chlorophyll "a", measured in 1991 (LWQA), were used along with various analyses of the submergent and floating-leaf macrophyte lake communities in 1991. Maximum hypolimnetic ammonia and maximum hypolimnetic total phosphorus from 1990 were used to determine trophic status. Minimum hypolimnetic oxygen and dissolved oxygen/temperature profiles for each lake at the peak of the growing season (August) were also used. Each lake was classified as eutrophic, mesotrophic or oligotrophic based on the collective numerical values and best scientific judgement.

The selection of key water quality and biological parameters used in the determination of a lake's trophic status can be highly conjectoral at times. Nevertheless, DEQ's major emphasis on secchi depth, chlorophyll "a", total phosphorus, the number of prevalent species of submergent macrophytes and dissolved oxygen/temperature profiles at the peak month of production (August) provided a balance of water quality and biological parameters for use in ascertaining lake trophic status.

Table 3 compares some of the lake trophic classification rating systems that have been used in recent years on the same lakes studied by DEQ. While there is agreement for trophic status with some of the 17 lakes, others are different. This may be a result of actual changes in trophic condition of these lakes over the years, and/or differences in the lake rating system.

The EPA-National Eutrophication Study of 1977 rates three of four lakes sampled as slightly more eutrophic than DEQ's rating (Table 3). The University of Idaho Study of 1983, with eleven variables weighted in their trophic index, generally rates many of the lakes as less fertile than does the DEQ Study, except for the three most oligotrophic DEQ-rated lakes. Wetzel's trophic classification of lakes, which uses secchi depth, chlorophyll "a" and total phosphorus solely, shows a closer consistency of lake ratings to DEQ's ratings than does the University of Idaho ratings. Again, these differences may be due to a combination of rating techniques and/or changes in the lake's condition.

It is important to realize that the time of year, sample location and depth, as well as field sampling and laboratory analysis can have a pronounced influence on the data results. The three studies were conducted in different years; 1991 (LWQA), 1983 (U of I) and 1977 (EPA). Snowpack and subsequent water recharge in the spring is variable from year to year. The most consistent lake trophic ratings among the different classification schemes was with the hyper-eutrophic and ultra-oligotrophic lakes.

The selection of what types and numbers of water quality and biological parameters to use in ascertaining lake trophic status is one of the most critical and controversial steps a limnologist will take at the outset of designing a lake study (Tables 4-5). EPA places secchi depth and dissolved oxygen and temperature profiles in a high priority group for sampling. It is strongly suggested from data obtained in this study and comparative literature, that in the design of any lake study plan, the parameters should include secchi depth, chlorophyll "a", total phosphorus, the number of prevalent species of submergent macrophytes, the maximum depth of submergent macrophyte growth, and dissolved oxygen/temperature profiles during peak productivity (August). More specific discussion of each lake trophic status and lake assessment is provided in each of the 17 individual lake assessment sections of this report.

The most reliable, useful and cost-effective parameters used in the LWQA Study were determined to be secchi depth, dissolved oxygen/temperature profiles and the number of prevalent species of submergent macrophytes. These parameters, when used collectively, provided an extremely efficient and cost-effective means to determine lake trophic status.

Secchi depth was found to be extremely consistent and cost-effective to ascertain lake trophic status. The dissolved oxygen/temperature profile taken at cumulative peak productivity during August, also provided exceptionally useful, reliable and cost-effective data in evaluating lake trophic status. Both secchi depth and dissolved oxygen/temperature profiles were ranked by EPA (EPA, 1988) and DEQ (Mossier, 1992) as two of the highest priority parameters in lake monitoring (Table 4). Submergent macrophytes were also ranked as one of the highest priority parameters recommended for use in a lake monitoring management plan.

Other parameters sampled in the LWQA Study which ranked as less essential and less useful in classifying lake trophic status by EPA and DEQ included: Total phosphorus, orthophosphate, pH, total nitrogen and chlorophyll "a". Total phosphorus one meter above the lake bottom in the deep hypolimnion was found to be useful, despite being somewhat variable throughout the sampling seasons. The rest of these parameters had limited usefulness in the determination of lake trophic status.

Based on our projected budget and the data obtained in this LWQA Study, a proposed LWQA and CVMP Study for 24 Idaho lakes in 1992 and 1993 is provided in Table 5. The sampling frequency and sampling program are outlined for a number of sampling parameters including: Chlorophyll "a", secchi depth, total phosphorus, fecal coliform bacteria, total hardness, alkalinity, pH, dissolved oxygen/temperature profiles and submergent macrophytes (Table 5).

Beneficial Use Support Status

The Idaho State Water Quality Standards specify the beneficial uses for many of the lakes studied. Table 6 indicates the beneficial uses for the 17 LWQA lakes and whether they are threatened or impaired beneficial uses. DEQ determined whether beneficial uses were either threatened or impaired, based on analysis of water quality data and best professional judgement. Those lakes which had no designated beneficial uses in the Idaho Water Quality Standards were recognized as having beneficial uses based on LWQA data and best professional judgement.

Sources of Pollution, Nutrients and Recommended Management Actions

Both point and nonpoint pollution sources for the 17 LWQA lakes are discussed in the individual lake assessment sections. Phosphorus is the limiting nutrient resulting in eutrophication of some of the more mesotrophic and eutrophic lakes. Specific management action recommendations for each lake are also discussed.

Secchi Depth

A number of parameters were utilized to evaluate the trophic status of 17 LWQA lakes studied, secchi depth being one of them. It was determined that generally, eutrophic lakes have a secchi depth of less than 4 meters; mesotrophic lakes have a secchi depth of 4-7 meters; and oligotrophic lakes have a secchi depth from 8-13 meters (Figure 1). Secchi depth alone can be a reliable and useful basis to evaluate lake water quality, but it is best used in combination with other parameters. For example, the number of prevalent submergent macrophyte species increases as secchi depth increases (Figure 2). Secchi depth and the maximum depth of submergent aquatic plant growth were positively correlated (r=0.83), providing another valuable measurement tool to evaluate lake trophic status (Figure 3).

Water clarity (secchi depth) is a function of many factors, both biological and environmental (Figure 4). Algal blooms, lignins and tannins, wave action and both point and nonpoint pollution will affect the amount of suspended solids, toxins and nutrients in the lake. Seasonal turnovers in the spring and fall, further recycle bottom sediments and nutrients throughout the lake, reducing water clarity. In addition, the angle and intensity of sunlight will change the water clarity of a lake. Nevertheless, secchi depth is an effective means to determine trophic status. Secchi depth is strongly correlated ($r = 0.83$) to the maximum depth at which rooted aquatic plants grow in a lake, since light penetration in a lake is critical in determining the distribution of submergent macrophytes (Figure 3).

Chlorophyll "a"

Eutrophic Winchester Lake had the highest chlorophyll "a" (Figure 5) production of all the LWQA lakes studied (21.1 ug/L). In contrast, Priest Lake had the lowest chlorophyll "a" production (1.0 ug/L). The four oligotrophic lakes studied, which included Priest, Hayden, Spirit and Upper Priest, had very low chlorophyll "a" production.

Reservoir lakes such as Mann and Waha Lakes, although determined to be eutrophic, had low chlorophyll "a" production; however, this may be a result of extreme fluctuations in water levels from drawdown for irrigation. Water level fluctuation is a very significant factor influencing phytoplankton production throughout the year. Another problem with using chlorophyll "a" as an index of lake trophic status is the variability and "pulsing" of algal blooms that occurs with blue-green algae.

Phytoplankton (Algal) Groups

In 1991, blue-green algae were a very significant and dominant component of the phytoplankton population for many of the eutrophic and mesotrophic lakes studied. Oligotrophic lakes, on the other hand, showed no blue-green algal component (Table 7, Figure 6).

Diatoms generally were abundant in all types of lakes, including oligotrophic, mesotrophic and eutrophic lakes. Only the more eutrophic lakes lacked a significant diatom population.

Flagellates, like diatoms were also ubiquitous (found everywhere). The flagellates were not associated with a specific lake trophic status. Generally speaking, the percent frequency of flagellates tended to be highly variable among lakes of different trophic status (Table 7, Figure 6).

Since many species of diatoms and flagellates are ubiquitous, the categorization of genera and species into one of these algal groups may obscure any real relationship of phytoplankton to specific lake trophic status.

The depth at which the phytoplankton populations were sampled, undoubtedly, influenced the representation of algal groups. Phytoplankton populations are often distributed unevenly throughout the lake basin and concentrate at different depths depending on the time of day. Also, seasonal temperature changes influence the amount of light and nutrients available. Consequently, algal samples taken from the same location throughout the year will be remarkably different, depending on whether they were taken at the surface, secchi depth or as a composite sample of the euphotic zone.

Another important limitation of using algal groups as indicators of lake trophic status is the variability of water quality that may occur within large, more diverse, complex lakes. For example, samples taken in August, at four different sampling locations from Hayden Lake, Idaho, (Figure 7) showed considerable variability. The per cent frequency of blue-green algae was highest at the eutrophic sampling location, relative to the more oligotrophic sampling locations, which showed no or very low frequency of blue-greens. Similarly, flagellates were more abundant in eutrophic and mesotrophic sampling locations than oligotrophic locations. Diatoms as a group, however, were ubiquitous throughout all of the lake sampling locations. As expected, chlorophyll "a" production showed a progressive increase from oligotrophic locations to eutrophic stations in Hayden Lake.

Wetzel (1975) points out that associations of algal species among different lakes have been studied extensively ...

> A great deal of descriptive work has been devoted to the association of algal species among different lakes ... The diversity of algae among the thousands of species is great, and many exhibit a very wide tolerance to environmental conditions found under natural limnological situations. Nonetheless, certain characteristic planktonic algal associations occur repeatedly among lakes of increasing nutrient enrichment ... However, such categorizations are not very satisfactory because of the wide spectrum of integradations often observed and the shifts that occur seasonally from one type of algae to another, especially among more productive waters. Even though such categorizations yield little insight into regulating environmental factors, they are useful from the standpoint of general correlations between qualitative and quantitative abundance and available nutrient supply.
>
> A number of phytoplankton indices have been developed ... in an attempt to quantify the relationships of rarely occurring and dominant algal species as indicators of lake productivity.

Comparisons of these indices with more modern measurements of algal productivity show weak positive correlations, but exceptions are many. Great variations are found among different regions of the world and among lake districts. It is apparent that these indices, while having some value in determining species relationships, are much too superficial in physiological foundation to be of significant use in evaluations of productivity among lakes and of casual mechanisms underlying the composite growth of algae.

Maximum Hypolimnetic Phosphorus and Ammonia

Maximum hypolimnetic phosphorus in the most eutrophic lakes is much higher compared to phosphorus found in oligotrophic and mesotrophic lakes (Figure 8). Phosphorus in the water column near organic lake bottoms are enriched by decomposition of extensive blue-green algae blooms, which contributes significantly to the internal recycling of phosphorus.

Maximum hypolimnetic ammonia levels do not appear to be as good an indicator of lake trophic status as phosphorus (Figure 9). However, high ammonia levels in the hypolimnion near the lake bottom are very evident in lakes with anaerobic or anoxic hypolimnions such as Winchester and Granite Lakes (Tables 63 and 49, Figures 47 and 37). Ammonia levels were extremely low in the four oligotrophic lakes studied (Figure 9).

Minimum Hypolimnetic Dissolved Oxygen

The minimum hypolimnetic dissolved oxygen (Figure 10) is much higher for all four oligotrophic lakes studied in the LWQA project. The only exceptions to this were Upper Twin and Mann Lakes, which did not thermally stratify because of their shallowness and wind-induced mixing from the bottom to the top of the lake. Consequently, dissolved oxygen from these two lakes cannot be compared to the four thermally stratified, deep oligotrophic lakes. The presence or absence of ample dissolved oxygen in the deep hypolimnion in late summer is a critical limnological and useful measurement as related to lake trophic status (Figure 10).

Dissolved Oxygen/Temperature Profiles

The dissolved oxygen/temperature profiles for the 17 lakes studied in the Idaho Lake Water Quality Assessment (LWQA) Project are discussed in each individual lake section of this report. The profiles provided some of the most reliable and useful data for categorizing lake trophic conditions. The 1991 dissolved oxygen/temperature profiles were determined in late July or August.

Submergent Macrophytes

Submergent macrophyte communities provide an excellent means of studying and monitoring changes in the trophic status of lakes. In the summer of 1991, the number of prevalent species in submergent macrophyte communities were determined for the 17 lakes (Table 8). Field observations and data were recorded during August. This information provided a broader data base with which to assess lake dynamics and conditions.

The number of prevalent species equals those species found in at least 25 percent of the lake samples. The diversity of prevalent species (Figure 11) generally demonstrated a twofold increase from eutrophic to mesotrophic to oligotrophic lakes. That is, oligotrophic lakes have approximately four times the number of prevalent species compared to eutrophic lakes. Mesotrophic lakes have twice the number of prevalent species found in eutrophic and half the number of prevalent species found in oligotrophic lakes (Figure 11).

The rationale for using submergent macrophytes and water quality measurements to determine trophic status is as follows: submergent and floating-leaf macrophytes form associations of communities in lakes which are indicative of the water quality. Submergent macrophyte communities have environmentally-dependent successional patterns; changes occur with changes in lake water quality. Since submergent and floating-leaf macrophytes are found in the lake throughout the year, their study and analysis provides a basis to evaluate lake eutrophication and detect changes in water quality at anytime. These macrophytes also provide a good basis for trend monitoring over many years.

Generally speaking, the number of species (Figure 12) is higher for early eutrophic, mesotrophic and oligotrophic lakes than in hyper-eutrophic lakes. Eutrophic lakes (Winchester) and lakes that experience frequent drawdown and fluctuating water levels (Mann, Waha, and Soldier's Meadow) may have few or no submergent macrophytes. The drawdown also has a major impact on the submergent aquatic plant communities in these lakes, virtually eliminating all submergent macrophyte species from the reservoirs.

It should be noted that the use of prevalent species, rather than species diversity, was a more refined and reliable indicator of lake trophic status. The total number of submergent species (Table 1, Figure 12) do not appear to provide a definitive picture of lake trophic status at this time. This is mainly due to the ubiquitous nature of some submergent macrophyte species and the "masking effect" of interacting factors affecting submergent macrophyte distribution and abundance. These interacting factors include: water depth and clarity as related to light availability, metal toxicity, nutrient levels, lake bottom substrate type, wave action, especially in the shallow littoral areas, and dissolved oxygen and temperature extremes and averages. A list of the common and scientific names of submergent and floating-leaf macrophytes found in the LWQA Study for the 17 lakes are provided in Table 9.

Figure 13 demonstrates the increased depths at which submergent plants grow in oligotrophic lakes in contrast to eutrophic lakes. Furthermore, the maximum depth at which submergent aquatic plants were found was positively related to the water clarity as measured by secchi depth (Figure 3).

Recommendations For Lake Water Quality Assessment Study Approaches and Assessment of Lake Water Quality and Biological Parameters

The time and effort spent on obtaining information on secchi depth, chlorophyll "a" and total phosphorus along with prevalent submergent macrophyte communities, the maximum depth of submergent macrophytes and dissolved oxygen and temperature profiles, will provide more reliable, useful and cost-effective data for lake water quality analysis, than time spent on extensive phytoplankton analysis. Submergent and floating-leaf macrophytes are reliable long-term indicators of autotrophic communities (primary producers) and productivity in lakes. These aquatic macrophyte communities fluctuate less on a seasonal and annual basis, than do phytoplankton communities.

Table 1. Trophic status of 17 Idaho Lakes in the Lake Water Quality Assessment Project. Secchi depth, chlorophyll a, the number of submergent species, the maximum depth of submergents and hypolimnetic values for total phosphorus, total ammonia and dissolved oxygen are indicated. KEY: Depth in meters
O = Oligotrophic M = Mesotrophic ME = Meso-Eutrophic E = Eutrophic

Name of Lake	Trophic Status	Secchi Depth	Chlor. "a" (ug/L)	# of Species Submergent Plants	Max. Depth Sub. Plants	Hypolimnetic Total Phosphorus (mg/L)	Hypolimnetic Total Ammonia (mg/L)	Hypolimnetic Dissolved Oxygen (mg/L)
Winchester	E	1.0	24.1	3	0.5	1.200	1.880	0.2
Mann	E	1.3	1.9	0	0.0	0.640	0.093	3.3
Rose	E	1.4	11.8	4	1.5	1.300	0.371	1.6
Waha	E	1.5	1.6	0	0.0	0.108	0.117	0.4
Sold. Meadow	E	2.1	7.2	1	1.5	0.110	0.228	1.4
Granite	E	3.5	9.0	11	2.5	0.970	4.780	0.3
Round	E	3.0	13.4	13	1.8	0.380	0.921	0.2
Hauser	E	2.5	16.9	12	4.5	0.170	1.270	0.7
Cocolalla	E	2.5	9.3	12	2.0	0.220	0.688	0.2
Upper Twin	ME	3.0	7.0	7	5.0	0.018	0.477	6.7
Kelso	ME	3.5	6.1	12	3.0	0.150	0.522	0.3
Fernan	M	3.3	3.8	17	3.9	0.030	0.066	0.8
Lower Twin	M	5.0	2.7	10	5.5	0.320	0.744	0.3
Upper Priest	O	5.0	2.7	17	6.0	0.005	0.130	4.3
Spirit	O	5.2	1.7	11	5.0	0.133	0.133	4.0
Hayden	O	7.8	1.9	23	9.0	0.020	0.135	8.8
Priest	O	11.0	1.0	13	7.0	0.005	0.063	9.9

Table 2. Trophic status, lake acres, location, elevation and storet codes for 17 lakes studied in the Idaho Lake Water Quality Assessment (LWQA) Project.

Name of Lake	Trophic Status*	Lake Acres	Location (County)	Latitude	Longitude		Storet Codes (ID No.)
Winchester	E	94	Nez Perce	46 14 12	116 44 25	3902	2020287
Mann	E	130	Nez Perce	46 22 15	116 51 15	1800	2020365
Rose	E	320	Kootenai	47 33 12	116 27 59	2117	2000396
Waha	E	93	Nez Perce	46 12 35	116 50 10	3389	2020363
Soldier Meadow	E	120	Nez Perce	46 09 56	116 44 08	4522	2020364
Granite	E	20	Bonner	48 00 15	116 42 25	2145	2000388
Round	E	46	Bonner	48 09 46	116 38 15	2122	2000399
Hauser	E	604	Kootenai	47 46 42	117 0103	2187	2000361
Cocolalla	E	806	Bonner	48 07 55	116 36 54	2203	2000391
Upper Twin	ME	959	Kootenai	47 53 29	116 59 00	2306	2000393
Kelso	ME	54	Bonner	48 00 38	116 41 12	2150	2000386
Fernan	M	355	Kootenai	47 41 16	116 43 19	2125	2000395
Lower Twin	M	959	Kootenai	47 52 31	116 51 40	2306	2000394
Upper Priest	O	1,352	Bonner	48 47 06	116 53 13	2438	2000304
Spirit	O	1,280	Kootenai	47 56 34	116 53 11	2440	2000392
Hayden	O	4,200	Kootenai	47 45 37	116 44 25	2238	2000279
				47 45 26	116 42 25	2238	2000280
Priest	O	23,680	Bonner	48 33 14	116 49 57	2438	2000299
				48 33 14	116 49 57	2438	2000410

* E = Eutrophic = 3,303 acres ME = Meso–Eutrophic = 1,013 acres M = Mesotrophic = 1,314 acres O = Oligotrophic = 30,512 acres

Table 3. Trophic classification of Idaho's Lake Water Quality Assessment (LWQA) lakes by various methods: LWQA, University of Idaho (Milligan, 1983), EPA National Eutrophication Survey (1977), and Wetzel's lake trophic system (Wetzel, 1975).

Name of Lake	Trophic Status			Secchi Depth	Chlorophyll "a"	Max. Total Phosphorus	Secchi Depth (meters)	Chlor. "a" (ug/L)	Max. Total Phosphorus (mg/L)
	LWQA	U of I	EPA-NES	Wetzel*					
Winchester	E	E	--	E	E	E	1.0	24.1	1.200
Mann	E	E	--	E	O	E	1.3	1.9	0.640
Rose	E	ME	--	E	E	E	1.4	11.8	1.300
Waha	E	E	--	E	O	E	1.5	1.6	0.108
Sold. Meadow	E	OM	--	M	E	E	2.1	7.2	0.110
Granite	E	--	--	M	E	E	3.5	9.0	0.970
Round	E	OM	--	M	E	E	3.0	13.4	0.380
Hauser	E	OM	E	M	E	E	2.5	16.9	0.170
Cocolalla	E	ME	--	M	E	E	2.5	9.3	0.220
Upper Twin	ME	O	E	M	E	M	3.0	7.0	0.018
Kelso	ME	--	--	M	E	E	3.5	6.1	0.150
Fernan	M	O	--	M	M	E	3.3	3.8	0.030
Lower Twin	M	O	E	M	M	E	5.0	2.7	0.320
Upper Priest	O	OM	--	M	M	O	5.0	2.7	0.005
Spirit	O	O	--	M	O	E	5.2	1.7	0.133
Hayden	O	O	OM	O	O	M	7.8	1.9	0.020
Priest	O	O	--	O	O	O	11.0	1.0	0.005
* Wetzel's	Oligotrophic (O) =						7–16	0.3–2.0	.003–.009
Trophic	Mesotrophic (M) =						2–6	2–6	.009–.024
Classification:	Eutrophic (E) =						0.7–2.0	6–40	.024–.075

Key: O = Oligotrophic OM = Oligo–Mesotrophic M = Mesotrophic
ME = Meso–Eutrophic E = Eutrophic

Table 4. A list of parameters recommended by EPA for implementing a lake monitoring management plan and sampling parameters used and recommended by Idaho DEQ for Lake Water Quality Assessment (LWQA) Studies and the Citizen Volunteer Monitoring Program (CVMP).

Priority Groups*	Parameter	EPA	Idaho DEQ	DEQ – LWQA & CVMP Sampling Program**
I	Secchi Depth	A	A	one for small lakes, 2–3 for larger lakes
	D.O./Temperature Profiles	A	A	lake surface to lake bottom
II	Total Phosphorus	C	C	one each in the hypolimnion & epilimnion
	Chlorophyll "a"	C	C	composite trophogenic or 2 @ secchi depth
	Sp. Conductivity Profiles	C	C	lake surface to lake bottom
	Total Nitrogen	D	D	one each in the hypolimnion & epilimnion
III	pH Profiles	D	D	lake surface to lake bottom
	Alkalinity	--	E	one in the epilimnion
	Sol. Reactive Phosphorus	E	E	one at secchi depth
IV	Total Hardness	--	E	one in the epilimnion
	Fecal Coliform Bacteria	--	C	1–3 in the epilimnion and/or littoral zone
	Submergent Macrophytes	A	A	to maximum water depth of submergent plant growth
	Phytoplankton Species	E	E	composite trophogenic or 2 @ secchi depth

* The lower the number and the closer to "A", the higher the priority for sampling.

** All parameters are sampled 4 times per year, except for submergent macrophytes (sampled July/August only).

Table 5. A list of sampling parameters and sampling frequency of 24 Idaho Lakes proposed for FY 92 & FY 93 Lake Water Quality Assessment (LWQA) and Citizen Volunteer Monitoring Program (CVMP). *

Sampling Parameter	Sampling Frequency	Sampling Program
Chlorophyll "a"	4 times/year	composite trophogenic or 2 @ secchi depth
Secchi Depth	4 times/year	one for small lakes, 2-3 for larger lakes
Total Phosphorus	4 times/year	one each in the hypolimnion & epilimnion
Fecal Coliform Bacteria	4 times/year	1-3 in the epilimnion and/or littoral zone
Total Hardness	4 times/year	one in the epilimnion
Alkalinity	4 times/year	one in the epilimnion
pH Profiles	4 times/year	lake surface to lake bottom
Sp. Conductivity Profiles	4 times/year	lake surface to lake bottom
D.O./Temperature Profiles	4 times/year	lake surface to lake bottom
Submergent Macrophytes	1 time/year	to maximum water depth of plant growth

* This Table lists the sampling program for 1992 only. The sampling program for 1993 will be modified as needed based on preliminary data analysis.

Table 6. Summary of Beneficial Uses for 17 Idaho lakes studied in a Lake Water Quality Assessment Project (LWQA).

Name of Lake	Domestic Water Supply	Agricultural Water Supply	Cold Water Biota	Warm Water Biota	Salmonid Spawning	Primary Contact Recreation	Secondary Contact Recreation	Special Resource Water
Winchester	[#]	(#)	[#]	(x)	[*]	[#]	(#)	#
Mann	--	(x)	--	--	--	--	(x)	--
Rose	--	x	(x)	x	--	(x)	x	--
Waha	x	x	(x)	x	--	x	x	--
S. Meadows	--	x	(x)	--	--	x	x	--
Granite	--	--	[x]	(x)	--	--	x	--
Round	--	--	(x)	x	--	(x)	x	--
Hauser	(#)	#	(#)	x	(*)	(#)	#	--
Cocolalla	(#)	(#)	(#)	x	--	(#)	#	#
Upper Twin	(#)	(#)	(#)	x	*	(#)	#	--
Kelso	(#)	#	(#)	x	(#)	#	#	--
Fernan	(#)	#	#	x	#	#	#	--
Lower Twin	(#)	#	(#)	x	*	#	#	--
Upper Priest	#	#	#	x	#	#	#	#
Spirit	#	#	#	x	#	#	#	#
Hayden	(#)	#	#	x	#	#	#	#
Priest	#	#	#	x	#	#	#	#

Designated Beneficial Uses in Idaho Water Quality Standards protected for general use.

x Existing Beneficial Uses NOT designated in Idaho Water Quality Standards.

* Designated Beneficial Uses in Idaho Water Quality Standards protected for future use.

( ) Threatened Beneficial Uses.

[ ] Impaired Beneficial Uses.

Table 7. Algal Groups and Chlorophyll "a" Abundance for 17 Idaho Lakes during August, 1991, from a Lake Water Quality Assessment Study (LWQA).

Name of Lake	Trophic Status	Chlorophyll "a" (ug/L)	Blue-Green* Algae	Flagellates*	Diatoms*
Winchester	E	24.1	83	90	--
Mann	E	1.9	--	80	--
Rose	E	11.8	--	57	70
Waha	E	1.6	--	57	63
Sold. Meadow	E	7.2	60	57	--
Granite	E	9.0	--	73	--
Round	E	13.4	87	73	--
Hauser	E	16.9	97	57	--
Cocolalla	E	9.3	93	57	--
Upper Twin	ME	7.0	67	27	90
Kelso	ME	6.1	43	63	97
Fernan	M	3.8	83	--	--
Lower Twin	M	2.7	23	13	93
Upper Priest	O	2.7	--	60	97
Spirit	O	1.7	--	40	87
Hayden	O	1.9	--	--	70
Priest	O	1.0	--	54	90

* Percent Frequency
E = Eutrophic
ME = Meso-Eutrophic
M = Mesotrophic
O = Oligotophic

Table 8. Trophic status of 17 Idaho lakes in a Lake Water Quality Assessment (LWQA) Study as related to the number of prevalent species of submergent aquatic plants, maximum depth of growth, lake bottom substrate and secchi depth.

Name of Lake	Trophic Status	Prevalent Species*	# Prevalent Species	# Species Sub. Plants	Max.** Depth Plants	Lake Bottom Substrate	Secchi Depth
Winchester	E	M, W	2	3	0.5	1	1.0
Mann	E	None	0	0	0.0	1	1.3
Rose	E	RP,LP,WS,YWL	4	4	1.5	1	1.4
Waha	E	None	0	0	0.0	2	1.5
Sold. Meadow	E	MG	1	1	1.5	2	2.1
Granite	E	LP,C,M,WS,YWL	5	11	2.5	2	3.5
Round	E	RP,W,WS,YWL,LP	5	13	1.8	2	3.0
Hauser	E	RP,W,YWL	3	12	4.5	2	2.5
Cocolalla	E	RP,W,WS,YWL,VP	5	12	2.0	2	2.5
Upper Twin	ME	RP,C,MG,YWL	4	7	5.0	2	3.0
Kelso	ME	WS,YWL,C,M,LP	5	12	3.0	2	3.5
Fernan	M	LP,RP,MG,WWL,AM	5	17	3.9	2	3.3
Lower Twin	M	RP,W,MG,Q,WC,NR	6	10	5.5	2	5.0
Upper Priest	O	RP,VP,HP,MG,W,LP,	6	17	6.0	2	5.0
Spirit	O	NR,Q,WC,WWL,WS,MG,W,C	8	11	5.0	2	5.2
Hayden	O	RP,MG,LP,BP,AM,FP,M,WB,CP,W,BFP,NR,WP,C	14	23	9.0	2	7.8
Priest	O	RP,MG,LP,CP,WP,BP,WB,M,VP,NR,W,AM,BFP	13	13	7.0	3	11.0

* M=Milfoil W=Waterweed RP=Robbins Pondweed LP=Largeleaf Pondweed WS=Water Shield YWL=Yellow Water Lily MG=Muskgrass C=Coontail VP=Variable Pondweed WWL=White Water Lily AM=Aquatic Moss Q=Quillwort WC=Wild Celery NR=Needle Rush HP=Horned Pondweed BP=Bushy Pondweed FP=Flatstem Pondweed WB=Water Buttercup CP=Claspingleaf Pondweed BFP=Brownleaf Floating Pondweed WP=Whitestem Pondweed.

** Water depth in meters.

Key: O = Oligotrophic M = Mesotrophic ME = Meso–Eutrophic E = Eutrophic

Lake bottom substrate type: 1 = Organic 2 = Both 3 = Inorganic

Table 9. List of common and scientific names of submergent and floating-leaf aquatic plants (mostly macrophytes) found in selected north Idaho lakes.

PONDWEEDS: (POTAMOGETON)

FLOATING BROWNLEAF, FLOATING-LEAF PONDWEED	POTAMOGETON NATANS
SAGO PONDWEED	POTAMOGETON PECTINATUS
LARGE-LEAF PONDWEED, MUSKIE WEED, BASS WEED	POTAMOGETON AMPLIFOLIUS
WHITESTEM PONDWEED, MUSKIE WEED	POTAMOGETON PRAELONGUS
CLASPINGLEAF PONDWEED, BASS WEED	POTAMOGETON RICHARDSONII
VARIABLE PONDWEED	POTAMOGETON GRAMINEUS
FINELEAF PONDWEED	POTAMOGETON FILIFORMIS
ROBBINS PONDWEED	POTAMOGETON ROBBINSII
LEAFY PONDWEED	POTAMOGETON EPIHYDRUS
FLATSTEM PONDWEED	POTAMOGETON ZOSTERIFORMIS
NARROW-LEAF PONDWEED	POTAMOGETON FOLIOSUS
A FINE-LEAF PONDWEED	POTAMOGETON PUSILLUS (BERCHTOLDII)

OTHER SUBMERGENTS AND FLOATING-LEAF SPECIES:

WATER CROWFOOT, WATER BUTTERCUP	RANUNCULUS TRICHOPHYLLUS
WATER SHIELD	BRASENIA SCHREBERI
YELLOW WATER LILY	NUPHAR VARIEGATUM
WHITE WATER LILY	NYMPHAEA SPP.
COONTAIL	CERATOPHYLLUM DEMERSUM
WILD RICE	ZIZANIA AQUATICA
WATERWEED	ELODEA (ANACHARIS) CANADENSIS ELODEA (ANACHARIS) OCCIDENTALIS
WILD CELERY, TAPE GRASS	VALLISNERIA AMERICANA
BUSHY PONDWEED	NAJAS FLEXILIS
HORNED PONDWEED	ZANNICHELLIA PALUSTRIS
WATER (COMMON) MILFOIL	MYRIOPHYLLUM EXALBESCENS (SPICATUM)
GREEN MILFOIL	MYRIOPHYLLUM VERTICILLATUM
NEEDLE RUSH (A SPIKE RUSH)	ELEOCHARIS ACICULARIS
WATER MOSS	FONTINALIS SPP.
QUILLWORT	ISOETES SP.
HORSETAIL, SCOURING RUSH	EQUISETUM SP.
COMMON CATTAIL	TYPHA LATIFOLIA
BLADDERWORT	UTRICULARIA VULGARIS
STONEWARTS, MUSKGRASS	CHARA VULGARIS NITELLA FLEXILIS
WATER SMARTWEED ("THE AMPHIBIOUS POLYGONUMS")	POLYGONUM NATANS

Figure 1. Secchi depth and lake trophic status for seventeen Idaho Lakes during August, 1991.

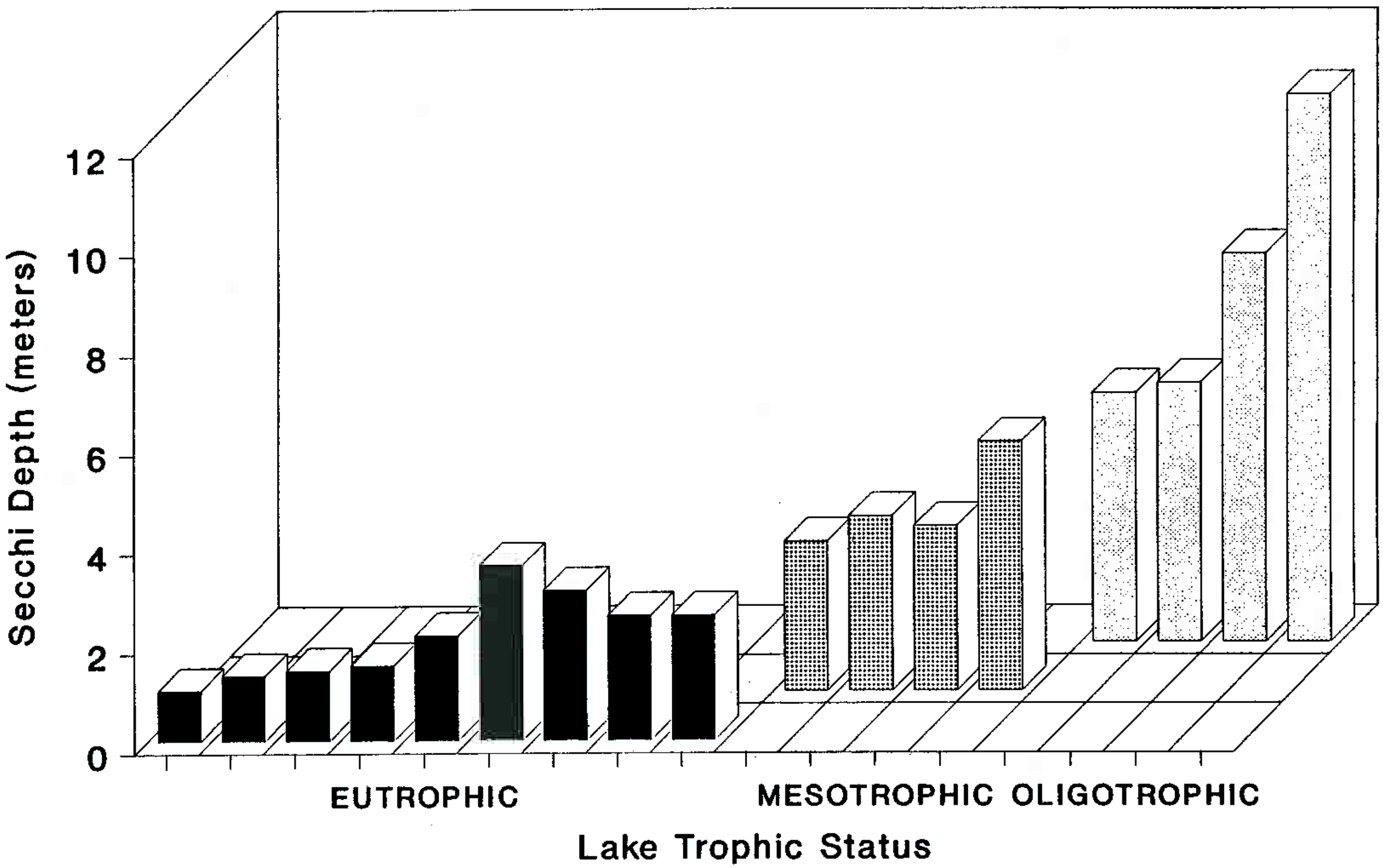
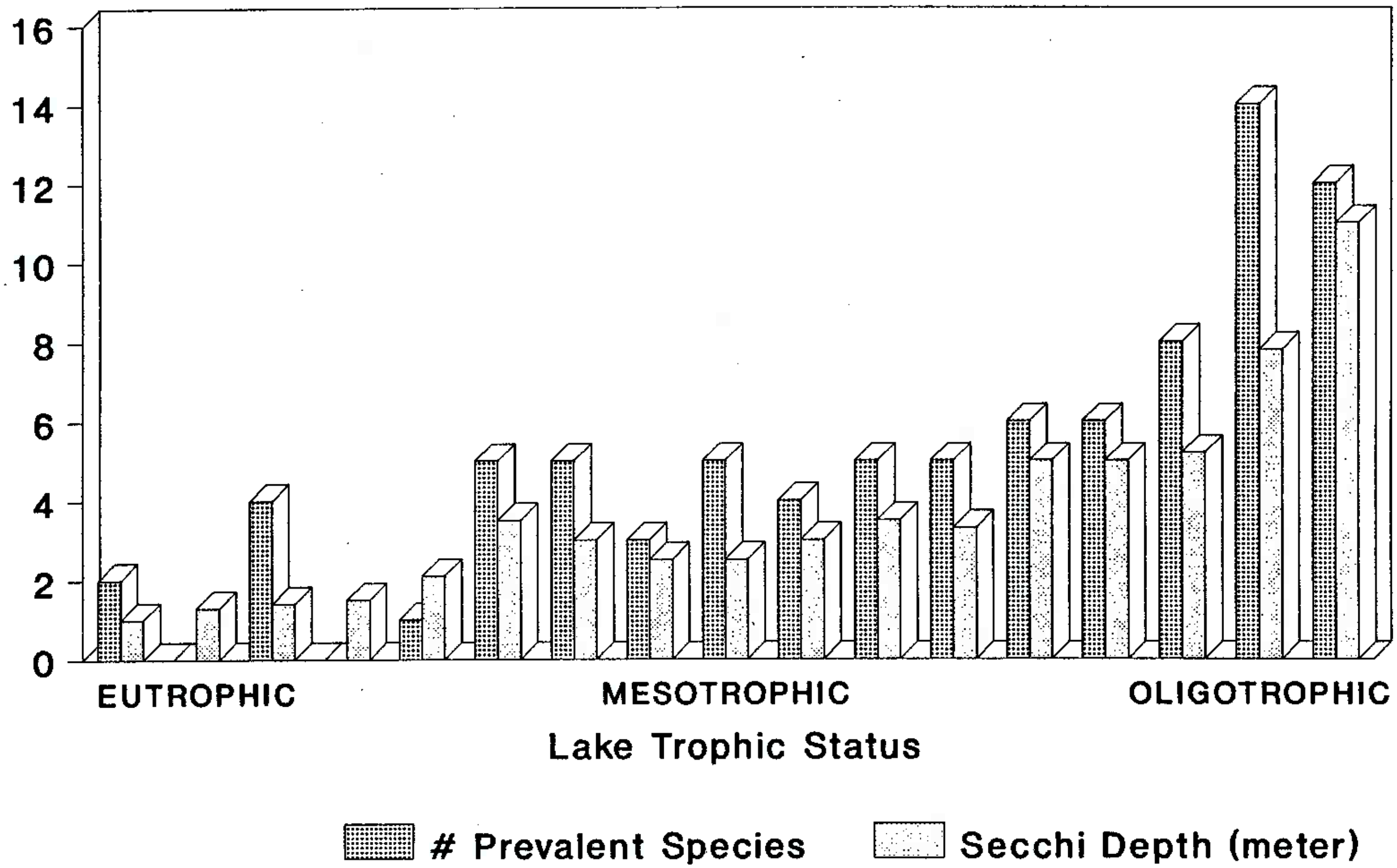


Figure 2. Number of prevalent submergent macrophyte species and secchi depth in 17 Idaho Lakes during August, 1991.



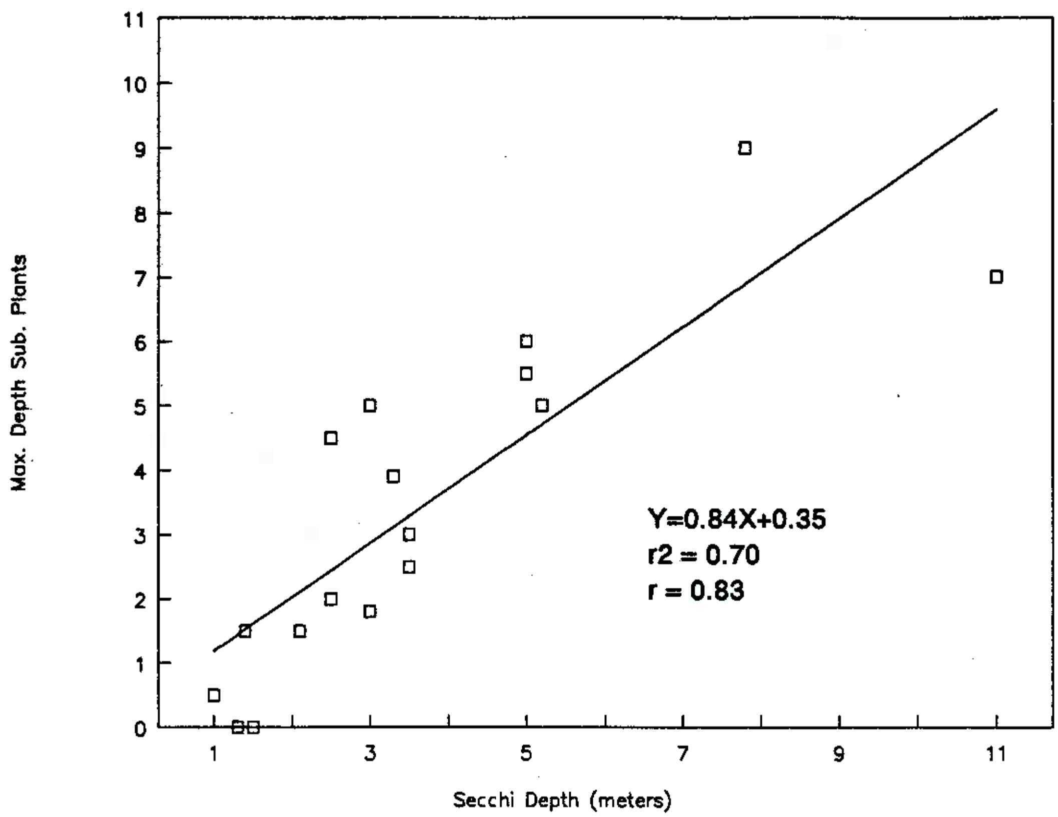


Figure 3. Linear regression of Secchi Depth as related to the Maximum Depth of Submergent Plant growth.

Figure 4. Secchi depth (transparency) for seventeen Idaho Lakes during August, 1991.

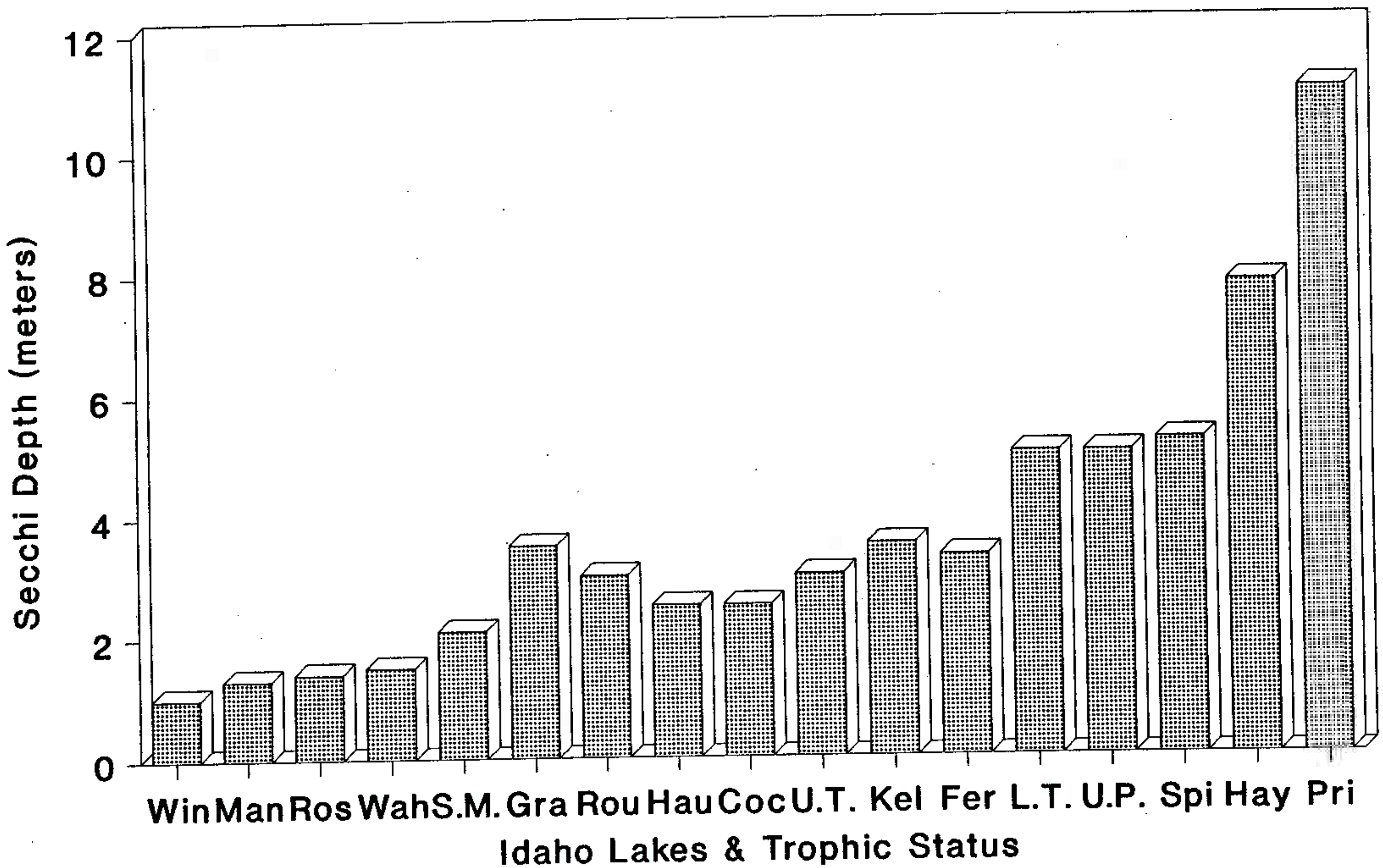


Figure 5. Average chlorophyll "a" production for seventeen Idaho Lakes during August, 1991.

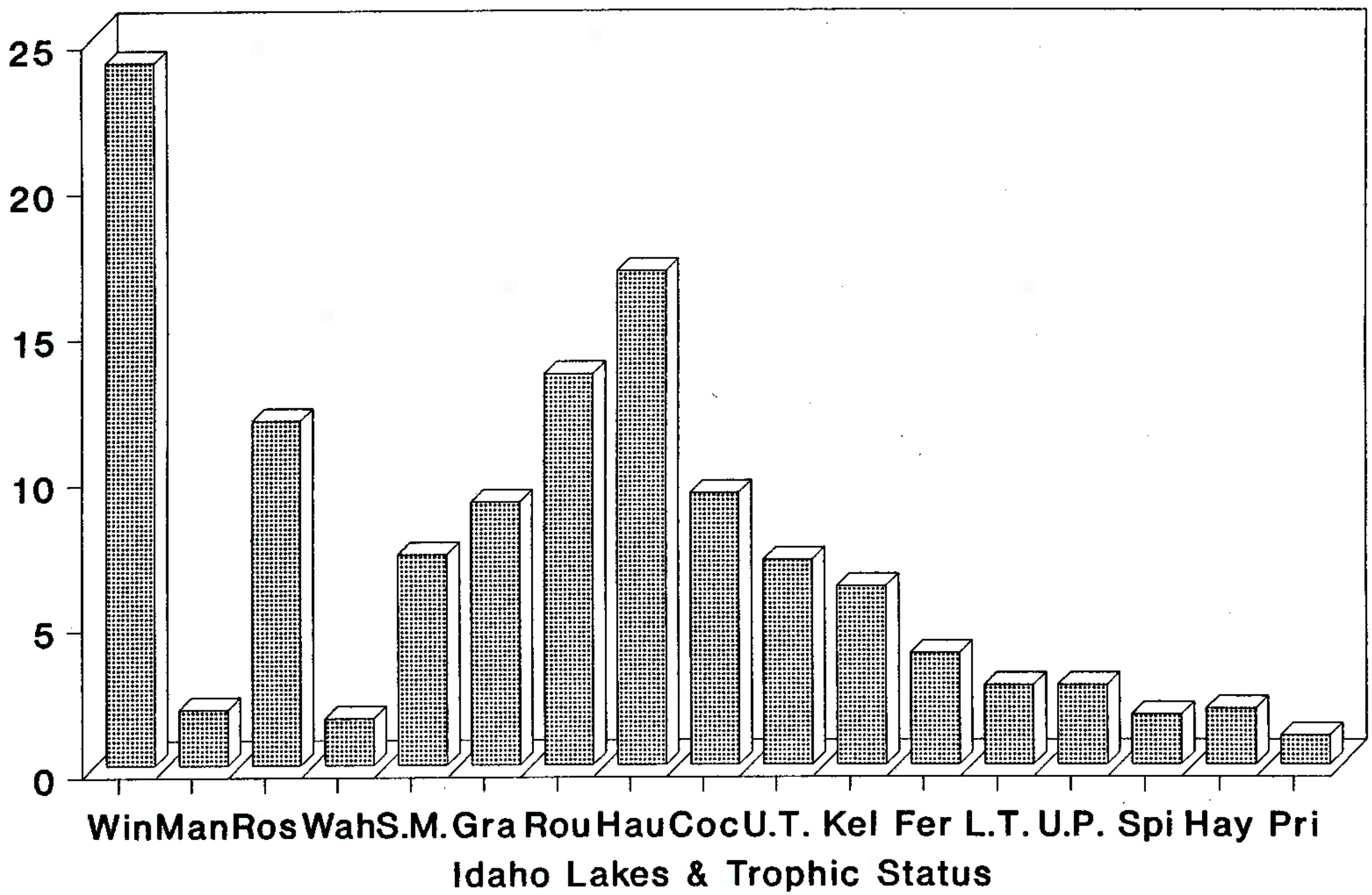


Figure 6. Algal groups and chlorophyll "a" production for seventeen Idaho Lakes.

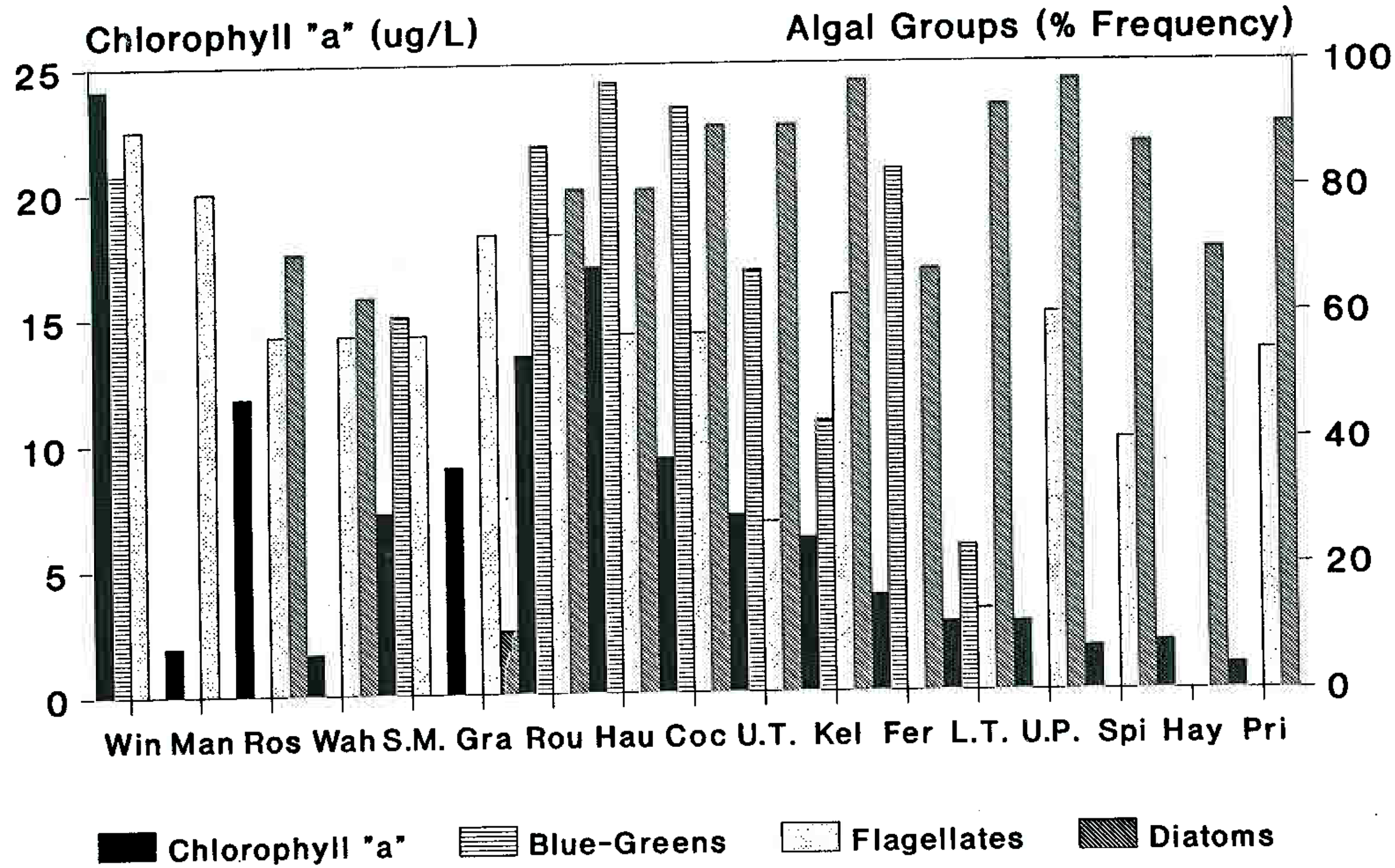
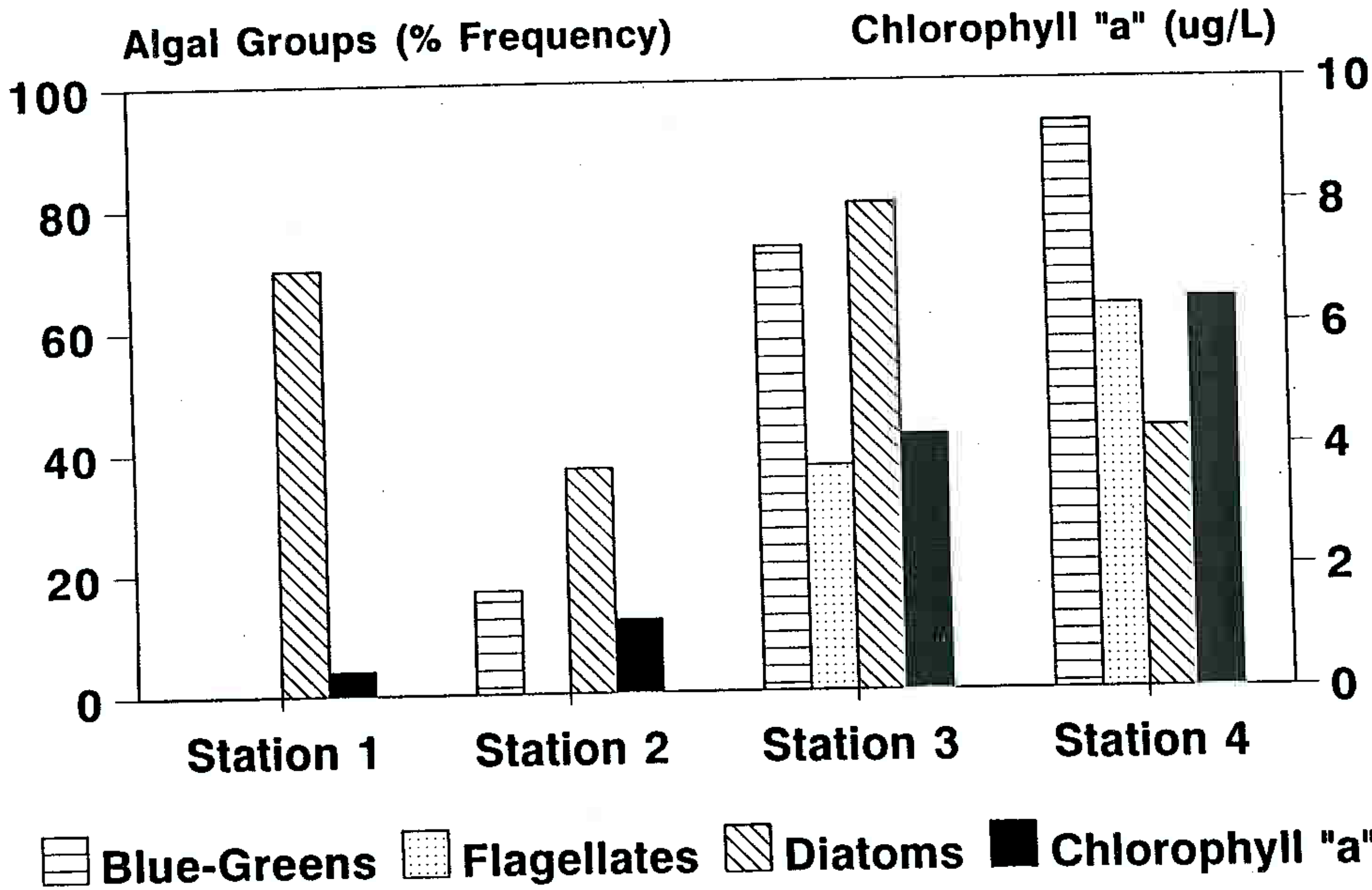


Figure 7. Algal groups and chlorophyll "a" production at different stations (water quality) in Hayden Lake, Idaho.



Station 1 = most oligotrophic
Station 2 = less oligotrophic
Station 3 = mesotrophic; Station 4 = eutrophic

Figure 8. Maximum hypolimnetic phosphorus for seventeen Idaho lakes.

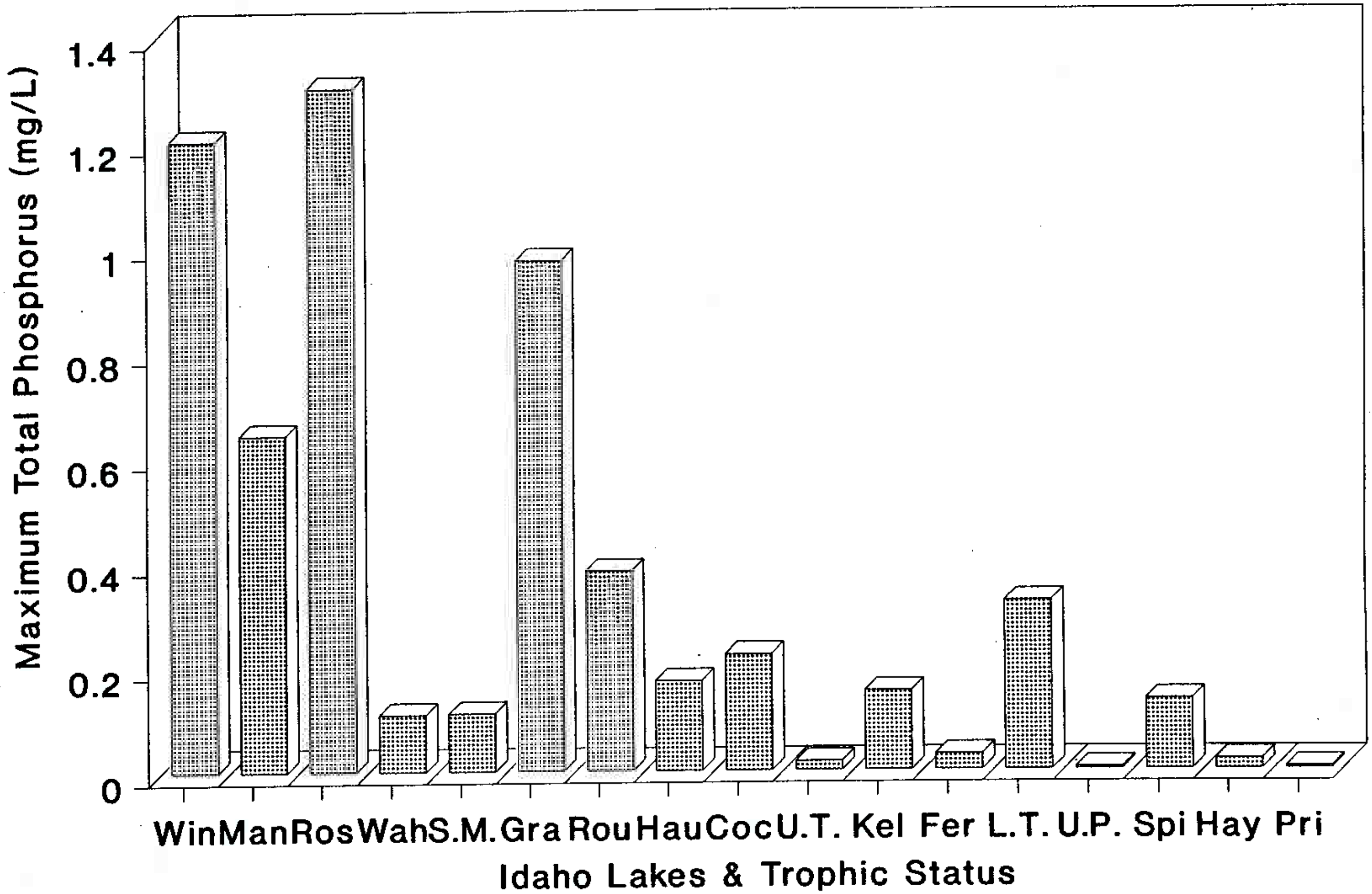


Figure 9. Maximum hypolimnetic ammonia for seventeen Idaho lakes.

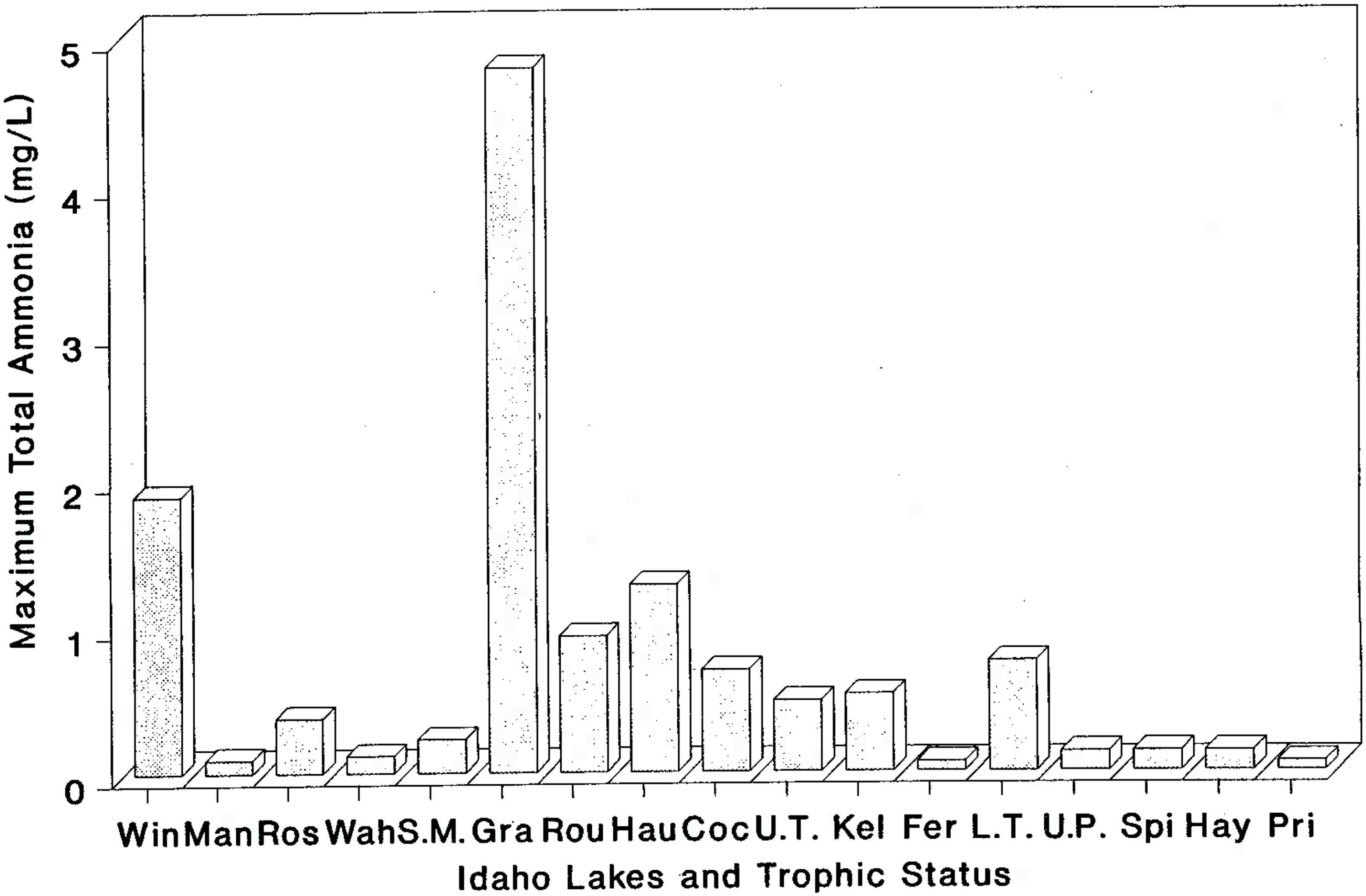


Figure 10. Minimum hypolimnetic dissolved oxygen for seventeen Idaho lakes.

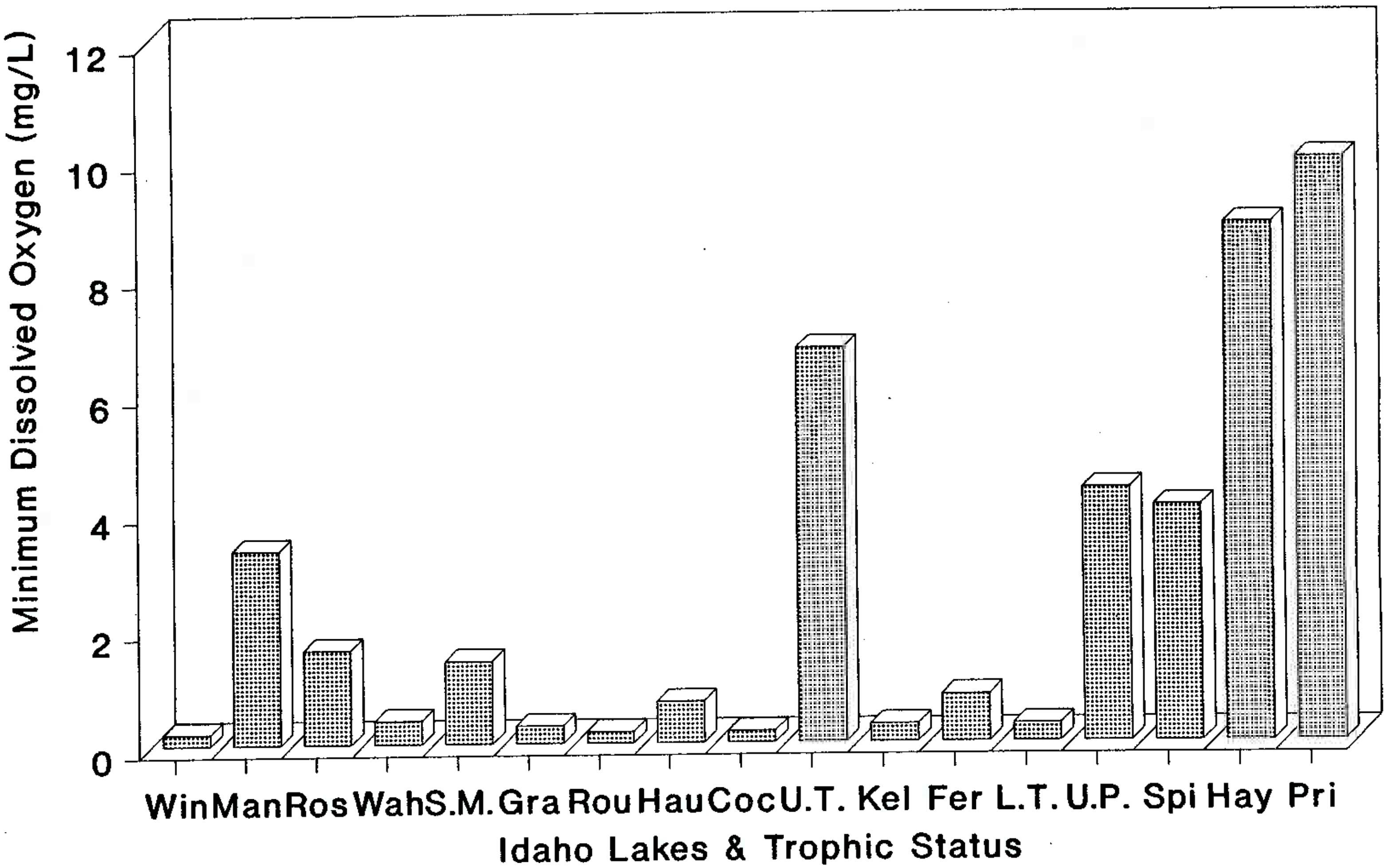


Figure 11. Average number of prevalent submergent aquatic macrophyte species in seventeen Idaho lakes.

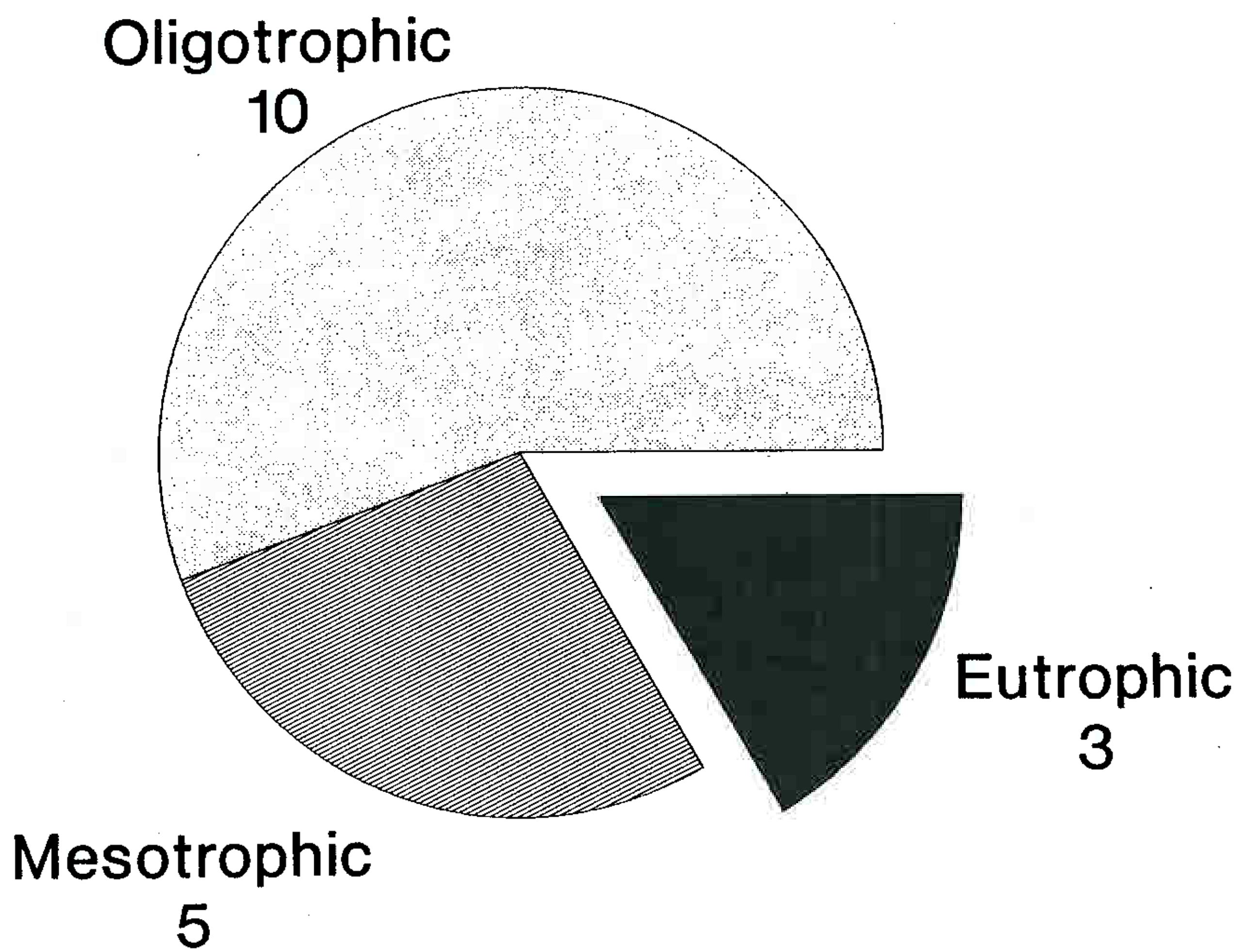


Figure 12. Total number of submergent macrophyte species in seventeen Idaho lakes.

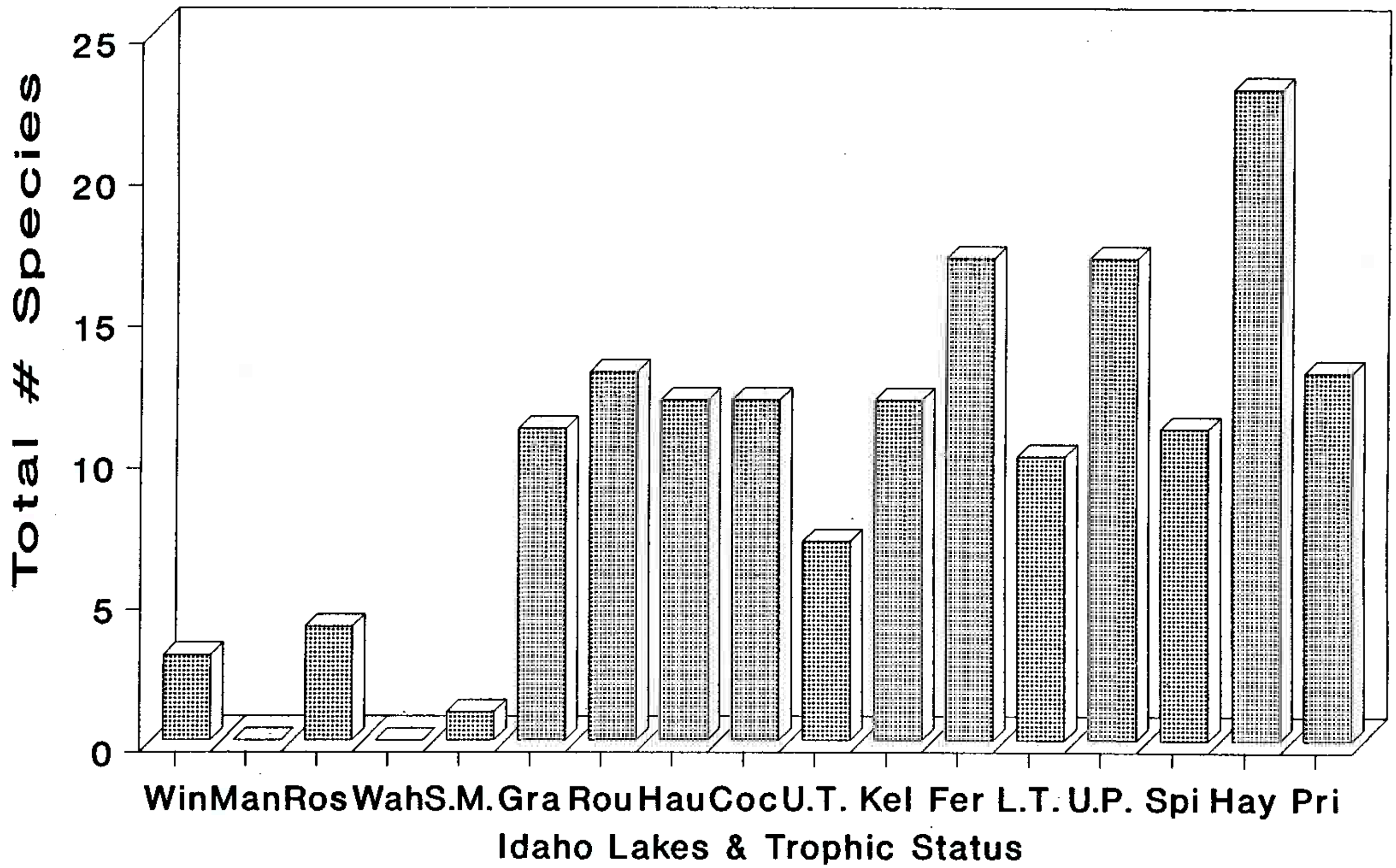
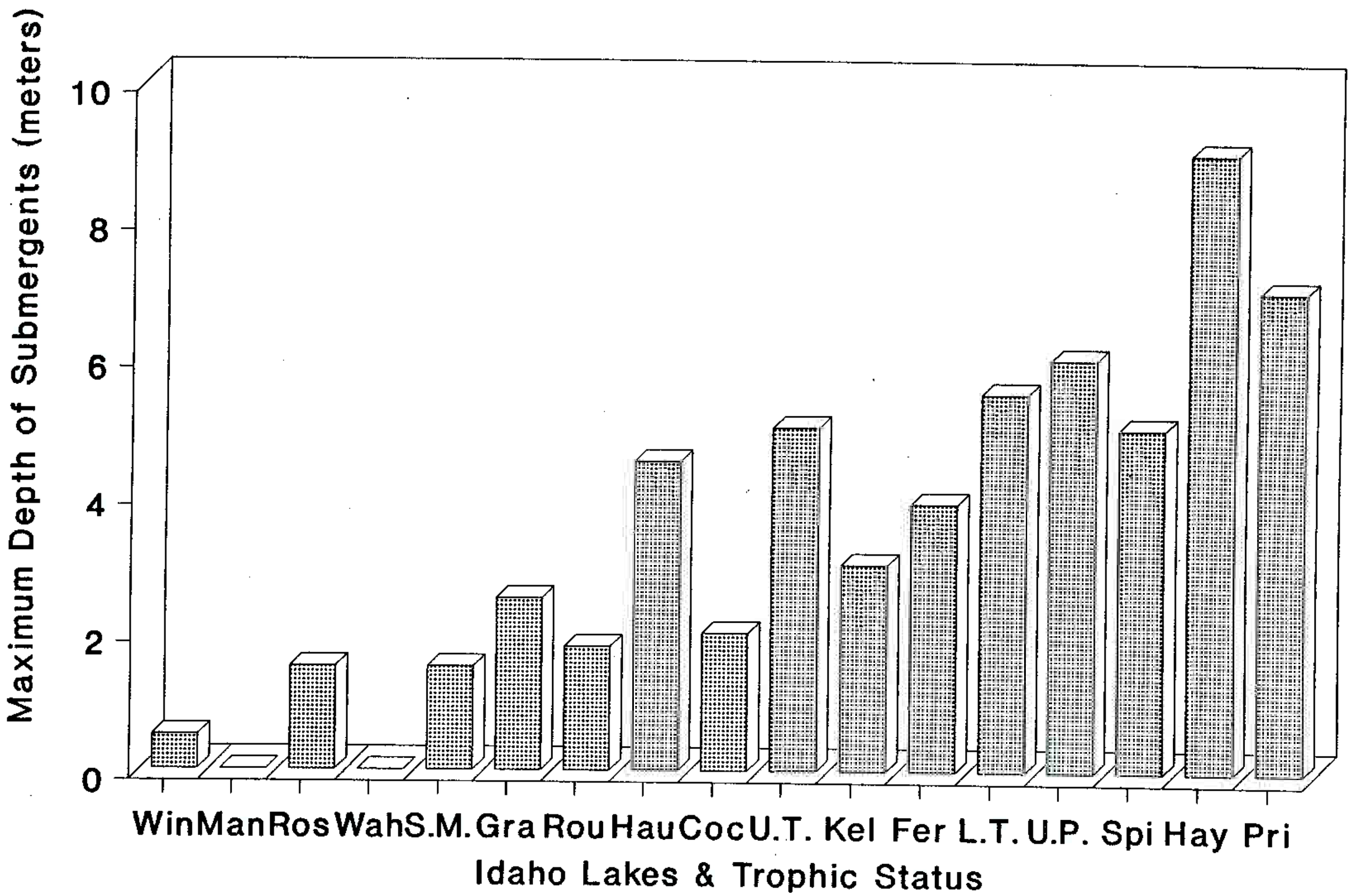


Figure 13. Maximum water depth of submergent macrophytes in seventeen Idaho lakes.



PRIEST LAKE:

General

Priest Lake is located in Bonner County, Idaho, and has 23,680 acres of surface water and 27 miles of shoreline with a maximum water depth of 321 feet (98 meters) (Figure 14). The watershed is pristine, mountainous and forested (Plate 1). The large size, spectacular forested, mountains and pristine water make Priest Lake one of the most sought-after recreational lakes in the Pacific Northwest. A majority of the sandy, lake bottom lacks aquatic plant growth.

In order to preserve Priest Lake's water quality and exceptional beauty, a lake management plan must be developed to control the nutrient and pollutant sources in the watershed. More specific evaluation of the near-shore bay area directly adjacent to the town of Coolin is needed.

LWQA water sampling occurred four times at two stations in 1990. LWQA dissolved oxygen and temperature profiles, secchi depth, chlorophyll "a" and submergent macrophyte distribution were determined once in 1991. LWQA water samples were taken at secchi depth and one meter off the lake bottom. The citizen monitors sampled the lake once at six stations in 1990 and four times at six stations in 1991. All CVMP water samples were taken at secchi depth.

Beneficial Uses

Idaho Water Quality Standards protect Priest Lake for: domestic water supply, agricultural water supply, cold water biota, salmonid spawning, primary contact recreation, secondary contact recreation, and a special resource water (Table 6). In addition, warm water biota is an existing use in Priest Lake. All beneficial uses of Priest Lake are fully <u>supported</u> at this time.

Some residents of Priest Lake use the lake water for drinking. Numerous commercial marinas operate on the Lake. There are more than a dozen public and private boat landings on the Lake. Camping is a major recreational use of Priest Lake. Lake trout fishing and the fishing guide business are major recreational uses. The aesthetic and visual qualities of Priest Lake are exceptional and some of the finest to be found anywhere in the world. There is an abundance of both residential and commercial resort developments on Priest Lake. Boating, swimming, skiing, hiking, sightseeing and sunbathing are all frequent recreational uses for Priest Lake.

The small rural town of Coolin is located on the extreme south shore of the Lake and provides economic and recreational opportunities. Just to the west is Priest River, the outlet of Priest Lake, which flows to Pend Oreille River. Generally speaking, paved highways run along the south and western sides of Priest Lake, while mostly unpaved roads run along the east and north watershed areas. The western paved road has some farming and pastureland on both sides.

Sources of Pollution, Nutrients and Recommended Management Actions

Priest Lake is highly oligotrophic and has excellent water quality. The Lake has high levels of dissolved oxygen at all depths throughout the year. The sandy, infertile, deep lake basin and

densely-forested shoreline are some of the reasons for low nutrient levels in Priest Lake. Most of the shoreline and watershed are forested, which contributes to the stability of the surrounding soils. However, some harvesting of timber and road building has occurred. The town of Coolin, Idaho, has some commercial resorts and marinas. Others can be found on the west and south side of the lake. Residential development and commercial resort development have been increasing on the Lake, both of which can be sources of pollution.

Important management recommendations for Priest Lake should include: A thorough evaluation of the effects of timber management activities in the watershed and the establishment of ecologically-sound alternatives for lakeshore development and building. Some unpaved roads running along the east side may be contributing to dust and sediment loading in the Lake. This potential problem should be studied to reduce long-term erosion contributing sediment to the Lake. Tributary streams which are impacted by roads and timber harvests should be monitored for potential changes in water quality (such as suspended sediment). Other riparian habitat alterations, may potentially affect the water quality of these streams and Priest Lake. Regulations should be enforced regarding the proper disposal of human waste from boats. Priest Lake should be managed to protect and maintain its pristine oligotrophic status and exceptional water quality.

Limnological Characteristics of Priest Lake:

Secchi Depth: 1991 LWQA range = 9.0-12.5 meters, average = 11.4 meters; 1990 LWQA range (north sample station) = 5-11 meters, average = 8.4 meters; 1990 LWQA range (south station) = 7.25-11.5 meters, average = 9.2 meters. 1991 CVMP range = 6.4-12.1 meters, average = 10.8 meters; 1990 CVMP range = 9-10 meters, average = 9.5 meters.

Priest Lake is one of clearest freshwater lakes in North America. It has one of the highest secchi depth readings of all Idaho lakes.

Chlorophyll "a": 1991 LWQA range = 0.5-1.4 ug/L, average = 0.95 ug/L; 1991 CVMP range = 0.6-3.0 ug/L, average = 1.4 ug/L.

Priest Lake has one of the lowest phytoplankton productions of any oligotrophic lake in Idaho and is ultra-oligotrophic.

Total Phosphorus: 1990 LWQA range (north station) = 0.003-0.005 mg/L, average = 0.004 ug/L; 1990 LWQA (south station) = 0.002-0.004 ug/L, average = 0.0035 ug/L. 1991 CVMP range = 0.002-0.008 ug/L; 1990 CVMP range = 0.002-0.004 ug/L, average = 0.0028 ug/L.

Phosphorus is definitely a major limiting-nutrient and was found at extremely low levels throughout Priest Lake.

Dissolved Oxygen/Temperature Profiles

Priest Lake has exceptionally high levels of dissolved oxygen throughout the epilimnion, thermocline and hypolimnion (top to bottom) during late, summer thermal stratification. The dissolved oxygen actually increased in the hypolimnion to 10.2 mg/L, relative to 8.1 mg/L at the surface (Figure 15, Table 10). In many lakes, the dissolved oxygen will decline near the lake bottom. Priest Lake, however, had 9.9 mg/L of dissolved oxygen near the lake bottom (26 meters water depth). The hypolimnetic dissolved oxygen alone tells us that Priest Lake has at this time, excellent water quality.

Submergent Macrophytes

Priest Lake has 13 different species of submergent macrophytes, most of which historically are associated with oligotrophic or clean water lakes. This diversity of submergent plants, and the relative abundance of oligotrophic-associated species was indicative of the diverse habitat available for aquatic plant community growth in Priest Lake. Both the species diversity and the dominant submergent species in the Lake, indicate that water quality is excellent. The great variety of submerged aquatic plants found in Priest Lake provides the complex cover, feeding and reproductive habitat required by fish and other aquatic organisms to survive. Sparse stands of aquatic moss and periphyton can be found only at a few locations in the Lake. Many of the more northerly sandy bays lack any submergent plants.

Submergent macrophyte communities are most extensive in shallow bays. Some dropoffs have submergent macrophytes, while others have none. Submergent plants do not grow any deeper than 6 meters in Priest Lake.

Submergent plant communities, overall are sparse, diverse or even absent in many bays, despite the extremely clear water. Where submergent vegetation occurs, no one bay in Priest Lake is dominated by less than three species. Most bays have 8 to 9 species of submergents with some clean water associated species found in every bay.

The following submergent macrophyte species were found in Priest Lake: Najas flexilis (bushy pondweed), Rannunculus (water buttercup), Nitella and Chara (muskgrass), Elodea (waterweed), Eleocharis (needle rush), Potamogeton gramineus (variable pondweed), Potamogeton praelongus (whitestem pondweed), Potamogeton Richardsonii (claspingleaf pondweed, Potamogeton amplifolius (largeleaf pondweed), Potamogeton robbinsii (robbins pondweed), Fontanalis (aquatic moss) and Myriophyllum verticilatum (green milfoil). Nitella, Elodea and Chara are the dominant species at water depths ranging from four to six meters.

Visual inspection and a modified rake and Eckman dredge sampler were used to sample the submergent plant communities. The use of SCUBA and more intensive plant survey/study efforts would provide a more reliable data base with which to draw conclusions, regarding the trophic nature and water quality of Priest Lake.

LWQA and CVMP Water Quality Data

LWQA and CVMP water chemistry data indicate that Priest Lake is oligotrophic. Low levels of ammonia, nitrate and nitrite, and total kjehldahl nitrogen, total phosphorus and ortho-phosphate, chlorophyll "a" and specific conductivity indicate the Lake is in excellent condition (Tables 11-16). More discussion of Priest Lake water quality data may be found under discussion of specific parameters in this report.

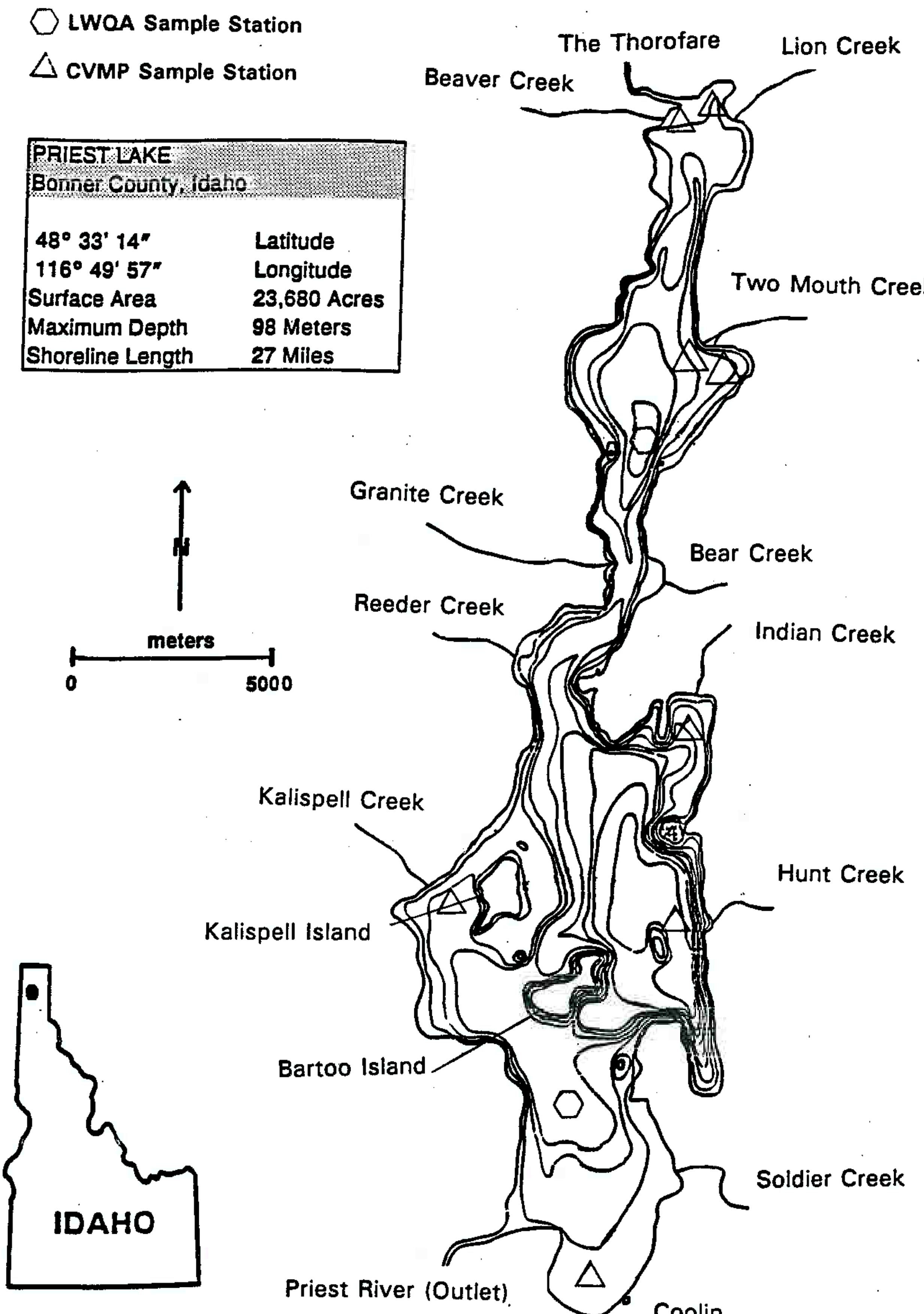


Figure 14. Map of Priest Lake.

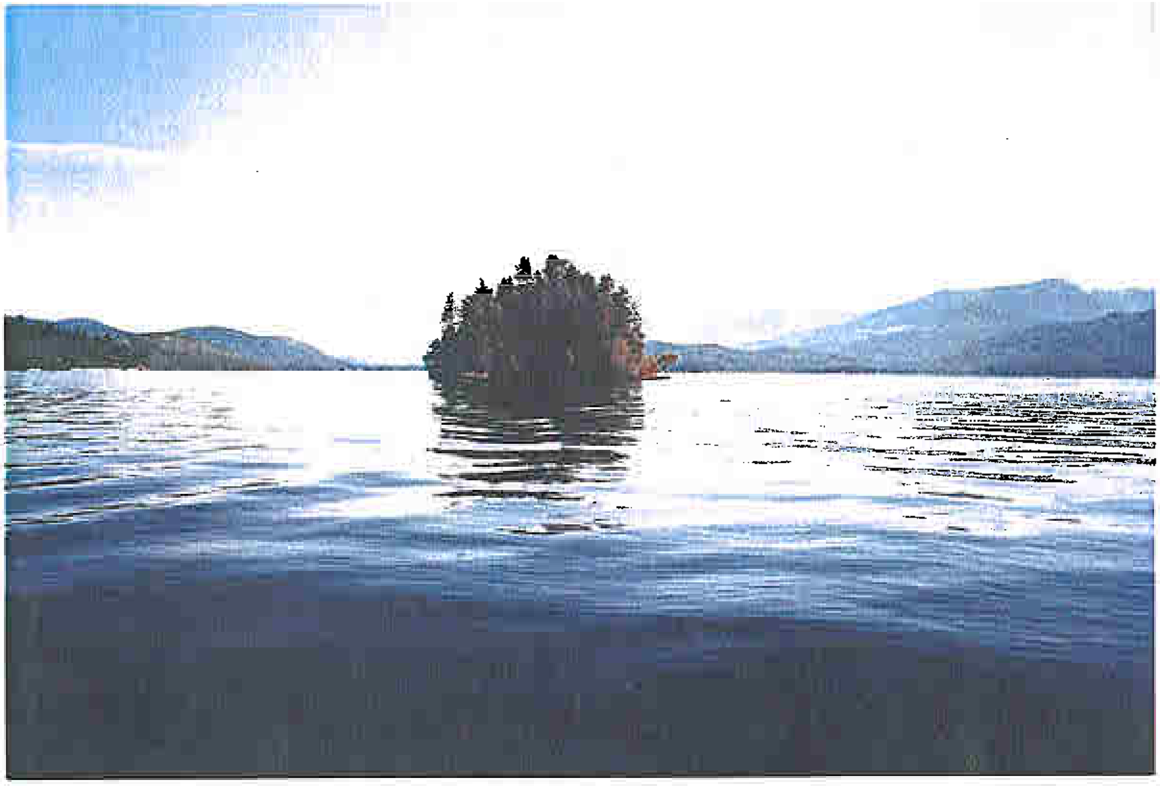


Plate 1. Priest Lake photographs showing pristine water and mountainous, forested watershed.

Figure 15. Dissolved oxygen and temperature profile for Priest Lake, August 2, 1991.

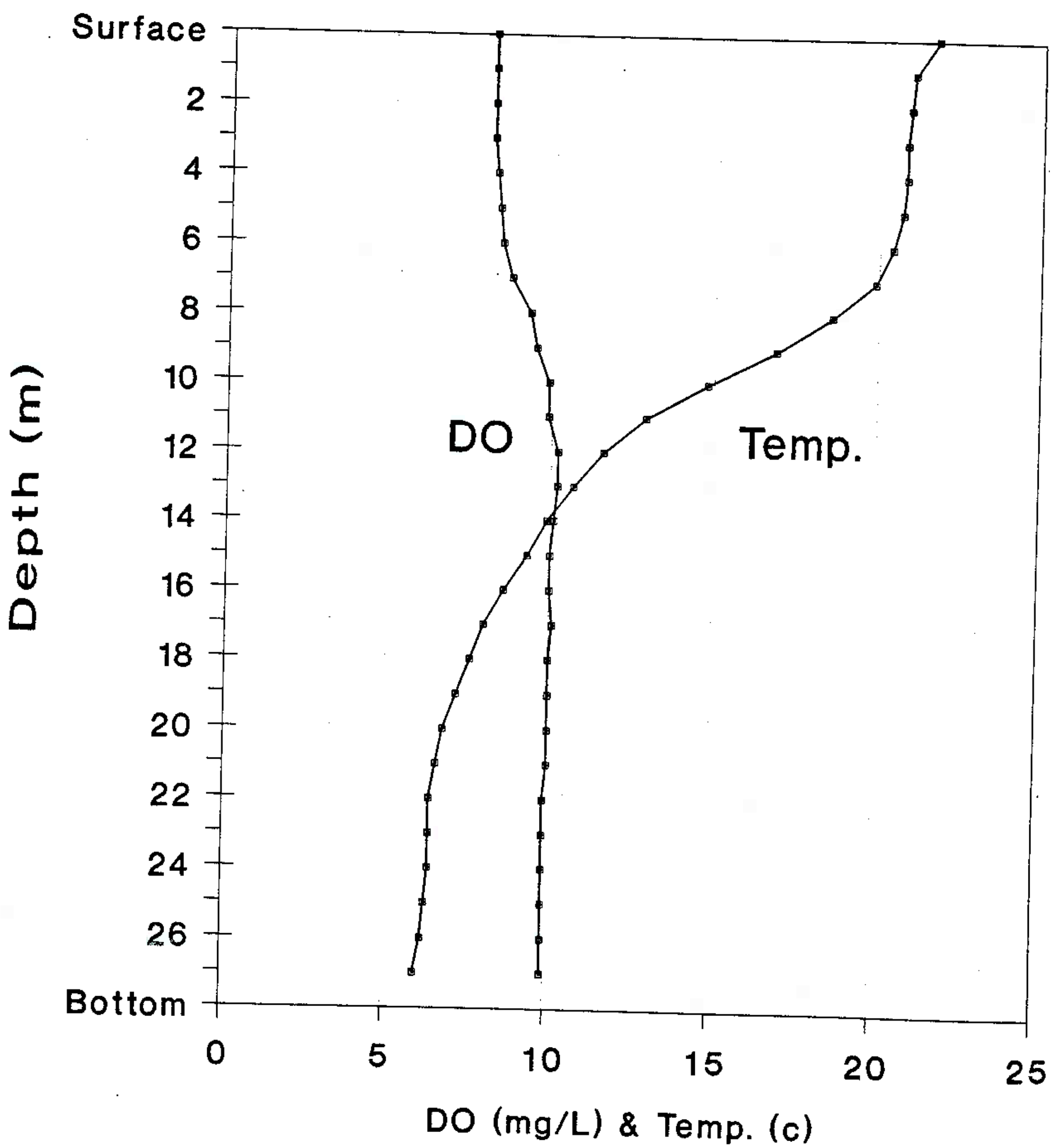


Table 10. Dissolved oxygen/temperature profiles during summer thermal stratification for Priest Lake (South) on August 2, 1991.

Depth (meters)	Dissolved Oxygen (mg/L)	Temperature (°C)
0.0	8.1	21.7
1.0	8.1	21.0
2.0	8.1	20.9
3.0	8.1	20.8
4.0	8.2	20.8
5.0	8.3	20.7
6.0	8.4	20.4
7.0	8.7	19.9
8.0	9.3	18.6
9.0	9.5	16.9
10.0	9.9	14.8
11.0	9.9	12.9
12.0	10.2	11.6
13.0	10.2	10.7
14.0	10.1	9.9
15.0	10.0	9.3
16.0	10.0	8.6
17.0	10.1	8.0
18.0	10.0	7.6
19.0	10.0	7.2
20.0	10.0	6.8
21.0	10.0	6.6
22.0	9.9	6.4
23.0	9.9	6.4
24.0	9.9	6.4
25.0	9.9	6.3
26.0	9.9	6.2
27.0	--	6.0

Table 11. 1990 Lake Water Quality Assessment (LWQA) water chemistry data* for Priest Lake (North).

Date	6-25-90	6-25-90	8-7-90	9-18-90	10-29-90	10-29-90
Time	1405	1405	1300	1300	1230	1230
Sample Depth	70	5	65	10	32	10
Secchi Depth	5	5	11	10	9.6	9.6
Total Depth	79.2	79.2	69.2	70.1	65.3	65.3
T. NH3-N	0.027	0.022	0.051	0.043	0.063	0.052
T. NO2+NO3-N	0.048	<.005	0.059	0.029	0.044	<.005
T. Kjeldahl-N	0.21	0.08	0.27	0.2	0.17	0.13
T. Phosphorus-P	0.005	0.004	0.004	0.005	0.003	0.003
Dissl. Phosphate-P	0.001	0.001	<.002	0.003	<.002	<.002
Hardness-CaCO3	24	20	24	24	24	24
T.Alkalinity-CaCO3	22	21	22	22	22	22

* Depth in meters and water chemistry data in mg/L.

Table 12. 1990 Lake Water Quality Assessment (LWQA) dissolved oxygen, temperature, conductivity and pH for Priest Lake (North). *

	6–25				8–7				9–18				10–29			
	Temp	pH	Cond	D.O.	Temp	pH	Cond	D.O.	Temp	pH	Cond	D.O.	Temp	pH	Cond	D.O.
Meters	17.3	6.8	49	9.6	22.6	6.8	51	8.3	18.7	6.9	51	8.5	10.4	6.2	51	10.1
1	10.4	6.9	49	9.9	21.9	6.8	51	8.3	18.6	6.9	52	8.5	10.4	6.5	52	10
5	9.6	6.8	52	10.	14.6	6.8	49	10.4	18.4	6.9	52	8.5	10.3	6.6	51	9.8
10	7.3	6.6	49	10	9	6.5	49	10.9	18.3	6.9	51	8.5	10.3	6.7	50	9.8
15	6.4	6.5	51	10.	7.6	6.3	50	10.6	10.8	6.6	50	10.3	10.2	6.7	50	9.9
20	5.9	6.4	51	10.	6.6	6.2	50	10.6	7.6	6.4	51	10.4	10.2	6.7	50	9.8
25	5.7	6.4	51	10.	6.2	6.2	50	10.6	6.8	6.2	51	10.1	10.2	6.6	50	9.9
30	5.7	6.4	50	10.	5.9	6.1	50	10.5	6.4	6.2	50	10.1	9.7	6.4	51	9.7
35	5.1	6.3	50	10.	5.7	6.1	50	10.6	6.3	6.1	50	10.1	7.3	6.3	50	9.7
40	5.1	6.3	50	10.	5.4	6	51	10.4	6	6.1	50	10.1	6.6	6.2	50	9.6
45	5.1	6.3	51	10.	5.3	6	50	10.2	5.7	6.1	49	10.1	5.9	6.1	50	9.4
50	5.1	6.3	51	10.	5.2	6	51	10.1	5.5	6.1	49	9.9	5.6	6.1	50	9.2
55	5.1	6.3	51	10.	—	—	—	—	5.4	6	50	9.5	5.6	6.1	50	9
60	5.1	6.3	51	10.	—	—	—	—	5.4	6	50	9.4	5.6	6.1	51	8.9
65	5.1	6.3	51	10.	—	—	—	—	—	—	—	—	—	—	—	—
70	5	6.3	50	9.8	—	—	—	—	—	—	—	—	—	—	—	—

* Temperature in Degrees Centigrade, Conductivity in umhos/cm and Dissolved oxygen in mg/L.

Table 13. 1990 Lake Water Quality Assessment (LWQA) water chemistry data for Priest Lake (south). *

Date Time	6-25-90 1550	6-25-90 1550	8-7-90 1500	9-18-90 1500	10-29-90 1330	10-29-90 1330
Sample Depth	70	7	70	11.5	32	12
Secchi Depth	7.25	7.25	8.8	11.5	---	---
Total Depth	---	---	99.4	101.2	---	---
T. NH3-N	0.075	0.02	0.05	0.049	0.118	0.077
T. NO2+NO3-N	0.105	<.005	0.057	<.005	0.053	<.005
T. Kjeldahl-N	0.07	0.19	0.98	0.2	0.07	0.13
T. Phosphorus-P	0.003	0.004	0.002	0.004	0.004	0.004
Orthophosphate-P	0.001	0.001	0.002	,.002	<.002	<.002
Hardness-CaCO3	20	24	24	24	24	20
T.Alkalinity-CaCO3	27	21	21	21	21	22

* Depth in meters and water chemistry data in mg/L.

Table 14. 1990 Lake Water Quality Assessment (LWQA) dissolved oxygen, temperature, conductivity and pH for Priest Lake (south). *

	6-25				8-7				9-18				10-29			
Meters	Temp	pH	Cond	D.O.	Temp	pH	Cond	D.O.	Temp	pH	Cond	D.O.	Temp	pH	Cond	D.O.
1	19.2	6.7	49	8.7	23.2	6.5	49	8.4	18.8	6.9	50	8.5	10.4	6.4	52	9.9
5	12.1	6.8	46	9.6	22.2	6.8	49	8.4	18.4	6.9	50	8.6	10.3	6.6	51	9.8
10	9.9	6.8	48	10	14.4	6.9	49	10.7	18.2	7	50	8.6	10.2	6.7	51	9.8
15	8.7	6.5	49	9.8	9.4	6.6	49	11.2	18.1	6.9	50	8.6	10.2	6.7	50	9.8
20	7.2	6.4	50	9.8	7.7	6.4	50	10.8	13.8	6.9	49	10.1	10.2	6.7	49	9.7
25	6.2	6.4	49	9.9	6.8	6.2	50	10.7	11	6.6	49	10.7	10.1	6.7	49	9.8
30	5.7	6.3	50	9.9	6.2	6.2	50	10.8	8.3	6.4	49	10.5	8.4	6.6	51	9.7
35	5.4	6.3	49	9.9	5.8	6.1	50	10.7	7.1	6.3	50	10.3	6.6	6.4	51	9.7
40	5.2	6.3	50	9.9	5.6	6.1	50	10.8	6.6	6.2	50	10.2	6.1	6.3	50	9.6
45	5.1	6.3	50	10	5.4	6.1	50	10.7	6.3	6.1	49	10.2	6	6.2	50	9.6
50	4.9	6.3	49	9.9	5.2	6.1	50	10.8	5.9	6.1	50	10.2	5.9	6.2	50	9.6
60	4.7	6.2	50	9.9	5	6	50	10.9	5.4	6.1	49	10.3	5.3	6.2	49	9.8
70	4.6	6.2	50	10	4.6	6	50	10.9	5	6.1	49	10.5	4.9	6.2	50	9.9
80	4.4	6.2	49	10	--	--	--	--	4.7	6.1	50	10.6	--	--	--	--
90	4.3	6.2	49	10	--	--	--	--	4.6	6.1	49	10.7	4.7	6.2	50	10

* Temperature in degrees Centigrade, conductivity in umhos/cm and dissolved oxygen in mg/L.

Table 15. 1990 Citizen Volunteer Monitoring Program (CVMP) water quality data for Priest Lake. *

Sample station location:	Coolin Bay	Kalispell Creek	Hunt Creek	Indian Creek	Huckleberry Bay	Mosquito Bay
Date of Sample	09/30/90	09/30/90	09/30/90	09/30/90	09/30/90	09/30/90
Secchi sample depth	10	9	10	9	9	9
T. Ammonia	0.028	0.031	0.026	0.014	0.028	0.038
T. NO2+NO3	0.005	0.005	0.005	0.005	0.005	0.005
T.K. Nitrogen	0.09	0.09	0.07	0.09	0.1	0.1
T. Phosphorus	0.004	0.002	0.002	0.003	0.003	0.003

* units in mg/L and depth in meters unless otherwise indicated.

Table 16. 1991 Citizen Volunteer Monitoring Program (CVMP) water quality data for Priest Lake.

Sample station location:	Coolin Bay	Kalispell Creek	Hunt Creek	Pinto Point	Two Mouth Creek	Beaver Creek
Date of Sample * (CVMP)	05/28/91	05/28/91	05/28/91	05/28/91	05/28/91	05/28/91
Secchi sample depth:**	7.3	7.3	7.3	8.2	7.3	6.4
T. Ammonia	0.049	0.089	0.055	0.038	0.039	0.038
T. NO2+NO3	0.005	0.005	0.025	0.018	0.017	0.008
T.K. Nitrogen	0.41	0.24	0.22	0.12	0.1	0.55
T. Phosphorus	0.004	0.006	0.006	0.008	0.005	0.006
Ortho Phosphate	0.001	0.001	0.001	0.001	0.001	0.001
Chlorophyll a (ug/L)	2.6	1.4	2.7	3	2.1	2.1
Date of Sample	07/01/91	07/01/91	07/01/91	07/01/91	07/01/91	07/01/91
Secchi sample depth:	7	8	10	10	9	8
T. Ammonia	0.036	0.043	0.048	0.072	0.021	0.079
T. NO2+NO3	0.005	0.005	0.029	0.011	0.006	0.005
T.K. Nitrogen	0.26	0.11	0.21	0.22	0.29	0.16
T. Phosphorus	0.005	0.006	0.005	0.008	--	0.003
Ortho Phosphate	0.002	0.002	0.002	0.002	0.002	0.002
Chlorophyll a (ug/L)	--	--	2.1	2.1	1.3	1.1
Date of Sample	8/12/91	8/12/91	8/12/91	8/12/91	8/12/91	8/12/91
Secchi sample depth:	11.7	10	10.8	11.7	10.8	11.7
T. Ammonia	0.034	0.032	0.048	0.018	0.065	0.015
T. NO2+NO3	0.006	0.01	0.005	0.007	0.01	0.005
T.K. Nitrogen	0.25	0.21	0.3	0.17	0.23	0.17
T. Phosphorus	0.004	0.002	0.003	0.002	0.003	0.003
Ortho Phosphate	0.002	0.002	0.002	0.002	0.002	0.002
Chlorophyll a (ug/L)	1	0.6	1.4	1	0.9	1.7
Date of Sample	09/17/91	09/17/91	09/17/91	09/17/91	09/17/91	09/17/91
Secchi sample depth:	11.1	12.1	11	11.1	10	10.8
T. Ammonia	0.029	0.028	0.021	0.024	0.085	0.011
T. NO2+NO3	0.012	0.015	0.01	0.012	0.01	0.011
T.K. Nitrogen	0.2	0.019	0.35	0.26	0.36	0.21
T. Phosphorus	0.003	--	--	--	0.003	0.004
Ortho Phosphate	0.002	0.002	0.002	0.002	0.002	0.002
Chlorophyll a (ug/L)	1	1	1	1	1	1
Date of Sample (DEQ)	09/17/91	--	09/17/91	09/17/91	09/17/91	--
Secchi sample depth:	11.1	--	11	11.1	10	--
T. Ammonia	0.016	--	0.01	0.032	0.018	--
T. NO2+NO3	0.01	--	0.01	0.01	0.009	--
T.K. Nitrogen	0.05	--	0.2	0.26	0.31	--
T. Phosphorus	0.005	--	0.005	0.003	0.003	--
Ortho Phosphate	0.002	--	0.002	0.002	0.002	--
Chlorophyll a (ug/L)	1	--	1	1	1	--

* mg/L unless otherwise indicated.
** In meters.

HAYDEN LAKE:

General

Hayden Lake is located in Kootenai County, Idaho, and has 4,200 acres of surface water, 27 miles of shoreline and a maximum water depth of 178 feet (54.3 meters) (Figure 16). The watershed is mountainous and forested with considerable residential lakeshore development (Plate 2). The beauty of the Lake and its forested, mountainous watershed, along with its proximity to the city of Coeur d'Alene has resulted in explosive residential home development in the last two years.

Additional water quality information concerning phosphorus, secchi depth, dissolved oxygen and temperature profiles, and biological information concerning chlorophyll "a" and submergent macrophyte communities, will help to provide the data base needed for the development of a comprehensive lake management plan for Hayden Lake.

The north end of the Lake also has excessive submergent aquatic plant growth, which reached the surface of the water in July and August and effectively eliminated any boating activity.

LWQA water sampling occurred once at two stations in 1990. LWQA dissolved oxygen and temperature profiles, secchi depth and chlorophyll "a" and submergent macrophyte distribution were determined once in 1991. The citizen monitors (CVMP) sampled the lake five times at two stations in 1990 and 1991. LWQA and CVMP water samples were taken at secchi depth and one meter off the lake bottom.

Beneficial Uses

Hayden Lake designated beneficial uses include: domestic water supply, agricultural water supply, cold water biota, warm water biota, salmonid spawning, primary contact recreation and secondary contact recreation (Table 6). Hayden Lake is designated as a special resource water. The domestic water supply of Hayden Lake is <u>threatened</u> based on background information and professional judgement.

Cutthroat trout, smallmouth and largemouth bass fishing are outstanding in Hayden Lake. Fishing, boating, water skiing, swimming, sightseeing and sunbathing are major recreational uses. The aesthetic and visual qualities of Hayden Lake are outstanding and some of the finest to be found in Idaho. Extensive residential homes and some commercial resort developments can be found throughout most of the shoreline. There are two public accesses, one at the south end and one at the north end of the lake. A large swimming beach and picnic area is located adjacent to the southern public boat access at Honeysuckle Beach. Water is drawn from the

Lake by a pumphouse located at the south end of the Lake at

Honeysuckle Beach. The Hayden Lake Irrigation District uses the water for agricultural purposes.

Sources of Pollution, Nutrients and Recommended Management Actions

The north bay of the Lake is extremely eutrophic as a result of former intensive cattle grazing and feedlot activity on the lakeshore. The north end has extensive weed beds in July and August which effectively eliminate boating activity. In addition, Hayden Creek contributes significant silt and suspended solids to the Lake. Some of this siltation is a result of intensive timber harvesting in the Hayden Creek drainage. All of these aforementioned factors and a shallow water depth appear to be contributing to the enrichment of the north bay and the deterioration of water quality.

Hayden Lake has diverse trophic conditions. The lateral bays are variable from mesotrophic to oligotrophic. The south end of the Lake is oligotrophic in most of the deep areas of the bays and main open water areas. Lakeshore development and erosion is extensive and contributes silt and nutrients to some of the near-shore water areas making them more eutrophic.

It appears that the residential development has been relatively unchecked in many instances, as a result of the lack of lakeshore building regulations and variances that are being granted of the minimum 25 foot setback building requirements by Kootenai County.

Some of the southern lakeshore is newly sewered, which will eliminate some of the drainage field seepage problems which have occurred in the past. However, the newly installed sewer system allows for increased density of lake home development and shoreline erosion. Numerous tributary streams from the east and the north Coeur d'Alene Mountains contribute sediment and nutrients to Hayden Lake, as well. If further deterioration continues in the Lake, notable changes will include: a significant loss in water clarity, a reduction of dissolved oxygen in the deep hypolimnetic waters, algal blooms along the shorelines and in the bays, and other characteristics associated with more eutrophic lakes.

Important management recommendations for Hayden Lake should also include more conscientious application and enforcement of best management practices (BMP's) for timber harvesting in the watershed and closer adherence of lakeshore development and building regulations.

Limnological Characteristics of Hayden Lake:

Secchi Depth: 1991 LWQA range = 5.0-8.0 meters, average = 6.6 meters; 1991 CVMP range = 6.0-9.5 meters, average = 8.5 meters;

1990 CVMP range = 3.5-9.0 meters, average = 7.5 meters.

Hayden Lake generally has excellent water clarity throughout the year, especially in the deeper, open water areas. However, the extreme north bay in the Lake has significantly lower water clarity than other areas of Hayden Lake.

Chlorophyll "a": 1991 LWQA range = 0.3-6.7 ug/L, average = 1.9 ug/L; 1990 LWQA range = 1.0-3.7 ug/L, average = 2.1 ug/L; 1991 CVMP range = 0.6-2.0 ug/L, average = 1.2 ug/L. 1990 CVMP range = 1.0-2.6 ug/L, average = 1.7 ug/L.

Chlorophyll "a" production varied with the site at which the sample was taken. In the shallow, detritus-laden north bay, where sumbergent macrophytes are prolific, chlorophyll "a" production was the highest ranging from 6.1 to 6.7 ug/L. In the open water, just outside the weed bed, chlorophyll "a" declined to 3.8 to 4.5 ug/L. The deeper, more oligotrophic regions of the lake were significantly lower in chlorophyll "a" production, ranging from 0.3 to 1.4 ug/L. Hence, there are extreme differences in phytoplankton production in different areas of the lake.

Total Phosphorus: 1990 LWQA range = .002-.024 mg/L, average = .012 ug/L; 1991 CVMP range = .002-.038 ug/L, average = .011; 1990 CVMP range = .002-.024 ug/L, average = .009 ug/L.

Phosphorus levels were approximately ten times higher in hypolimnetic waters off the lake bottom, than those levels found at the surface. Bottom phosphorus levels were extremely low and no strong odor was found in water samples taken off the lake bottom (48 meters). This indicated that little or no anaerobic bacteria decomposition was occurring. Phosphorus data from Hayden Lake has been somewhat variable over a period of years. Consequently, further documentation and evaluation of phosphorus throughout the vertical lake basin is needed. Because of its low concentration, phosphorus is a limiting nutrient to phytoplankton and submergent macrophyte growth in Hayden Lake.

Dissolved Oxygen/Temperature Profiles

On July 25, 1991, the cooler, deeper water in the hypolimnion was higher in dissolved oxygen than the surface water for all three locations sampled, indicating that the lake was in good condition. On August 28, dissolved oxygen ranged from 8.1 mg/L at the surface to 8.8 mg/L at 48 meters near the lake bottom (Table 17, Figure 17). The relative increase in dissolved oxygen in the deeper water compared to the surface, illustrates the oligotrophic nature of Hayden Lake. The increased solubility of oxygen in the cooler, deeper waters accompanied by low phosphorus, low phytoplankton production and low nutrients result in the favorable dissolved oxygen levels found throughout the hypolimnion. The dissolved oxygen was higher throughout the thermocline than in the epilimnion.

Submergent Macrophytes

Generally, the submergent plant communities of Hayden Lake were extremely diverse and had an excellent variety of submergent aquatic macrophytes. These submergent plants are dependent on water quality and water depth, as well as the type of lake bottom in which they are rooted (sand, rocks, organic soils, detritus, etc.). The tremendous diversity (23 species) is indicative of the diverse habitat that is available for the development of submergent aquatic plant communities. The variety and the dominant species of submergent macrophytes, indicates that water quality is highly variable, ranging from nutrient-poor to nutrient-rich. Aquatic plants provide cover, feeding and reproductive habitat that fish and other aquatic organisms require to survive.

Clean water associated submergent macrophytes make up a significant portion of the submergent plant communities. Some of the clean-water associated species include: wild celery, spike rush, fineleaf pondweed, quillwort, water buttercup, clasping-leaf pondweed, muskgrass, bushy pondweed and whitestem pondweed. These submergent species are often associated with less fertile water, less organic lake bottoms (sand, rock) and lakes of high water clarity. High densities of some submergent species associated with more mesotrophic/eutrophic lakes were found in some of the more fertile, shallow bays of Hayden Lake.

The following 23 aquatic macrophyte species were found in Hayden Lake: Chara (muskgrass), Elodea spp., (waterweed), Eleocharis (needle rush), Potamogeton robbinsii (robbins pondweed), Potamogeton filiformis (fineleaf pondweed), Fontinalis (aquatic moss), Ceratophyllum demersum (coontail), Vallisneria americana (wild celery), P. amplifolius (largeleaf pondweed), P. praelongus (whitestem pondweed), Najas flexilis (bushy pondweed), P. natans (floatingleaf pondweed), P. foliosus (narrow-leaf pondweed), Ranunculus (water buttercup), P. zosteriformis (flatstem pondweed), Eleocharis acicularis (needle rush), Utricularis vulgaris (bladderwort), Nuphar (yellow water lily), P. Richarsonnii (claspingleaf pondweed), Myriophyllum exalbescens (water milfoil), P. spirillus (minature floating-leaf pondweed) and Polygonum natans (water smartweed).

There was a definite progression of species succession and replacement that occurs with both the water depth and the amount of organic and detritus in the lake bottom. The north eutrophic bay of Hayden Lake is dominated by excessive, dense stands of coontail, flatstem pondweed, milfoil and robbins pondweed. Species such as largeleaf pondweed, flatstem pondweed, water milfoil, coontail, waterweed and robbins pondweed were rooted in the organic, shallow bottoms. No submergent macrophytes were found in water deeper than 9.0 meters in Hayden Lake.

The water quality of the different regions of the Lake, however, is the major factor interacting with and determining the makeup and distribution of underwater plant communities.

Visual inspection and a modified rake and Eckman dredge sampler were used to sample these submergent plant communities. The use of SCUBA and a more refined and intensive study effort, would provide a more reliable data base with which to draw conclusions regarding the trophic nature and water quality of Hayden Lake.

LWQA and CVMP Water Quality Data

LWQA and CVMP water chemistry data indicated that Hayden Lake is oligotrophic. Low levels of ammonia, nitrate and nitrite, and total kjehldahl nitrogen, total phosphorus and ortho-phosphate, chlorophyll "a" and specific conductivity indicated the Lake is in excellent condition (Tables 18-20). More specific discussion of some of these and other parameters can be found under specific subtitles for water quality parameters in this report.

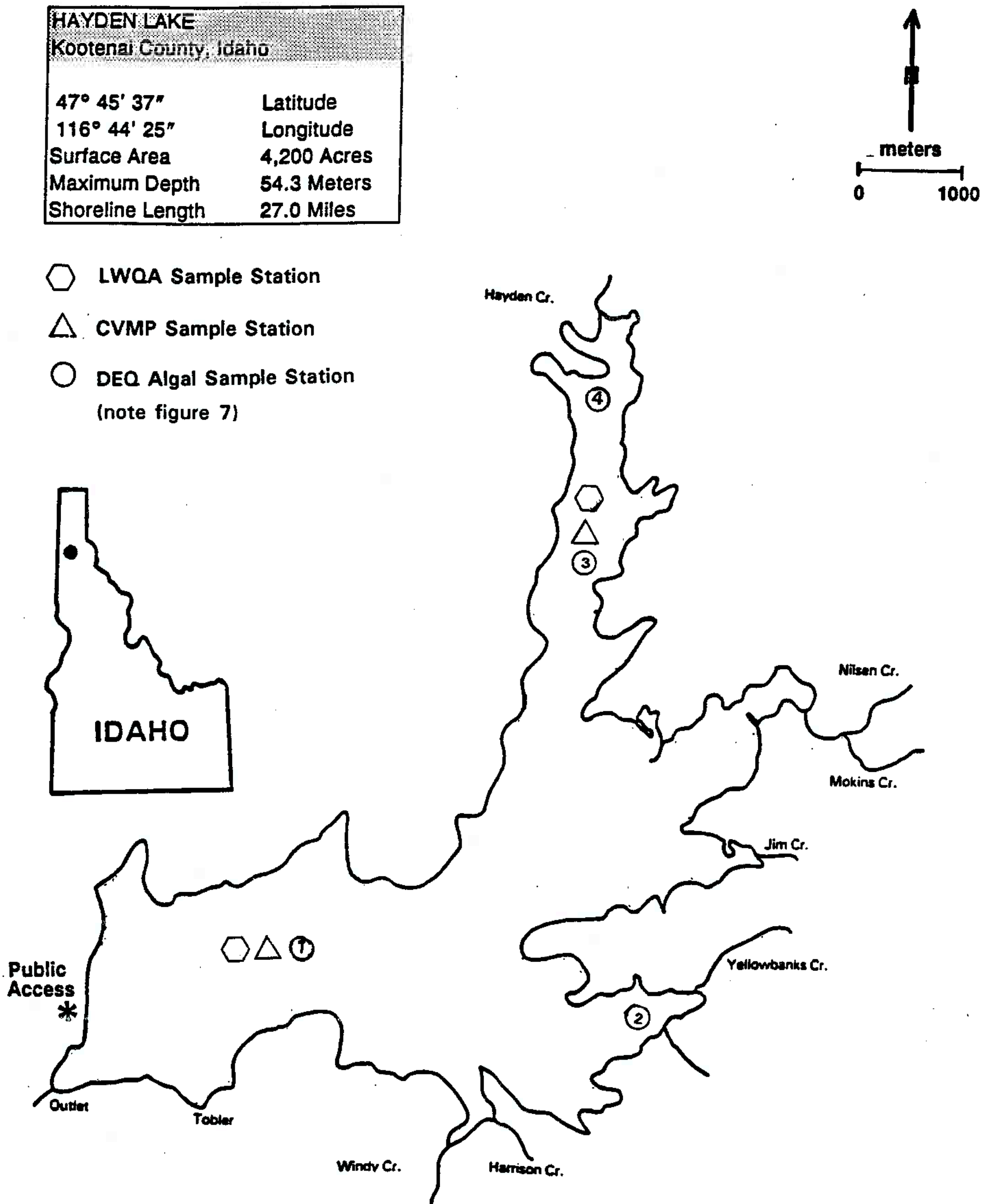


Figure 16. Map of Hayden Lake.

Plate 2. Hayden Lake photographs showing forested mountains in the watershed and high density residential development on the shoreline.

Figure 17. Dissolved oxygen and temperature profile for Hayden Lake, August 28, 1991.

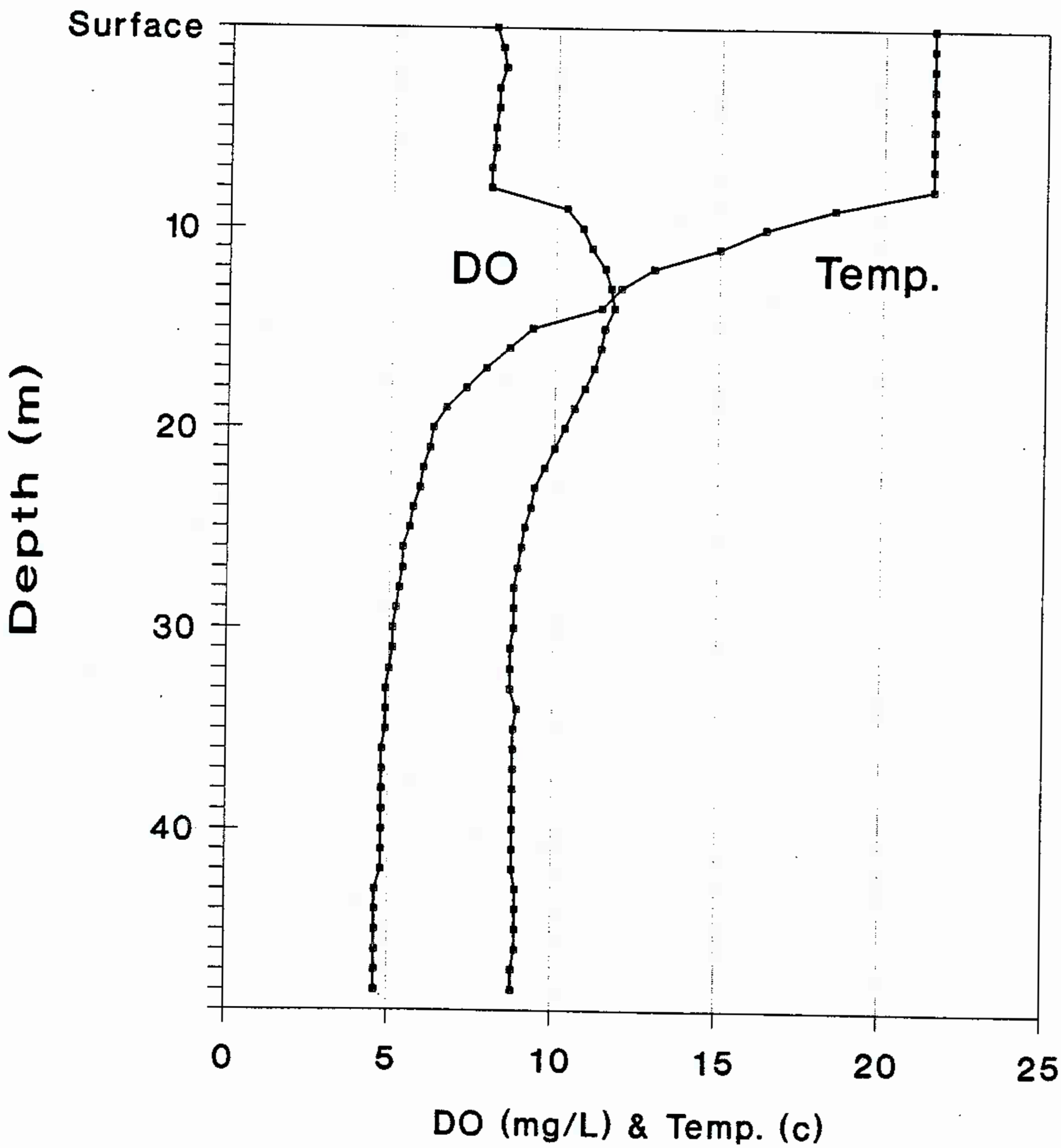


Table 17. LWQA dissolved oxygen/temperature profiles, specific conductivity and pH during summer thermal stratification for Hayden Lake (South) on August 28, 1991. *

Depth (meters)	Dissolved Oxygen	Temperature	Specific Conductance	pH
0.0	8.1	21.5	56.0	7.1
1.0	8.3	21.5	56.0	7.2
2.0	8.4	21.5	56.0	7.2
3.0	8.2	21.5	56.0	7.2
4.0	8.2	21.5	56.0	7.2
5.0	8.1	21.5	56.0	7.2
6.0	8.1	21.5	56.0	7.2
7.0	8.0	21.5	56.0	7.2
8.0	8.0	21.5	56.0	7.2
9.0	10.3	18.5	56.0	7.4
10.0	10.8	16.4	54.0	7.8
11.0	11.1	15.0	54.0	7.8
12.0	11.5	13.0	53.0	7.7
13.0	11.7	12.0	52.0	7.7
14.0	11.8	11.4	53.0	7.4
15.0	11.5	9.3	52.0	7.2
16.0	11.4	8.6	52.0	7.0
17.0	11.2	7.9	54.0	6.9
18.0	10.9	7.3	52.0	6.7
19.0	10.6	6.7	52.0	6.5
20.0	10.3	6.3	52.0	6.4
21.0	10.0	6.2	53.0	6.3
22.0	9.7	6.0	53.0	6.2
23.0	9.4	5.9	52.0	6.2
24.0	9.3	5.7	52.0	6.2
25.0	9.1	5.6	52.0	6.1
26.0	9.0	5.4	53.0	6.1
27.0	8.9	5.4	53.0	6.1
28.0	8.8	5.3	53.0	6.1
29.0	8.8	5.2	52.0	6.0
30.0	8.8	5.1	52.0	6.0
31.0	8.7	5.1	53.0	6.0
32.0	8.7	5.0	52.0	6.0
33.0	8.7	4.9	52.0	6.0
34.0	8.9	4.9	52.0	6.0
35.0	8.8	4.9	53.0	6.0
36.0	8.8	4.8	53.0	6.0
37.0	8.8	4.8	53.0	6.0
38.0	8.8	4.8	53.0	6.0
39.0	8.8	4.8	53.0	6.0
40.0	8.8	4.8	53.0	6.0
41.0	8.8	4.8	53.0	6.0
42.0	8.8	4.6	53.0	6.0
43.0	8.9	4.6	53.0	6.0
44.0	8.9	4.6	53.0	6.0
45.0	8.9	4.6	53.0	6.0
46.0	8.9	4.6	53.0	6.0
47.0	8.8	4.6	53.0	6.0
48.0	8.8	4.6	52.0	6.0

* Temperature in degrees Centigrade, conductivity in umhos/cm and dissolved oxygen in mg/L.

Table 18. 1990 Lake Water Quality Assessment (LWQA) water chemistry data for Hayden Lake (South). *

Date	8-27-90	8-27-90	8-27-90	8-27-90	8-27-90		8-27-90			
Time	1400	1400	1400	1400	1600	Meters	Temp.	pH	Cond.	D.O.
Sample Depth	51	52	8.5	9	1	1	20.9	7	64	8.5
Total Depth	---	---	---	---	---	5	20.5	7.4	64	8.4
Secchi Depth	---	---	---	---	---	10	15.7	8.5	63	12.8
T. NH3-N	0.135	0.058	0.283	0.119	0.131	15	8.1	7.4	62	11.4
T. NO2+NO3-N	0.114	0.087	<.005	<.005	<.005	20	5.8	7	62	9.3
T. Kjeldahl-N	0.14	0.12	0.33	0.18	0.17	25	5.1	6.7	62	9.1
T. Phosphorus-P	0.024	0.018	0.002	0.004	0.012	30	4.8	6.6	60	9
Ortho Phosphate-P	---	0.012	<.001	---	0.002	35	4.6	6.3	60	9.3
Dissl.Phosphate-P	0.005	---	---	<.001	---	40	4.6	6.5	60	9.4
Hardness-CaCO3	24	---	---	28	---	45	4.4	6.2	61	9.1
T.Alkalinity-CaCO3	27	---	---	25	---	50	4.4	6.4	61	7.6
Chlorophyll a (ug/L)	---	---	1	1.6	3.7	53	4.4	6	62	2.4

* Depth in meters, water chemistry data in mg/L, temperature in degrees Centigrade, conductivity in umhos/cm.

Table 19. 1990 Citizen Volunteer Monitoring Program (CVMP) water quality data for Hayden Lake, Idaho (southwest sample station).

Date of Sample *	CVMP 05/04/90	CVMP 06/11/90	CVMP 07/23/90	CVMP 08/27/90	DEQ*** 08/27/90	CVMP 10/15/90
Secchi sample depth (meters):	7.5	3.5	9	8.5	9	7.5
T. Ammonia	0.037	0.014	0.011	0.283	0.119	0.04
T. NO2+NO3	0.005	0.005	0.005	0.005	0.005	0.005
T.K. Nitrogen	0.178	0.19	0.21	0.33	0.18	0.18
T. Phosphorus	0.006	0.01	0.011	0.002	0.004	0.008
Ortho Phosphate	---	0.005	0.001	0.005	0.005	0.003
Temperature (degrees Centigrade)	11	14	19	8.5	15.7	15
Dissolved Oxygen	9	11	11.4	10.2	12.8	---
Chlorophyll a (ug/L)	2.1	2.6	1.1	1	1.6	1.8
Deep sample depth **:	52	54	53	52	51	52
T. Ammonia	0.087	0.022	0.027	0.058	0.135	0.267
T. NO2+NO3	0.005	0.012	0.007	0.087	0.114	0.005
T.K. Nitrogen	0.123	0.2	0.21	0.12	0.14	0.31
T. Phosphorus	0.008	0.009	0.009	0.018	0.024	0.004
Ortho Phosphate	---	0.001	0.003	0.012	0.005	0.003
Temperature	10	6	6	6	4.4	15
Dissolved Oxygen	8	9	8.5	6.8	7.6	11

* mg/L unless otherwise indicated.

** Sample taken one meter above the lake bottom.

*** Idaho Division of Environmental Quality/Quality Assurance/Quality Control

Table 20. 1991 Citizen Volunteer Monitoring Program (CVMP) water quality data for Hayden Lake, Idaho (southwest sample station).

Date of Sample *	CVMP 05/20/91	CVMP 07/02/91	CVMP*** 08/13/91	CVMP*** 08/13/91	CVMP 09/16/91	DEQ**** 9/16/91	% Spike Recovery	% "Blank" Recovery	CVMP 10/22/91
Secchi sample depth (meters):	7	8.5	9.5	9.5	9.5	9.5	---	---	6
T. Ammonia	0.026	0.016	0.025	0.026	0.051	0.037	84	111	0.033
T. NO2+NO3	0.069	0.005	0.01	0.011	0.014	0.014	88	95	0.012
T.K. Nitrogen	0.06	0.26	0.16	0.43	0.16	0.2	90	101	0.05
T. Phosphorus	0.007	0.008	0.002	0.004	0.004	0.005	105	99	0.009
Ortho Phosphate	0.002	0.002	0.003	0.002	0.002	0.002	99	97	0.003
Temperature (degrees Centigrade)	12	17	20	20	21	19	---	---	15
Dissolved Oxygen	11	10.5	9	9	7.6	8.7	---	---	---
Chlorophyll a (ug/L)	2	1.3	0.6	0.8	1	1	---	---	1.4
Deep sample depth: **	52	52	51	51	51	50	---	---	52
T. Ammonia	0.207	0.052	0.037	0.023	0.039	0.044	99	---	0.034
T. NO2+NO3	0.041	0.089	0.1	0.094	0.125	0.128	69	---	0.076
T.K. Nitrogen	0.24	0.16	0.15	0.16	0.11	0.16	99	---	0.05
T. Phosphorus	0.008	0.014	0.011	0.011	0.014	0.012	100	---	0.038
Ortho Phosphate	0.002	0.007	0.01	0.006	0.011	0.01	97	---	0.007
Temperature	4	7	7	7	6.5	9.1	---	---	5
Dissolved Oxygen	10	9	9	9	6	4.7	---	---	9

* mg/L unless otherwise indicated.

** Sample taken one meter above the lake bottom.

*** CVMP duplicate samples.

**** Idaho Division of Environmental Quality/Quality Assurance/Quality Control

SPIRIT LAKE:

General

Spirit Lake is located in Kootenai County, Idaho, and has 1,280 acres of surface water, 13 miles of shoreline and a maximum water depth of 95 feet (29 meters) (Figure 18). The watershed is mountainous and forested and some of the Lake has rocky outcrops (Plate 3). The size, spectacular mountains, forested watershed and excellent water quality make Spirit Lake extremely picturesque.

Over 30 years ago, Spirit Lake was very clear with low nutrients, limited plant growth and substantial dissolved oxygen throughout the water column. The oligotrophic status of Spirit Lake in these earlier times, has begun to give way to an aging process called eutrophication, whereby the lake gradually increases in phosphorus and other nutrients and aquatic plant growth. Further changes in trophic status includes a significant loss in water clarity and a reduction of dissolved oxygen in the deeper, cooler hypolimnion.

LWQA water sampling occurred once at one station in 1990. LWQA dissolved oxygen and temperature profiles, secchi depth and chlorophyll "a" and submergent macrophyte distribution were determined once in 1991. The citizen monitors (CVMP) sampled the lake four times at one station in 1990 and five times at one station in 1991. LWQA and CVMP water samples were taken at secchi depth and one meter off the lake bottom.

Beneficial Uses

Idaho Water Quality Standards protect Spirit Lake for the following beneficial uses: domestic water supply, agricultural water supply, cold water biota, salmonid spawning, primary contact recreation, secondary contact recreation and as a designated special resource water (Table 6). Spirit Lake also supports significant populations of warm water biota. All beneficial uses of Spirit Lake are fully <u>supported</u> at the present time. Domestic water supply is <u>threatened.</u>

Kokanee and trout fishing are excellent in Spirit Lake. Fishing, boating, water skiing and ski-doing, swimming, sightseeing and sunbathing are major recreational uses of the Lake. The aesthetic and visual qualities of Spirit Lake are outstanding and some of the finest to be found in Idaho. Extensive residential homes and some commercial resort developments can be found throughout most of the shoreline. A public access and swimming beach are located at the northeast end of the Lake.

Sources of Pollution, Nutrients and Recommended Management Actions

Spirit Lake has residential home development on most of its shoreline. Consequently, the control of septic seepage from drainfields is an important management consideration in controlling

phosphorus input to the Lake. Other sources of pollution include: runoff from roads, tributary streams and timber management.

Limnological Characteristics of Spirit Lake:

Secchi Depth: 1991 LWQA range = 5.2-5.5 meters, average = 5.4 meters; 1990 LWQA range = 3.2-3.2 meters, average = 3.2 meters; 1991 CVMP range = 2.5-6.0 meters, average = 4.2 meters; 1990 CVMP range = 3.2-6.0 meters, average = 3.4 meters.

On July 30, 1991, Spirit Lake appeared very clear with no apparent algal bloom.

Chlorophyll "a": 1991 LWQA range = 1.28-2.08 ug/L, average =1.68 ug/L; 1991 CVMP range = 0.5-4.2 ug/L, average = 2.27 ug/L. 1990 CVMP range = 2.2-6.6 ug/L, average = 3.87 ug/L.

Chlorophyll "a" production was extremely low in Spirit Lake on July 30, 1991. These extremely low levels indicated that Spirit Lake was oligotrophic.

Total Phosphorus: 1990 LWQA range = 0.01-0.13 mg/L, average = .06 mg/L; 1991 CVMP range = 0.004-0.16 mg/L, average = 0.04 mg/L; 1990 CVMP range = 0.006-0.133 mg/L, average = 0.034 mg/L.

Total phosphorus levels were approximately ten times higher in hypolimnetic waters (one meter off the lake bottom), than phosphorus levels at the surface. There were strong odors in the lake bottom muds (23 meters), indicating anaerobic bacterial decomposition was occuring. Phosphorus data from Spirit Lake has been somewhat variable over a period of years. Further evaluation and documentation of total phosphorus levels throughout the vertical lake basin is needed. Phosphorus is one of the major limiting-nutrients for phytoplankton and submergent macrophyte growth in Spirit Lake.

Dissolved Oxygen/Temperature Profiles

There appeared to be a significant improvement in dissolved oxygen in 1991 at the deeper depths of Spirit Lake, compared to dissolved oxygen in 1990 at the same depth (Tables 21-24, Figure 19). Some of these changes may have been due to high snowpack runoff in the spring of 1991, which elevated the water level, and most likely, resulted in the improvement in dissolved oxygen in the deep hypolimnion.

Dissolved oxygen ranged from 10.9 mg/L to 4.0 mg/L. Highest levels of dissolved oxygen were found in the thermocline from 6 to 11 meters depths. Dissolved oxygen increased in the upper thermocline relative to the epilimnion, and decreased slightly in the hypolimnion. Water temperature ranged from 22.7 °C to 7.3 °C in the hypolimnion, indicating the lake was thermally strafified in July.

Submergent Macrophytes

The submergent plant communities of Spirit Lake are composed of a variety of submergent aquatic macrophytes. These submergent aquatic plants are dependent on water quality and water depth, as well as the type of lake bottom in which they are rooted (sand, rocks, organic soils, detritus, etc.). No submergent macrophytes were found in water deeper than 4.5 meters in Spirit Lake. Light is critical for submergent plant growth and becomes a limiting factor to submergent plant growth at this water depth.

The submergent aquatic macrophyte communities of Spirit Lake are less dense and less productive than those communities found in more eutrophic lakes. Clean-water associated submergent macrophytes were abundantly distributed throughout the submergent plant communities. The density of aquatic plants was not excessive, indicative that submergent macrophyte production was relatively balanced. Some of the clean-water associated species included: wild celery, spike rush, fineleaf pondweed, quillwort, muskgrass and white water lily. These clean-water species are often associated with less fertile water, less organic lake bottoms (sand, rock) and lakes of high water clarity.

Species associated with more mesotrophic lakes were also found in some of the more fertile, shallow bays of Spirit Lake. Species such as coontail, waterweed and robbins pondweed were found in organic shallow bottoms and grew to a maximum depth of 4.5 meters. Only the northwestern end of the Lake (where the lake bottom consisted of deep organic matter) were submergent plant communities dominated by waterweed, coontail, muskgrass and water shield.

As with many lakes, the general water quality conditions of Spirit Lake were reflected in the species composition and the relative abundance of submergent aquatic plants. The species diversity of submergent plants and the kinds of species present, indicated that the trophic status of Spirit Lake was oligotrophic-mesotrophic.

Both the variety and the dominant species of submergent macrophytes indicate that water quality is good. The great variety of submerged aquatic plants found in Spirit Lake provides the complex cover, feeding and reproductive habitats that fish and other aquatic organisms require to survive.

The following 11 aquatic macrophyte species were found in Spirit Lake: Chara (muskgrass), Elodea, (waterweed), Eleocharis (needle rush), Potamogeton robbinsii (robbins pondweed), Potamogeton filiformis (fineleaf pondweed), Isoetes (quillwort), Nymphaea (white water lily), Fontanalis (aquatic moss), Ceratophyllum demersum (coontail), Vallisneria americana (wild celery) and Brasenia (water shield).

Coontail was 100 per cent dominant in organic soils at two to four meters water depth. In sandy, rocky beach areas of less than one meter, needlerush, wild celery and quillwort were dominant. Wild celery is especially abundant and dominant in the shallow, sandy bottom areas. White water lily and water shield are the dominant floating-leaf species. No yellow water lily was found. Aquatic moss was prevalent in a few scattered littoral areas of the Lake.

Visual inspection and a modified rake and Eckman dredge sampler were used to sample these submergent plant communities. The use of SCUBA and a more refined and intensive submergent plant community study effort, would provide a more reliable data base with which to draw conclusions regarding the trophic nature and water quality of Spirit Lake.

LWQA and CVMP Water Quality Data

LWQA and CVMP water chemistry data indicated that Spirit Lake is oligotrophic (Tables 21-24, Figure 19). Low levels of ammonia, nitrate and nitrite, and total kjehldahl nitrogen, total phosphorus and ortho-phosphate, chlorophyll "a" and specific conductivity indicated the Lake is in excellent condition. More specific discussion of some of these and other parameters can be found under parameter subtitles in this report.

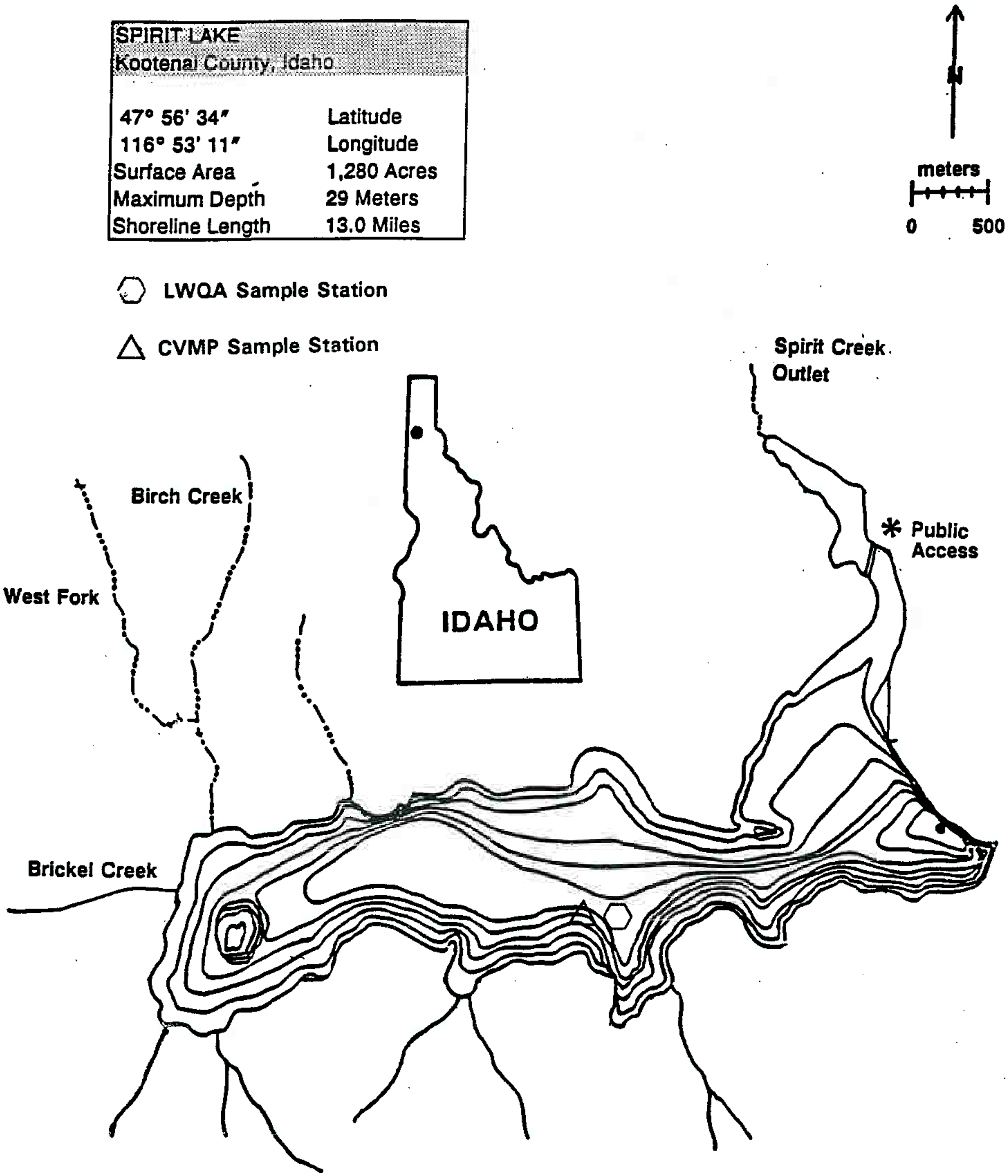


Figure 18. Map of Spirit Lake.

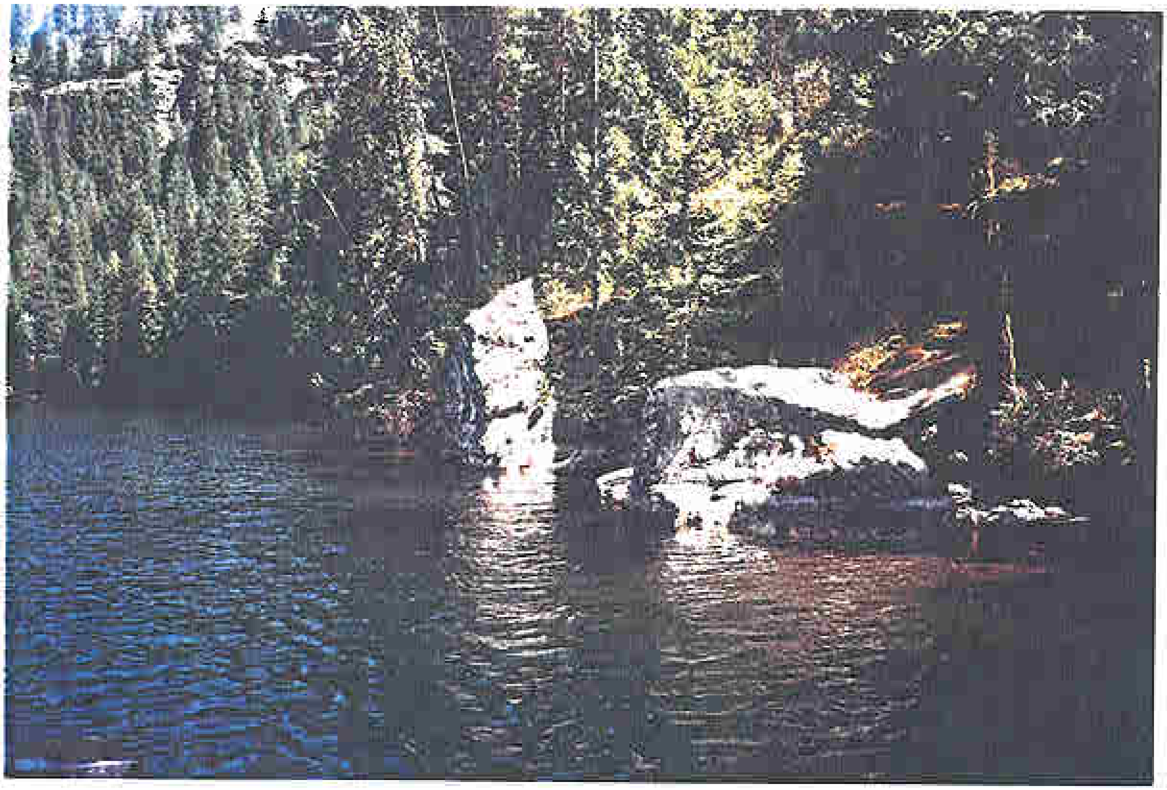


Plate 3. Spirit Lake Photographs showing forested Coeur d'Alene mountains in the watershed and rock shields and forested shoreline.

Figure 19. Dissolved oxygen and temperature profile for Spirit Lake, July 30, 1991.

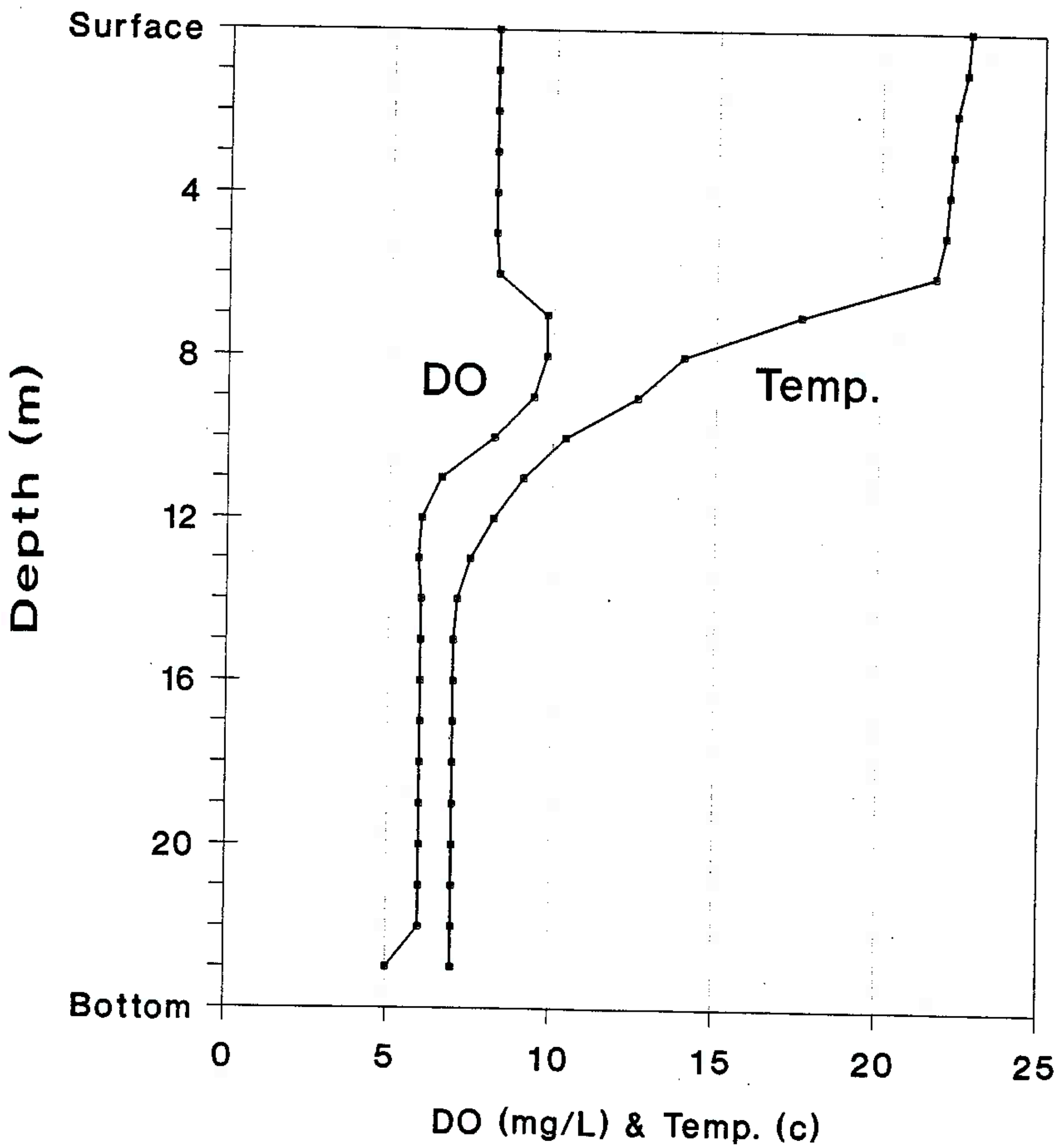


Table 21. LWQA dissolved oxygen/temperature profiles during summer thermal stratification for Spirit Lake on July 30, 1991.

Depth (meters)	Dissolved Oxygen (mg/L)	Temperature (°C)
0.0	8.2	22.7
1.0	8.2	22.6
2.0	8.2	22.3
3.0	8.2	22.2
4.0	8.2	22.1
5.0	8.2	22.0
6.0	8.3	21.7
7.0	9.8	17.6
8.0	9.8	14.0
9.0	9.4	12.6
10.0	8.2	10.4
11.0	6.6	9.1
12.0	6.0	8.2
13.0	5.9	7.5
14.0	6.0	7.1
15.0	6.0	7.0
16.0	6.0	7.0
17.0	6.0	7.0
18.0	6.0	7.0
19.0	6.0	7.0
20.0	6.0	7.0
21.0	6.0	7.0
22.0	6.0	7.0
23.0	5.0	7.0

Table 22. 1990 Lake Water Quality Assessment (LWQA) water chemistry data for Spirit Lake. *

Date	8-26-90	8-26-90	8-27-90	8-27-90
Time	--	--	1200	1200
Sample Depth	24.5	4.4	22	4.5
Total Depth	--	--	5.3	5.3
Secchi Depth	--	--	3.2	3.2
T. NH3-N	0.133	0.122	0.077	0.058
T. NO2+NO3-N	0.108	<.005	0.101	<.005
T. Kjeldahl-N	0.25	0.14	0.17	0.22
T. Phosphorus-P	0.133	0.01	0.1	0.012
Ortho Phosphate-P	0.095	<.001	--	--
Dissl.Phosphate-P	--	--	0.007	<.001
Hardness-CaCO3	--	--	12	8
T.Alkalinity-CaCO3	--	--	7	8

	8-27-90			
Meters	Temp.	pH	Cond.	D.O.
1	19.8	6.5	26	8.9
3	19.6	7.1	26	8.8
6	19.5	7.2	25	8.7
9	10.8	6.6	25	7.7
12	8.1	6.3	25	5.7
15	6.7	5.8	26	3.8
18	6.2	5.5	26	2.1
21	6	5.2	27	1.2
22	6	5.2	26	0.9

* Temperature in degrees Centigrade, conductivity in umhos/cm and water chemistry data in mg/L.

Table 23. 1990 Citizen Volunteer Monitoring Program (CVMP) water quality data for Spirit Lake.

	CVMP***	CVMP***	CVMP	CVMP	CVMP	DEQ****
Date of Sample *	04/30/90	04/30/90	06/12/90	07/23/90	08/27/90	08/27/90
Secchi sample depth (meters):	3.2	3.2	3.7	6	4.4	4.5
T. Ammonia	0.015	0.018	0.025	0.01	0.122	0.058
T. NO2+NO3	0.001	0.001	0.001	0.001	0.001	0.001
T.K. Nitrogen	0.13	0.09	0.2	0.18	0.14	0.22
T. Phosphorus	0.012	0.017	0.014	0.012	0.01	0.012
Ortho Phosphate	0.001	0.001	0.001	0.001	0.001	0.001
Temperature (degrees Centigrade)	8.3	---	---	---	18	19.5
Dissolved Oxygen	10	---	---	---	8.6	8.7
Chlorophyll a (ug/L)	6.6	6.6	2.4	2.7	2.2	2.7
Deep sample depth: **	25	25	21	24	24.5	22
T. Ammonia	0.017	0.001	0.001	0.087	0.133	0.077
T. NO2+NO3	0.001	0.001	0.001	0.008	0.108	0.101
T.K. Nitrogen	0.025	0.44	0.22	0.22	0.25	0.17
T. Phosphorus	0.006	0.009	0.022	0.059	0.133	0.1
Ortho Phosphate	0.001	0.001	0.008	0.041	0.095	0.007
Temperature	4	---	---	---	4.8	6
Dissolved Oxygen	8.4	---	---	---	0.2	0.9

* mg/L unless otherwise indicated.
** Sample taken one meter above the lake bottom.
*** CVMP duplicate samples.
**** Idaho Division of Environmental Quality/Quality Assurance/Quality Control.

Table 24. 1991 Citizen Volunteer Monitoring Program (CVMP) water quality data for Spirit Lake.

Date of Sample *	CVMP 05/21/91	DEQ*** 05/21/91	CVMP 07/01/91	CVMP 08/12/91	CVMP 09/17/91	CVMP 10/21/91
Secchi sample depth (meters):	2.5	2.5	5	6	4.8	4.5
T. Ammonia	0.059	0.327	0.016	0.041	0.021	0.03
T. NO2+NO3	0.021	0.023	0.005	0.066	0.01	0.008
T.K. Nitrogen	0.23	0.42	0.26	0.28	0.27	0.05
T. Phosphorus	0.012	0.016	0.012	0.004	0.009	0.015
Ortho Phosphate	0.002	0.002	0.002	0.002	0.002	0.004
Temperature (degrees Centigrade)	11	11	15	19	15.1	9
Dissolved Oxygen	11.2	11.2	9.8	8.4	10.3	10.5
Chlorophyll a (ug/L)	4.2	4.2	0.5	0.5	2	2.2
Deep sample depth: **	27	27	24	24	24	27
T. Ammonia	0.104	0.046	0.047	0.076	0.147	0.075
T. NO2+NO3	0.026	0.022	0.005	0.035	0.029	0.012
T.K. Nitrogen	0.11	0.28	0.21	0.26	0.39	0.05
T. Phosphorus	0.015	0.015	0.035	0.092	0.16	0.089
Ortho Phosphate	0.003	0.005	0.02	0.068	0.14	0.069
Temperature	3	3	6	3.8	3.5	5
Dissolved Oxygen	8.6	8.2	5.2	0.7	0.2	1.2

* mg/L unless otherwise indicated.

** Sample taken one meter above the lake bottom.

*** Idaho Division of Environmental Quality/Quality Assurance/Quality Control.

UPPER PRIEST LAKE:

General

Upper Priest Lake is located in Bonner County, Idaho, and has 1,352 acres of surface water, 7.5 miles of shoreline and a maximum water depth of 98 feet (30 meters) (Figure 20). The watershed is mountainous and forested, with steep rocky cliffs and numerous sandy beaches used for camping. No residential development has been allowed on Upper Priest Lake (Plate 4). The size, the spectacular mountains, the forested watershed, and the undeveloped pristine nature of the Lake make Upper Priest one of the most picturesque freshwater lakes in the Pacific Northwest.

The shoreline is heavily wooded and stabilized with rock outcrops and sandy shoals. No periphyton was found on rocks or sunken branches. Only occassional traces of marl and detritus were found in protected sandy, shallow depressions on the lake bottom.

In order to maintain the exceptional beauty, water quality and biological balance of Upper Priest Lake, a management plan must be developed for the Lake and its watershed.

LWQA water sampling occurred four times at one station in 1990. LWQA dissolved oxygen and temperature profiles, secchi depth and chlorophyll "a" and submergent macrophyte distribution were determined once in 1991. No citizen volunteer monitoring program (CVMP) sampling exists for Upper Priest Lake. LWQA water samples were taken at secchi depth and one meter off the lake bottom.

Beneficial Uses

Idaho Water Quality Standards protect Upper Priest Lake for the following beneficial uses: domestic water supply, agricultural water supply, cold water biota, salmonid spawning, primary contact recreation, secondary contact recreation and as a designated special resource water. All beneficial uses of Upper Priest Lake are fully <u>supported</u> at the present time. An existing beneficial use not currently designated for Upper Priest Lake is warm water biota.

There are a number of boat accesses and a connecting thoroughfare from Upper Priest Lake to Priest Lake. Both the Idaho State Parks and the Panhandle National Forest manage camping, boat access and outdoor recreational facilities adjacent to Upper Priest. Campsites with beautiful sandy beaches are surrounded by forests. Camping, canoeing, fishing, hiking, boating, swimming, sightseeing and sunbathing are major recreational uses of Upper Priest Lake. The aesthetic and visual qualities of the Upper Priest Lake Scenic Area are outstanding and offer some of the finest outdoor recreational opportunities to be found anywhere in the world.

There are no residential or commercial developments in the Upper Priest Lake Scenic Area. No paved highways run along Upper Priest Lake.

Sources of Pollution, Nutrients and Recommended Management Actions

Upper Priest Lake is a designated scenic area which is protected from lakeshore development. The control of sediment runoff from timber harvesting and unpaved roads in the watershed should be a primary concern in maintaining the pristine water quality of Upper Priest Lake. Also, the proper disposal of waste from outdoor recreationists visiting the area should be a primary concern.

Limnological Characteristics of Upper Priest Lake:

Secchi Depth: 1991 LWQA range = 5.0 meters, average = 5.0 meters; 1990 LWQA range = 4.5-12.6 meters, average = 7.4 meters.

Upper Priest Lake has good water clarity. However, the water transparency was less than that of Priest Lake. The Lake did not have any noticeable algal blooms.

Chlorophyll "a": 1991 LWQA range = 2.6-2.7 ug/L, average = 2.65 ug/L;

Upper Priest Lake has one of the lowest phytoplankton productivities of any lake in Idaho and has very low nutrient concentrations.

Total Phosphorus: 1990 LWQA range = .004-.006 mg/L, average = .005 mg/L;

Phosphorus is found at extremely low levels throughout Upper Priest Lake and therefore is a major limiting-nutrient.

Dissolved Oxygen/Temperature Profiles

Upper Priest Lake showed high dissolved oxygen throughout the epilimnion, thermocline and hypolimnion (top to bottom) during summer thermal stratification. Upper Priest Lake had approximately the same amount of dissolved oxygen (8.8 mg/L) at the lake bottom at 26 meters as at the surface in 1991. The increased solubility of dissolved oxygen at lower water temperatures was remarkedly portrayed in the dissolved oxygen/temperature profiles for Upper Priest Lake. The dissolved oxygen increased slightly at lower water temperatures, indicating nutrients and bacterial decomposition was not depleting the dissolved oxygen reserves (Tables 25 & 27, Figure 21).

Submergent Macrophytes

Upper Priest Lake had 17 different species of submergent macrophytes, many of which are associated with oligotrophic or clean water lakes. This diversity of submergent plants and the relative abundance of oligotrophic-associated species was indicative of the diverse habitats that were available for aquatic plant community development in Upper Priest Lake and high water quality. The great variety of submergent aquatic plants found in Upper Priest Lake provided the complex cover, feeding and reproductive habitats that fish and other aquatic organisms require to survive.

Despite the clear water, most of the sandy shoals and dropoffs have few or no submergent plants. Only the western bay, with its organic detritus and sandy mixed substrate, has extensive submergent macrophyte growth. Clean-water associated submergent species were found in every macrophyte community, further demonstrating the exceptional water quality of Upper Priest Lake.

The following 19 aquatic macrophyte species were found in Upper Priest Lake: Nitella, (muskgrass), Elodea, (waterweed), Rannunculus (water buttercup), Eleocharis (needle rush), Potamogeton gramineus (variable pondweed), Potamogeton praelongus (whitestem pondweed), Potamogeton Richardsonii (claspingleaf pondweed, Potamogeton amplifolius (largeleaf pondweed), Potamogeton robbinsii (robbins pondweed), Potamogeton pectinatus (sago pondweed), Equisetum (horsetail), Potamogeton natans (floating brownleaf pondweed), Potamogeton filiformis (fineleaf pondweed), Zannichellia palustris (horned pondweed), Potamogeton zosteriformis (flatstem pondweed), Isoetes (quillwort), Nuphar (yellow water lily), Fontanalis (aquatic moss) and Myriophyllum exalbescens (water milfoil). Zannichellia palustris is very prominent in the west bay of the Lake. High densities of this species is uncommon in North Idaho lakes and the abundance of horned pondweed is often associated with clean lakes.

Nitella, P. gramineus and Zanichellia are significant and dominant in shallow water (one meter) with sandy bottoms along the shoreline. Potamogeton Robbinsii was dominant in water depths of 2 to 5 meters. P. zosteriformis, Elodea, P.prelongus, P. Richarsonii and P. amplifolius were also part of the submergent plant communities at these depths. Sparse, monotypic stands of Nitella represented the only submergent species found at 6 meters. No macrophytes occurred deeper than 6 meters.

The thoroughfare channel between Priest and Upper Priest Lakes is a slow-moving current with a sandy bottom and few submergents. Rannunculus, P. gramineus, Isoetes and P. Richardsonii are the most common submergent macrophytes found here.

Visual inspection and a modified rake and Eckman dredge sampler were used to sample these submergent plant communities. The use of SCUBA and a more refined intensive study effort, would provide a more reliable data base with which to draw conclusions regarding the trophic nature and water quality of Upper Priest Lake.

LWQA and CVMP Water Quality Data

LWQA and CVMP water chemistry data indicate that Upper Priest Lake is oligotrophic (Tables 25-27, Figure 21). Low levels of ammonia, nitrate and nitrite, and total kjehldahl nitrogen, total phosphorus and ortho-phosphate, chlorophyll "a" and specific conductivity indicate the Lake is in excellent condition. More specific discussion of some of these and other parameters can be found under parameter subtitles in this report.

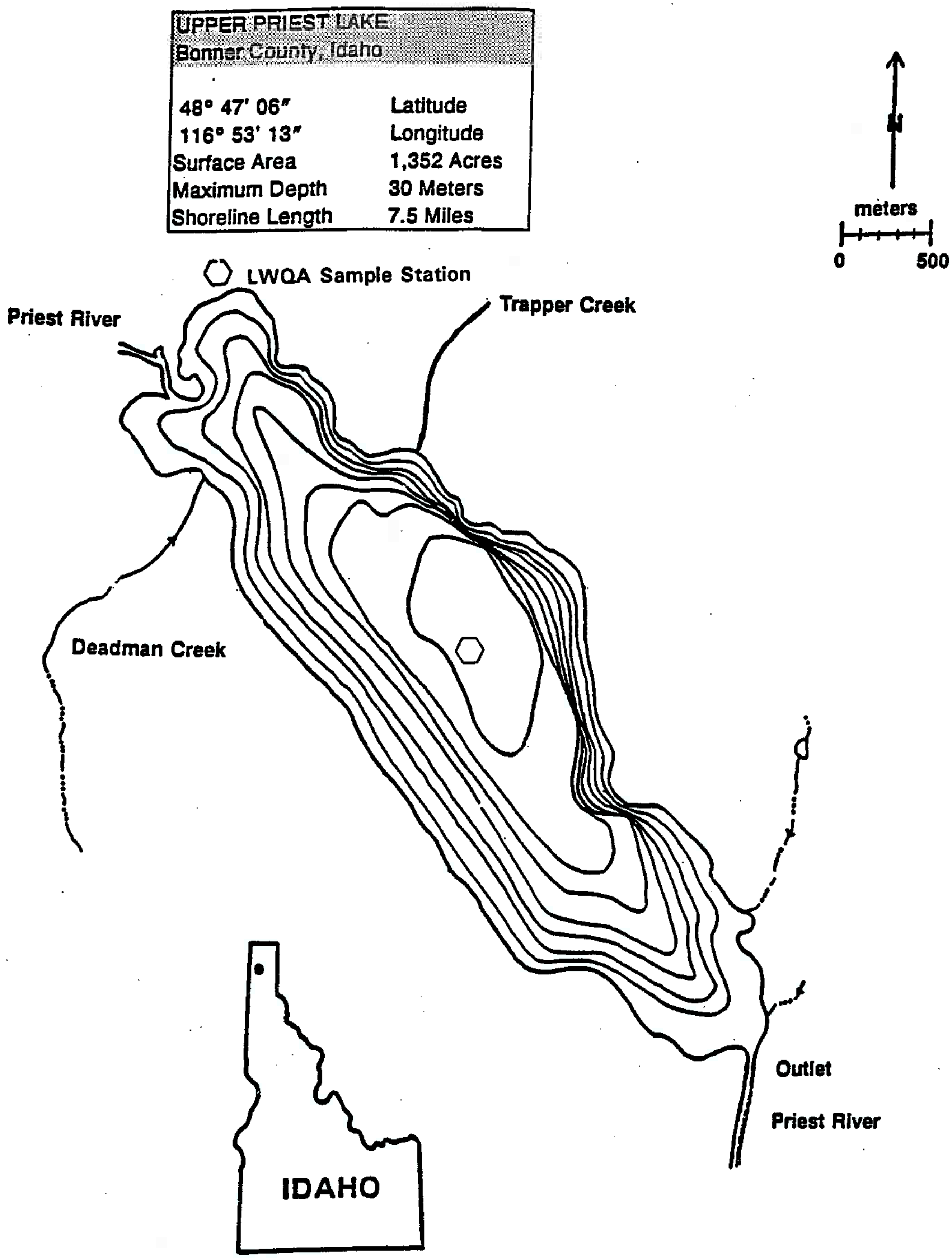


Figure 20. Map of Upper Priest Lake.

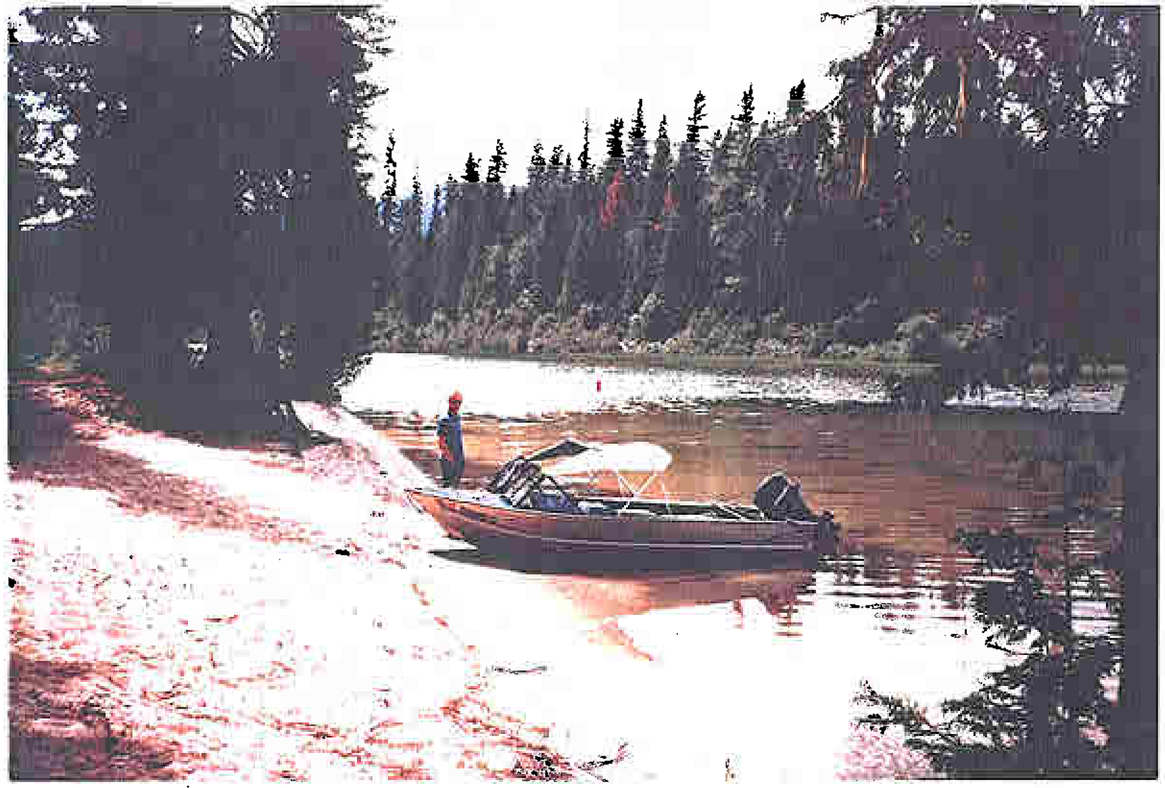


Plate 4. Upper Priest Lake photographs showing steep rocky, forested cliffs and sandy beach at outlet of Lake.

Figure 21. Dissolved oxygen and temperature profile for Upper Priest Lake, August 1, 1991.

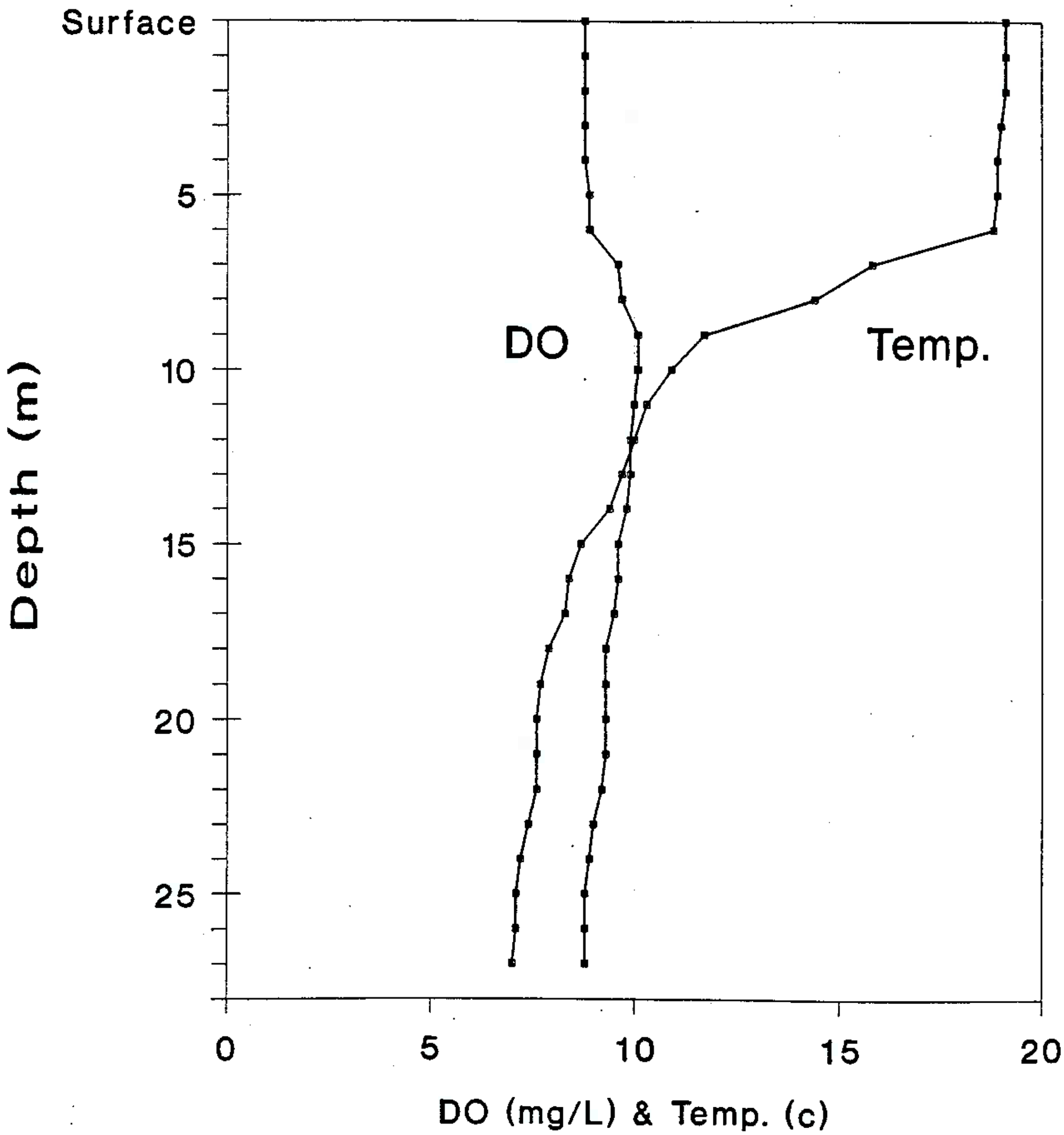


Table 25. LWQA dissolved oxygen/temperature profiles during summer thermal stratification for Upper Priest Lake on August 1, 1991.

Depth (meters)	Dissolved Oxygen (mg/L)	Temperature (°C)
0.0	8.8	19.1
1.0	8.8	19.1
2.0	8.8	19.1
3.0	8.8	19.0
4.0	8.8	18.9
5.0	8.9	18.9
6.0	8.9	18.8
7.0	9.6	15.8
8.0	9.7	14.4
9.0	10.1	11.7
10.0	10.1	10.9
11.0	10.0	10.3
12.0	9.9	10.0
13.0	9.9	9.7
14.0	9.8	9.4
15.0	9.6	8.7
16.0	9.6	8.4
17.0	9.5	8.3
18.0	9.3	7.9
19.0	9.3	7.7
20.0	9.3	7.6
21.0	9.3	7.6
22.0	9.2	7.6
23.0	9.0	7.4
24.0	8.9	7.2
25.0	8.8	7.1
26.0	8.8	7.1
27.0	8.0	7.0

Table 26. 1990 Lake Water Quality Assessment (LWQA) water chemistry for Upper Priest Lake. *

Date	6-25-90	6-25-90	8-7-90	9-18-90	10-29-90	10-29-90
Time	1135	1135	1100	1020	1040	1040
Sample Depth	30	4.5	27	12.5	27	8
Secchi Depth	4.5	4.5	8	12.6	—	—
Total Depth	31.1	31.1	30.2	30.2	—	—
T. NH3-N	0.031	0.031	0.04	0.072	0.12	0.134
T. NO2+NO3-N	0.098	0.043	0.123	0.039	0.146	0.019
T. Kjeldahl-N	0.2	0.19	0.24	0.2	0.11	0.1
T. Phosphorus-P	0.005	0.005	0.005	0.004	0.006	0.004
Dissl. Phosphate-P	0.002	0.002	<.002	0.003	<.002	<.002
Hardness-CaCO3	44	36	40	44	40	48
T.Alkalinity-CaCO3	39	37	35	38	38	46

* Depth in meters and water chemistry in mg/L.

Table 27. 1990 Lake Water Quality Assessment (LWQA) dissolved oxygen, temperature, conductivity and pH for Upper Priest Lake. *

	6-25-90				8-7-90				9-18-90				10-29-90			
Meters	Temp.	pH	Cond.	D.O.	Temp.	pH	Cond.	D.O.	Temp.	pH	Cond.	D.O.	Temp.	pH	Cond.	D.O.
1	13.2	6.9	78	10.	20.3	7.2	97	8.9	16.6	7.3	106	9	9.2	6.7	102	10.2
3	12	6.9	78	10.	20.1	7.2	97	8.9	16.5	7.3	105	9	9.1	6.9	101	10.1
6	10	6.9	78	10.	19.3	7.2	100	9.3	16.5	7.3	104	9	9.1	7	100	10
9	8.9	6.7	78	10.	12.8	7.1	86	10.8	14.8	7.1	102	9.4	9.1	7	100	10
12	7.8	6.6	77	10.	10.5	6.8	83	10.7	11.1	6.8	86	9.7	9.1	7	100	9.9
15	7.1	6.6	77	10.	8.5	6.6	80	10.1	8.8	6.5	82	9.3	7.9	6.6	90	8.3
18	6.8	6.6	78	10.	7.3	6.4	79	9.9	7.9	6.4	80	8.8	7.5	6.4	86	7.6
21	6.3	6.5	81	10.	6.8	6.3	80	9.1	7.1	6.3	80	8.7	7.1	6.3	82	7
24	6.1	6.5	82	10.	6.6	6.2	82	8.8	6.8	6.3	82	8.3	6.8	6.2	83	6.3
27	5.9	6.5	83	9.9	6.3	6.2	82	8.2	6.5	6.2	81	7.2	6.4	6.1	83	4.5
30	5.6	6.4	84	9.4	6.2	6.1	83	8	6.3	6.1	83	6.4	6.4	6.1	83	4.3

* Temperature in degrees Centigrade, conductivity in umhos/cm and dissolved oxygen in mg/L.

LOWER TWIN LAKE:

General

Lower Twin Lake is located in Kootenai County, Idaho, and has 391 acres of surface water and 7 miles of shoreline with a maximum water depth of 56 feet (17 meters) (Figure 22). The watershed is forested and mountainous, and the shoreline has extensive residential development (Plate 5).

Lower Twin Lake is mesotrophic. Lower Twin Lake has better water quality, higher water clarity and less algal blooms than its source water from Upper Twin Lake. The better water quality in Lower Twin Lake in part, is due to the greater water depth (17 meters). The Lake is thermally stratified in August. The dissolved oxygen drops rapidly in the lower thermocline and the hypolimnion, indicating that nutrient loading and bacterial decomposition may have been impacting dissolved oxygen levels. At 17 meters, the water had a strong hydrogen sulfide odor, indicating anaerobic decomposition was most likely occurring near the lake bottom.

Beneficial use impacts from sediment runoff from logging roads, from septic tank and drainage field seepage and from grazing in the west meadows area of Fish Creek should all be addressed through use of best management practices to prevent deterioration of water quality in Twin Lake.

There were strong indications that the connecting waterway between Upper and Lower Twin Lakes was contaminated by lakeshore septic tanks and drain fields. The presence of organic, floating materials in the channel, accompanied with strong rotten-egg gases rising from the channel bottom to the surface, indicated anaerobic decomposition was excessive. Noxious, large blue-green algal masses were found floating throughout the channel surface in August.

LWQA water sampling occurred once at one station in 1990. LWQA dissolved oxygen and temperature profiles, secchi depth and chlorophyll "a" and submergent macrophyte distribution were determined once in 1991. The citizen monitors (CVMP) sampled the lake three times at one station in 1990 and four times at one station in 1991. LWQA and CVMP water samples were taken at secchi depth and one meter off the lake bottom.

Beneficial Uses

The Idaho Water Quality Standards protect Lower Twin Lake for the following beneficial uses: domestic water supply, agricultural water supply, cold water biota, primary contact recreation, and secondary contact recreation (Table 6). <u>Threatened</u> beneficial uses include: domestic water supply and cold water biota. Idaho Water

Quality Standards protect Lower Twin Lake as future use for salmonid spawning.

Fishing, boating, water skiing, ski-doing, swimming, sightseeing and sunbathing are major recreational uses of Lower Twin Lake. The aesthetic and visual qualities of Lower Twin Lake are excellent. Extensive residential homes, private and religious camps and some commercial resort developments are located along the shoreline. A number of public accesses are available.

Sources of Pollution, Nutrients and Recommended Management Actions

Lower Twin Lake is highly dependent on the water quality of Upper Twin Lake and the water quality of the middle channel. The middle channel shoreline is heavily developed with residential homes that have inadequate containment of septic sewage. It is important that this sewage problem be remedied as soon as possible, since water flowing from Upper Twin Lake and the channel significantly deteriorates the water quality of Lower Twin Lake. Extensive residential homes can be found on the entire shoreline of Lower Twin Lake. Based on the large number and close proximity of homes on the shoreline, it is highly probable that numerous drainage fields are deteriorating the water quality of Lower Twin Lake. Residential homes should be certain that drain fields are set back far enough from the Lake and that absorption soils are retaining the sewage. Nutrient loading to the Lake from septic tanks and drainfields, along with siltation runoff from roads, improper logging practices and cattle grazing must be managed to protect the lake from further eutrophication.

Lower Twin Lake is in need of some remedial and near-shore nutrient contamination control measures if further eutrophication and water quality deterioration is to be prevented.

Limnological Characteristics of Lower Twin Lake:

Secchi Depth: 1991 LWQA range = 6.0-6.0 meters, average = 6.0 meters; 1990 LWQA range = 4.4-4.4 meters, average = 4.4 meters; 1991 CVMP range = 4.3-6.0 meters, average = 5.4 meters; 1990 CVMP range = 4.0-5.0 meters, average = 4.5 meters.

On August 12, 1991, Lower Twin Lake had a secchi disk of 6.0 meters and an algal bloom was apparent.

Chlorophyll "a": 1991 LWQA range = 1.8-1.8 ug/L, average = 1.8 ug/L; 1991 CVMP range = 2.0-3.2 ug/L, average = 2.5 ug/L. 1990 CVMP range = 1.4-3.7 ug/L, average = 2.2 ug/L.

Chlorophyll "a" production is indicative of late mesotrophic conditions. Lower Twin Lake is less eutrophic than Upper Twin Lake.

Total Phosphorus: 1990 LWQA range = 0.005-0.32 mg/L, average = 0.15 mg/L; 1991 CVMP range = .006-0.33 mg/L, average = .063 mg/L; 1990 CVMP range = .005-0.42 mg/L, average = .148 mg/L.

Phosphorus data were variable. In late summer, phosphorus was being released from bottom sediments into the water column.

Dissolved Oxygen/Temperature Profiles

Dissolved oxygen/temperature profiles taken in August of 1990 and 1991, demonstrated that Lower Twin Lake was thermally stratified, in contrast to eutrophic Upper Twin Lake, which was completely mixed from top to bottom. The dissolved oxygen in Lower Twin Lake showed signs of oxygen depletion at a water depth of 8 meters. The dissolved oxygen dropped from 7.6 mg/L at the surface to 0.3 mg/L at 17 meters near the lake bottom, while water temperature dropped from 23.2 to 7.3 degrees C. at the same respective depths. The dissolved oxygen declined in the thermocline and remained extremely low throughout the hypolimnion to the lake bottom (18 meters). A strong hydrogen sulfide odor at 17 meters indicated anaerobic bacterial activity and oxygen depletion is occurring in the deep hypolimnion (Tables 28-31, Figure 23).

Submergent Macrophytes

Generally, the submergent plant communities of Lower Twin Lake are dominated by a few species. Ten species make up the submergent plant communities. The distribution of dominant submergent plants found in Lower Twin Lake were highly dependent on water depth and the type of lake bottom in which they were rooted (sand, rocks, organic soils, detritus, etc.).

Clean water associated submergents do not make up a significant portion of the submergent plant communities. Instead, the submergent and floating-leaf aquatic macrophyte communities are dominated by species associated with mesotrophic/eutrophic lakes. Lower Twin Lake lacks the species diversity commonly found in cleaner, more oligotrophic lakes. Most of the aquatic plant communities are dominated by robbins pondweed and waterweed. The submergent vegetation grew at a maximum depth of seven meters, one meter deeper than the secchi depth reading.

The following ten submergent macrophyte species were found in Lower Twin Lake: Nitella, Chara (muskgrass), Elodea spp., (waterweed), Eleocharis (needle rush), Potamogeton robbinsii (robbins pondweed), Ceratophyllum demersum (coontail), Isoetes (quillwort), Potamogeton Berchtoldii (formerly, P. pulsillus, a fineleaf pondweed), Vallisneria americana (wild celery, tape grass) and Potamogeton epihydrus (leafy pondweed). Notably absent from Lower Twin Lake was Nuphar (yellow water lily) and largeleaf pondweed.

Lower Twin Lake had moderate species diversity; Robbins pondweed was dominant at 2-5 meters, Elodea was mostly dominant in shallow waters of 1-2 meters. Nitella was dominant at 6 meters in the organic lake bottom. Needle rush, tape grass and quillwort, which are all oligotrophic-associated species were found in moderate abundance on a few sandy, shallow lake areas.

The channel is almost entirely covered by yellow water lily, coontail, waterweed, Robbins pondweed and muskgrass despite the variability in bottom composition of rock, sand and organic detritus.

Visual inspection and a modified rake and Eckman dredge sampler were used to sample the submergent plant communities. The use of SCUBA and a more refined and intensive study effort, would provide a more reliable data base to draw conclusions regarding the trophic nature and water quality of Lower Twin Lake.

LWQA and CVMP Water Quality Data

LWQA and CVMP water chemistry data indicate that Lower Twin Lake is mesotrophic (Tables 28-31, Figure 23). Moderate levels of ammonia, nitrate and nitrite, and total kjehldahl nitrogen, total phosphorus and ortho-phosphate, chlorophyll "a" and specific conductivity indicate the Lake is most likely in transition and is experiencing eutrophication. More specific discussion of some of these and other parameters can be found under the appropriate subtitles in this report.

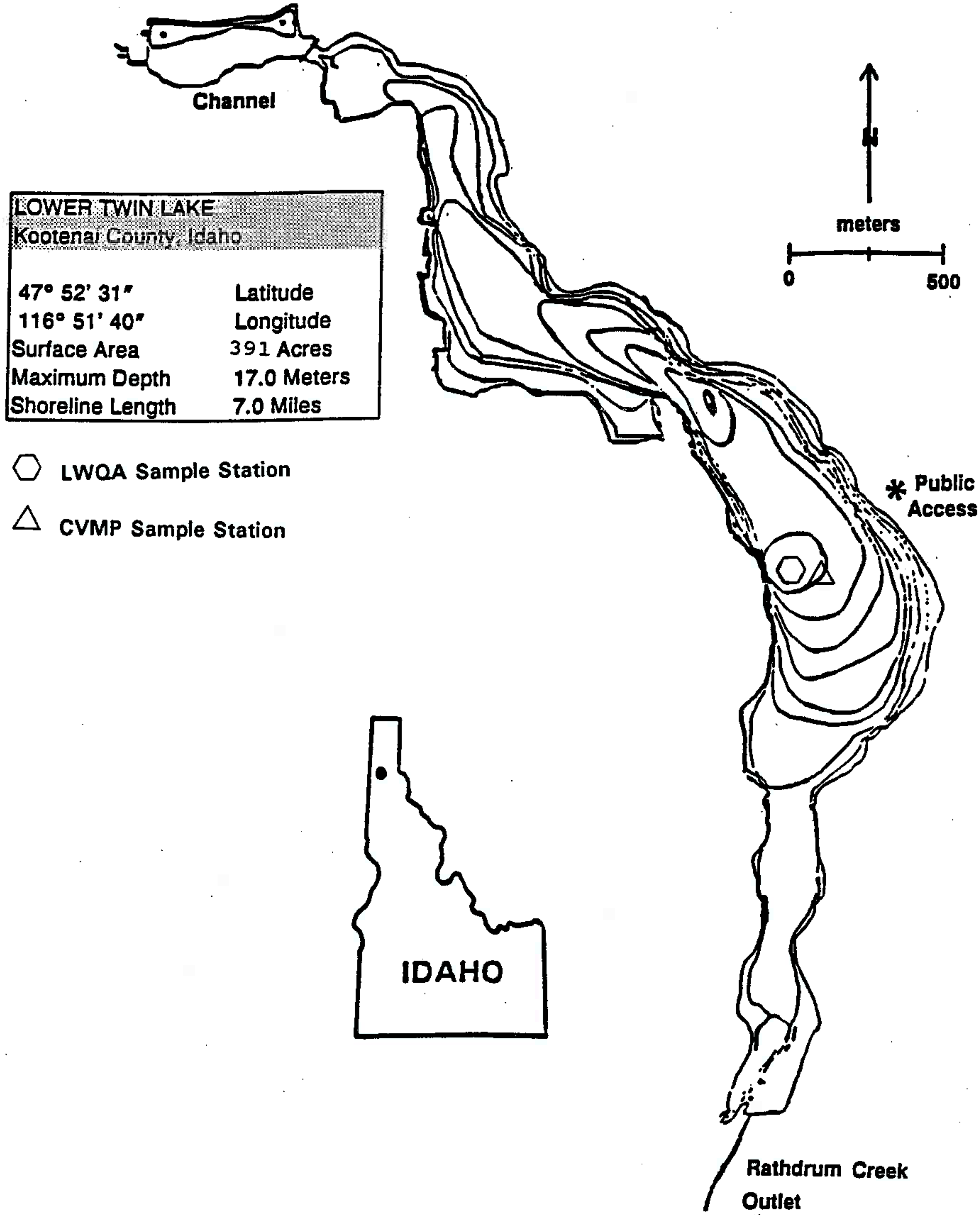


Figure 22. Map of Lower Twin Lake.

Plate 5. Lower Twin Lake photographs showing forested watershed and public access near high density of residential homes.

Figure 23. Dissolved oxygen and temperature profile for Lower Twin Lake, August 12, 1991.

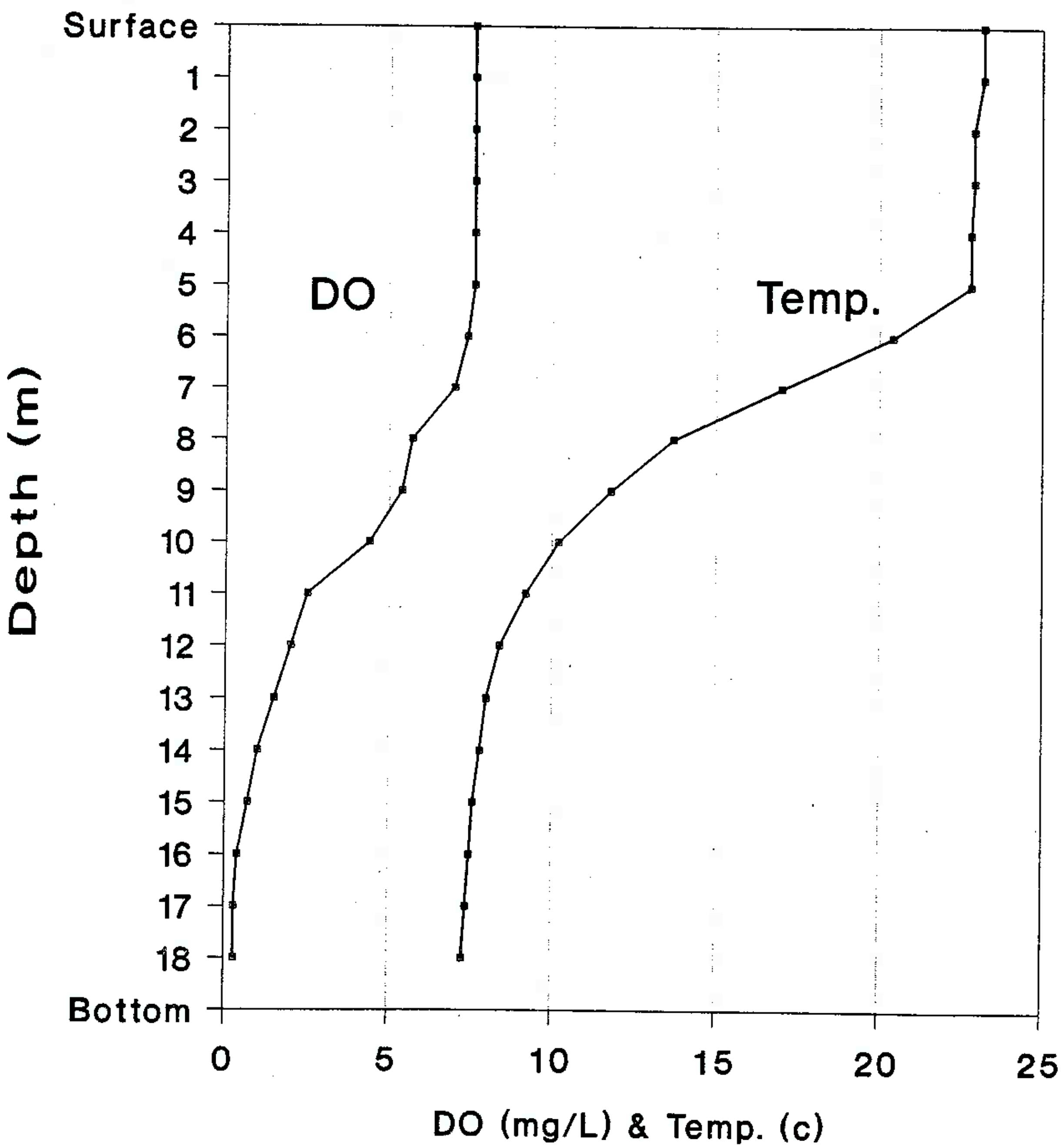


Table 28. LWQA dissolved oxygen/temperature profiles, specific conductivity and pH during summer thermal stratification for Lower Twin Lake on August 12, 1991.

Depth (meters)	Dissolved Oxygen (mg/L)	Temperature (°C)	Specific Conductance (umhos/cm)	pH
0.0	7.6	23.2	24.0	6.4
1.0	7.6	23.2	24.0	6.4
2.0	7.6	22.9	24.0	6.3
3.0	7.6	22.9	24.0	6.3
4.0	7.6	22.8	24.0	6.4
5.0	7.6	22.8	25.0	6.4
6.0	7.4	20.4	24.0	6.0
7.0	7.0	17.0	25.0	5.8
8.0	5.7	13.7	24.0	5.5
9.0	5.4	11.8	24.0	5.6
10.0	4.4	10.2	25.0	5.3
11.0	2.5	9.2	26.0	5.2
12.0	2.0	8.4	26.0	5.1
13.0	1.5	8.0	26.0	5.1
14.0	1.0	7.8	26.0	5.1
15.0	0.7	7.6	28.0	5.1
16.0	0.4	7.5	29.0	5.1
17.0	0.3	7.4	35.0	5.1
18.0	0.3	7.3	40.0	5.3

Table 29. 1990 Citizen Volunteer Monitoring Program (CVMP) water quality data for Lower Twin Lake, Idaho.

Date of Sample *	CVMP 06/12/90	CVMP*** 07/23/90	CVMP*** 07/23/90	CVMP 08/27/90	DEQ**** 08/27/90
Secchi sample depth (meters):	5	4	4	5	4.5
T. Ammonia	0.005	0.017	0.013	0.107	0.204
T. NO2+NO3	0.005	0.005	0.005	0.005	0.005
T. Kjeldahl	0.32	0.13	0.2	0.17	0.2
T. Phosphorus	0.013	0.009	0.009	0.005	0.009
Ortho Phosphate	0.001	0.001	0.001	0.001	0.001
Temperature (degrees Centigrade)	13	---	---	18	19.9
Dissolved Oxygen	9.4	---	---	7.8	8
Chlorophyll a (ug/L)	3.7	1.4	1.6	2.3	2
Deep sample depth **:	14	19	19	19	17.5
T. Ammonia	0.007	0.54	0.515	0.744	0.636
T. NO2+NO3	0.026	0.005	0.005	0.005	0.005
T. Kjeldahl	0.21	0.98	0.92	0.9	0.78
T. Phosphorus	0.014	0.4	0.42	0.32	0.283
Ortho Phosphate	0.005	0.38	0.32	0.27	0.171
Temperature	6.5	---	---	6	7.6
Dissolved Oxygen	4.8	---	---	0.1	0.2

* mg/L unless otherwise indicated.
** Sample taken one meter above the lake bottom.
*** CVMP duplicate samples
**** Idaho Division of Environmental Quality/Quality Assurance/Quality Control.

Table 30. 1990 Lake Water Quality Assessment (LWQA) and Citizen Volunteer Monitoring Program (CVMP) water chemistry data for Lower Twin Lake.

Date	*CVMP 8-27-90	*CVMP 8-27-90	LWQA 8-27-90	LWQA 8-27-90	Depth (meters)	Temp. (°C)	pH	Cond (umhos/cm)	D.O. (mg/L)
Time	1000	1000	1000	1000	1	20.1	5.9	27	8
Sample Depth	Secchi	Deep	17.5	4.5	2	20	6.1	28	8
Total Depth	18.5	18.5	18.5	18.5	3	20	6.2	28	8
Secchi Depth	4.4	4.4	4.4	4.4	4	19.9	6.2	28	8
T. NH3-N	0.107	0.744	0.636	0.204	5	19.9	6.3	27	8
T. NO2+NO3-N	<.005	<.005	<.005	<.005	6	19.9	6.3	28	7.9
T. Kjeldahl-N	0.17	0.9	0.78	0.2	7	16.6	5.8	28	5.3
T. Phosphorus-P	0.005	0.32	0.283	0.009	8	13.5	5.5	28	2.7
Ortho Phosphate-P	---	---	---	---	9	11.6	5.3	30	1
Dissl. Phosphate-P	<.001	0.27	0.171	<.001	10	10.2	5.3	30	0.4
Hardness-CaCO3	---	---	12	12	11	9.5	5.2	29	1.2
T.Alkalinity-CaCO3	---	---	14	11	12	8.8	5.2	30	0.3
					13	8.5	5.2	30	0.3
					14	8.3	5.2	28	0.4
					17	7.6	5.5	46	0.2

* Indicates Citizen Volunteer Monitoring Program (CVMP) data.

Table 31. 1991 Citizen Volunteer Monitoring Program (CVMP) water quality data for Lower Twin Lake, Idaho.

Date of Sample *	CVMP*** 05/20/91	CVMP*** 05/20/91	CVMP 07/01/91	CVMP 08/12/91	DEQ**** 08/12/91	CVMP 09/16/91
Secchi sample depth (meters):	6	6	5	6	5	4.3
T. Ammonia	0.051	0.033	0.017	0.058	0.044	0.1
T. NO2+NO3	0.036	0.026	0.005	0.008	0.012	0.013
T. Kjeldahl	0.12	0.06	0.19	0.26	0.75	0.24
T. Phosphorus	0.01	0.02	0.014	0.006	0.006	0.01
Ortho Phosphate	0.002	0.002	0.002	0.002	0.002	0.002
Temperature (degrees Centigrade)	11	11	15.8	19.7	19.7	15.7
Dissolved Oxygen	10.3	10.3	9.7	7.5	7.5	7.8
Chlorophyll a (ug/L)	2	2.9	2.1	2.2	3.2	2.6
Deep sample depth **:	19	19	19	17	17	18
T. Ammonia	0.045	0.065	0.123	0.161	0.168	0.788
T. NO2+NO3	0.028	0.031	0.005	0.009	0.011	0.005
T. Kjeldahl	0.48	0.34	0.23	0.48	0.58	1.01
T. Phosphorus	0.027	0.025	0.056	0.103	0.144	0.33
Ortho Phosphate	0.012	0.017	0.043	0.081	0.108	0.28
Temperature	5.5	5.5	---	5.4	7.4	7.4
Dissolved Oxygen	6.7	6.7	---	0.3	0.3	0.3

* mg/L unless otherwise indicated.
** Sample taken one meter above the lake bottom.
*** CVMP duplicate samples.
**** Idaho Division of Environmental Quality/Quality Assurance/Quality Control.

FERNAN LAKE:

General

Fernan Lake is located in Kootenai County, Idaho, and has 355 acres of surface water and 6.5 miles of shoreline with a maximum water depth of 23 feet (7 meters) (Figure 24). The watershed is mountainous, forested and picturesque (Plate 6).

Fernan Lake is mesotrophic to late-mesotrophic. Secchi depth readings average about 3.3 meters in this shallow lake with a maximum depth of five meters. Fernan Lake is an extremely important recreational fishing, boating and aesthetic lake in close proximity to the city of Coeur d'Alene.

LWQA water sampling occurred five times at one station in 1990. LWQA dissolved oxygen and temperature profiles, secchi depth and chlorophyll "a" and submergent macrophyte distribution were determined once in 1991. LWQA water samples were taken at secchi depth and one meter off the lake bottom. There was no citizen volunteer monitoring program (CVMP) in 1990 and 1991 for Fernan Lake.

Beneficial Uses

The designated beneficial uses for Fernan Lake are: domestic water supply, agricultural water supply, cold water biota, salmonid spawning, primary contact recreation and secondary contact recreation (Table 6). Significant populations of warm water fish and biota are found in Fernan Lake.

Data from the LWQA Study indicates all designated beneficial uses of Fernan Lake are <u>supported</u> at the present time, with the <u>exception</u> of domestic water supply. There is a high potential for further eutrophication from domestic, agricultural and forestry management activities in the watershed. Consequently, domestic water supply as a beneficial use is <u>threatened</u> in Fernan Lake.

There are two boat landings on Fernan Lake. Fishing is one of the primary recreational activities, along with boating, swimming, skiing and sunbathing. The aesthetics and visual qualities of Fernan Lake and the surrounding forested mountains are outstanding. Residential homes are located mostly in Fernan Village on the northwestern shore of Fernan Lake. The eastern and southern mountainous, forested shore have some excellent camping and picnic sites. The north shore has a narrow, winding paved road for sightseers, logging trucks, joggers and bicyclists. The road defintely has a dangerous mix of users and creates safety problems for many of the recreational users. The Fernan Creek watershed area is used as pastureland by ranchers for their horses and cattle.

Sources of Pollution, Nutrients and Recommended Management Actions

Fernan Village is located on the northwest shore of Fernan Lake and was sewered 20 years ago. Storm water runoff and riparian disturbance of Fernan Creek appear to be the major concerns of nutrient and sediment input to Fernan Lake at this time. The steep south shore is heavily forested and is part of the Coeur d'Alene National Forest. Fernan Lake is relatively shallow (4 meters) and has a strong susceptibility towards man-made eutrophication. Protection of runoff from roads and stabilization of riparian stream habitat will continue to be critical in maintaining good water quality and fishing/recreational opportunities in Fernan Lake.

Limnological Characteristics of Fernan Lake:

Secchi Depth: 1991 LWQA range = 3.3-3.3 meters, average = 3.3 meters; 1990 LWQA range = 2.2-4.5 meters, average = 3.1 meters;

Water clarity is limited due to blue-green algal blooms. Algal blooms were evident from the surface to the secchi depth.

Chlorophyll "a": 1991 LWQA range = 2.4-5.13 ug/L, average = 3.6 ug/L.

The phytoplankton production ranged from 2.4 ug/L to 5.13 ug/L at different locations throughout the lake.

Total Phosphorus: 1990 LWQA range = .013-.03 mg/L, average = 0.02 mg/L;

Total phosphorus data showed slightly higher values for deeper water than for surface water. However, these values are not different enough to speculate about the degree of internal phosphorus recycling. It appears that limited recycling of phosphorus may be occurring in Fernan Lake (maximum depth = 5.0 meters). Nutrients and sediment entering the lake from Fernan Creek are most likely deteriorating the water quality of Fernan Lake.

Dissolved Oxygen/Temperature Profiles

Fernan Lake is shallow enough to mix completely, even after the summer thermal stratification has occurred. The dissolved oxygen ranged from 8.4 mg/L at the surface, to 8.1 mg/L at four meters near the lake bottom on July 24, 1991. Fernan Lake exhibited signs of late mesotrophic conditions. The dissolved oxygen is progressively depleted at lower water depths as the summer progresses, thereby demonstrating that algal decomposition and bacterial activity are consuming oxygen in the deeper waters of the Lake. Once the lake turned over in September, the dissolved oxygen was replenished at all water depths (Tables 32-33, Figure 25).

Submergent Macrophytes

The maximum depth at which submergent macrophytes grow in Fernan Lake ranges from 3.2 meters to 4.5 meters. Seventeen species of submergent macrophytes make up the submergent macrophyte communities. The following observations of submergent macrophyte communities was evident: Bladderwort was abundant, Largeleaf pondweed was dominant in the deep water outside of the weed beds, and the variety of submergent plants associated within floating-leaf pondweed were significantly higher than the variety of submergents found among other submergent species.

The most common submergent macrophytes were robbins pondweed, muskgrass, largeleaf pondweed, white water lily, yellow water lily, aquatic moss, coontail, narrow-leaf pondweed and bushy pondweed.

The distribution of submergent macrophytes was most likely determined by a complex interaction of water quality, bottom substrate type (e.g., organic-detritus, infertile sand-rock) and light.

LWQA Water Quality Data

LWQA water chemistry data indicate that Fernan Lake is mesotrophic to late mesotrophic (Tables 32-33, Figure 25). Moderate levels of ammonia, nitrate and nitrite, and total kjehldahl nitrogen, total phosphorus and orthophosphate, chlorophyll "a" and specific conductivity indicate the Lake is most likely in transition and is experiencing eutrophication. More specific discussion of some of these and other parameters can be found under specific parameter subtitles in this report.

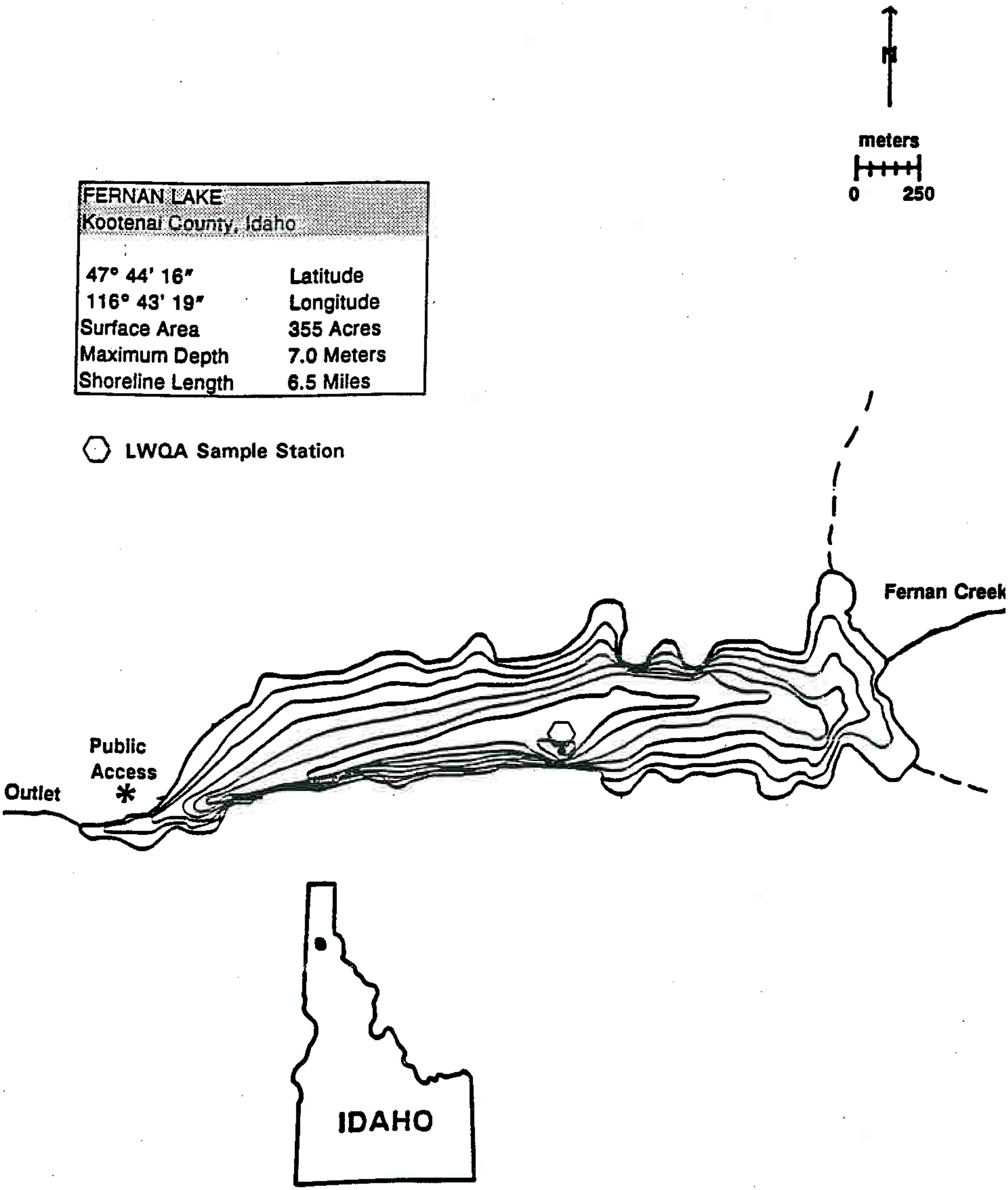


Figure 24. Map of Fernan Lake.

Plate 6. Fernan Lake photographs showing inlet (lower photo) and outlet bays of this excellent recreational fishing Lake in the city of Coeur d'Alene.

Figure 25. Dissolved oxygen and temperature profile for Fernan Lake, July 24, 1991.

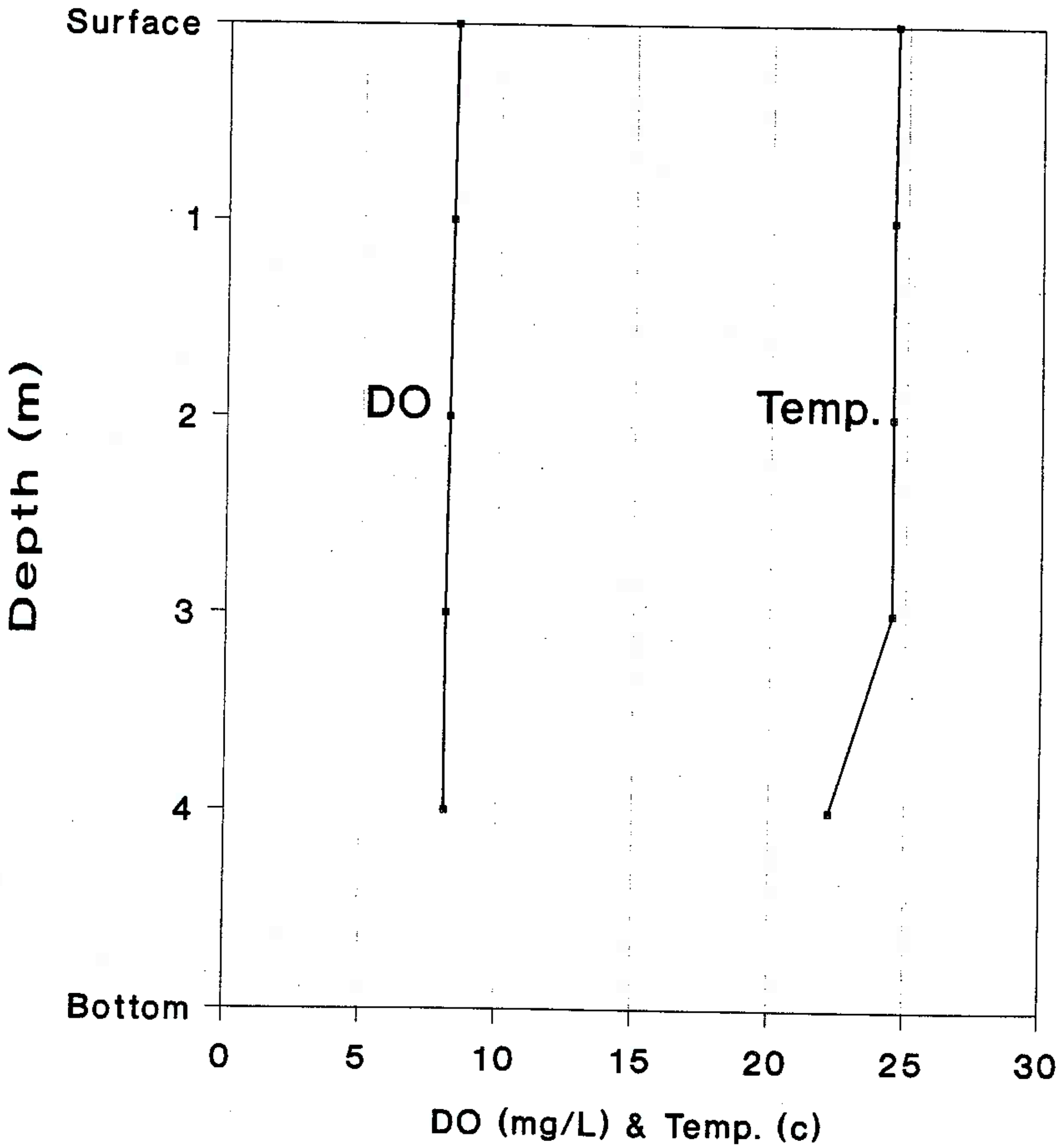


Table 32. LWQA dissolved oxygen/temperature profiles for Fernan Lake on July 24, 1991.

Depth (meters)	Dissolved Oxygen (mg/L)	Temperature (°C)
0.0	8.4	24.6
1.0	8.3	24.5
2.0	8.2	24.5
3.0	8.1	24.5
4.0	8.1	22.2

Table 33. 1990 Lake Water Quality Assessment (LWQA) water chemistry for Fernan Lake. *

Date	5-22	5-22	6-26	6-26	8-8	8-8	9-17	9-17	10-30
Time	1600	1600	1400	1400	1240	1240	6100	1600	1230
Sample Depth	6.5	4.5	7	3	6	2.5	5.5	2	4
Total Depth	7.5	7.5	8	8	7.1	7.1	6.4	6.4	--
Secchi Depth	4.5	4.5	3.25	3.25	2.6	2.6	2.2	2.2	--
T. NH3-N	0.06	0.066	0.019	0.022	0.061	0.053	0.052	0.048	0.044
T. NO2+NO3-N	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	0.021
T. Kjeldahl-N	0.37	0.39	0.36	0.24	0.6	0.6	0.49	0.5	0.37
T. Phosphorus-P	0.018	0.016	0.025	0.017	0.026	0.013	0.03	0.022	0.021
Dissl. Phosphate-P	0.003	0.003	0.002	0.002	0.002	<.002	<.001	<.001	<.002
Hardness-CaCO3	16	12	16	12	16	16	20	16	16
T.Alkalinity-CaCO3	11	11	12	12	14	11	15	15	14

Meters	Temp.	pH	Cond.	D.O.	Temp.	pH	Cond.	D.O.	Temp.	pH	Cond.	D.O.
	5-22				6-26				8-8			
1	15.5	6.3	39	9.4	22.7	6.2	42	8.3	24.2	6.3	44	8.2
2	15	6.3	40	9.2	22.6	6.3	42	8.4	24.1	6.6	44	8.2
3	14	6.3	39	9	21.5	6.3	41	8.6	23.5	6.6	44	8.2
4	13.7	6.3	39	8.7	18	6.3	41	9.2	23.4	6.7	44	8.2
5	13.4	6.2	39	7.9	15.4	6.1	41	6	23.1	6.5	44	6.3
6	13.2	6.1	39	7.5	14.8	5.7	42	4.1	22	5.9	45	5.1
7	--	--	--	--	14.6	5.6	42	3.6	20.4	5.6	53	0.8
	9-17				10-30							
1	20.3	6.5	4.7	8.5	8.7	5.8	44	9.1				
2	19.4	6.6	4.7	8.6	8.7	5.9	42	8.8				
3	19	6.5	4.7	8.4	8.7	5.9	43	8.7				
4	18.8	6.4	4.7	8.3	8.7	6	43	8.6				
5	18.8	6.3	4.7	7.9	8.7	6	42	8.6				
6	18.8	6.2	4.6	7.6	8.7	6	42	8.5				

* Temperature in degrees Centigrade, conductivity in umhos/cm, depth in meters and water chemistry data in mg/L.

KELSO LAKE:

General

Kelso Lake is located in Bonner County, Idaho, and has 54 acres of surface water and 1.9 miles of shoreline with a maximum water depth of 36 feet (11 meters) (Figure 26). The Lake has extensive weed growth and limited residential development (Plate 7).

Kelso Lake is early eutrophic with a secchi depth reading of 3.5 meters. The water frontage and watershed of Kelso Lake is heavily forested. The Lake is brown-stained, and on August 14, 1991, no algal bloom was present. The lake soils are highly organic and emit gas from the anaerobic bottom muds. Most of the lake bottom is silt and detritus.

LWQA water sampling occurred five times at one station in 1990. LWQA dissolved oxygen and temperature profiles, secchi depth and chlorophyll "a" and submergent macrophyte distribution were determined once in 1991. LWQA water samples were taken at secchi depth and one meter off the lake bottom. There was no citizen volunteer monitoring program (CVMP) in 1990 and 1991 for Kelso Lake.

Beneficial Uses

According to the Idaho Water Quality Standards, the designated beneficial uses of Kelso Lake are: domestic water supply, agricultural water supply, cold water biota, salmonid spawning, primary contact recreation and secondary contact recreation (Table 6). Threatened beneficial uses of Kelso Lake include domestic water supply and cold water biota.

A public boat access is available at the north side of the lake. However, no motorized boats are allowed on the lake. Development on Kelso lake includes residential homes and a commercial resort. Fishing, swimming, and sunbathing are all recreational opportunities. Wildlife and fisheries habitat are important.

Sources of Pollution, Nutrients and Recommended Management Actions

Kelso Lake is slightly brown-stained, since Granite Lake with the same water color, is its primary water source. Very little limnological data and background information exists for Kelso Lake. It is posted as a non-motorized boat Lake. Residential development is located on the north and southeast side of the shoreline. It is likely, that phosphorus and other nutrients may be originating from septic tanks of residential homes or resorts. Management action recommended for Kelso Lake should include the inspection of sewage drain fields from residential homes and resorts.

Limnological Characteristics of Kelso Lake:

Secchi Depth: 1991 LWQA range = 3.5-3.5 meters, average = 3.5 meters; 1990 LWQA range = 3.0-5.0 meters, average = 4.2 meters;

Water clarity in Kelso Lake was limited due to brown-stained water and organic matter.

Chlorophyll "a": 1991 LWQA range = 5.8-6.4 ug/L, average = 6.1 ug/L.

Phytoplankton production in Kelso Lake is moderate due to the brown-stained water and reduced light. The lake is early eutrophic.

Total Phosphorus: 1990 LWQA range = 0.015-0.15 mg/L, average = 0.04 mg/L.

Total phosphorus data indicated that the deep hypolimnion was higher in phosphorus than the epilimnion.

Dissolved Oxygen/Temperature Profiles

On August 14, 1991, the dissolved oxygen in Kelso Lake plummeted from 8.0 mg/L at the surface to 0.3 mg/L at 11 meters near the lake bottom (Table 34, Figure 27). Dissolved oxygen depletion occurred in the lower thermocline and the hypolimnion extending to 11 meters. Adequate dissolved oxygen in the summer is found only at four meters and above. The entire hypolimnion is severely depleted of dissolved oxygen, a condition that indicates severe lake eutrophication and heavy nutrient loading in Kelso Lake. (Total ammonia levels were consistently higher near the lake bottom than at the surface, indicating anaerobic bacterial decomposition is occurring and depleting the dissolved oxygen in the lake.)

Submergent Macrophytes

The submergent and floating-leaf aquatic plant communities of Kelso Lake consist of 12 different species. The submergent plant communities are dominated by a few species. These species are highly dependent on water quality, the lake bottom substrate and the amount of available light.

The twelve species of submergent and floating-leaf aquatic plants found in Kelso Lake include: Potamogeton Robbinsii (Robbins pondweed), Elodea (waterweed), Brasenia (water shield), Nuphar variegatum (yellow water lily), P. amplifolius (largeleaf pondweed), P. filiformis (fineleaf pondweed), Myriophyllum exabescens (water milfoil), P. zosteriformis (flatstem pondweed), Ceratophyllum demersum (coontail), P. gramineus (variable pondweed), P. praelongus (whitestem pondweed) and P. Berchtoldii (a fineleaf pondweed).

The dominant species throughout the entire littoral zone of the lake included: Brasenia, Ceratophyllum demersum, Myriophyllum exalbescens and Potamogeton amplifolius. The predominant floating-leaf species are Brasenia and yellow water lily (Nuphar). While both waterweed and Robbins pondweed are present, they are less of a significant part of the submergent plant communities than would be anticipated in a more eutrophic lake. These two species are somewhat ubiquitous at times, when used for classifying lakes according to their trophic status. Robbins pondweed is quite shade-tolerant and tends to grow profusely in lakes of high phosphorus and nutrient content and low water clarity.

No submergent species grew in water over three meters. The brown-stained water and reduced water clarity in Kelso Lake is a primary factor limiting the depth at which submergent aquatic plants were found.

Generally, the extensive development of water shield and yellow water lily communities and the absence of white water lily in the silt-ridden bay areas, further illustrated the eutrophic nature of Kelso Lake. Eleocharis and Isoetes were not found in shallow, sandy littoral areas, indicating that the lake is eutrophic. Coontail, water milfoil and largeleaf pondweed are the leading dominant species within most of the submergent plant communities, indicating that Kelso Lake has been going through a change in water quality and becoming more eutrophic.

LWQA Water Quality Data

LWQA water chemistry data indicates that Kelso Lake is meso-eutrophic (Tables 34-35, Figure 27). Moderate to moderately-high levels of ammonia, nitrate and nitrite, and total kjehldahl nitrogen, total phosphorus and ortho-phosphate, chlorophyll "a" and specific conductivity indicated the Lake is in transition and experiencing eutrophication. More specific discussion of some of these and other parameters can be found under appropriate parameter subtitles in this report.

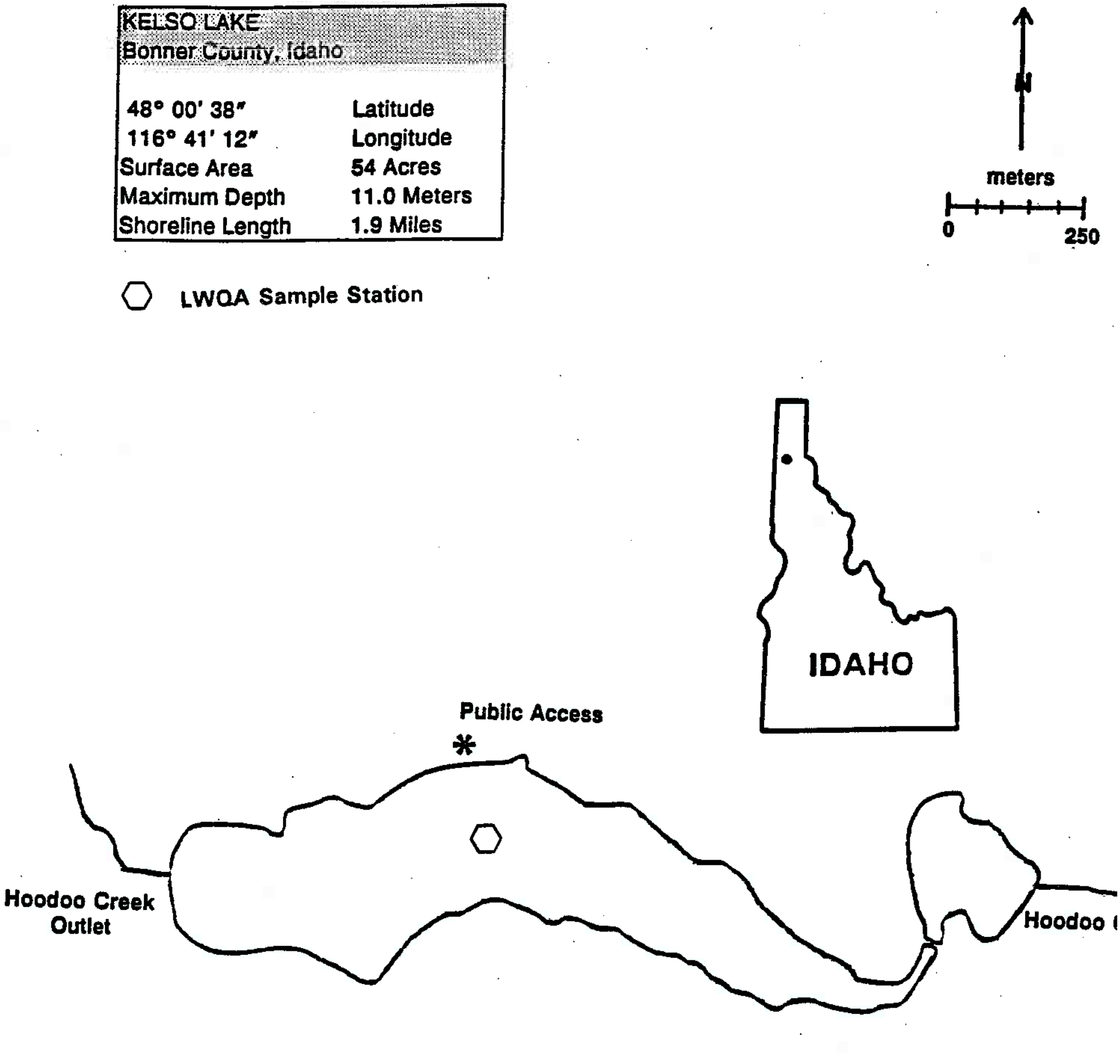


Figure 26. Map of Kelso Lake.

Plate 7. Kelso Lake photographs showing aquatic plant communities and residential homes.

Figure 27. Dissolved oxygen and temperature profile for Kelso Lake, August 14, 1991.

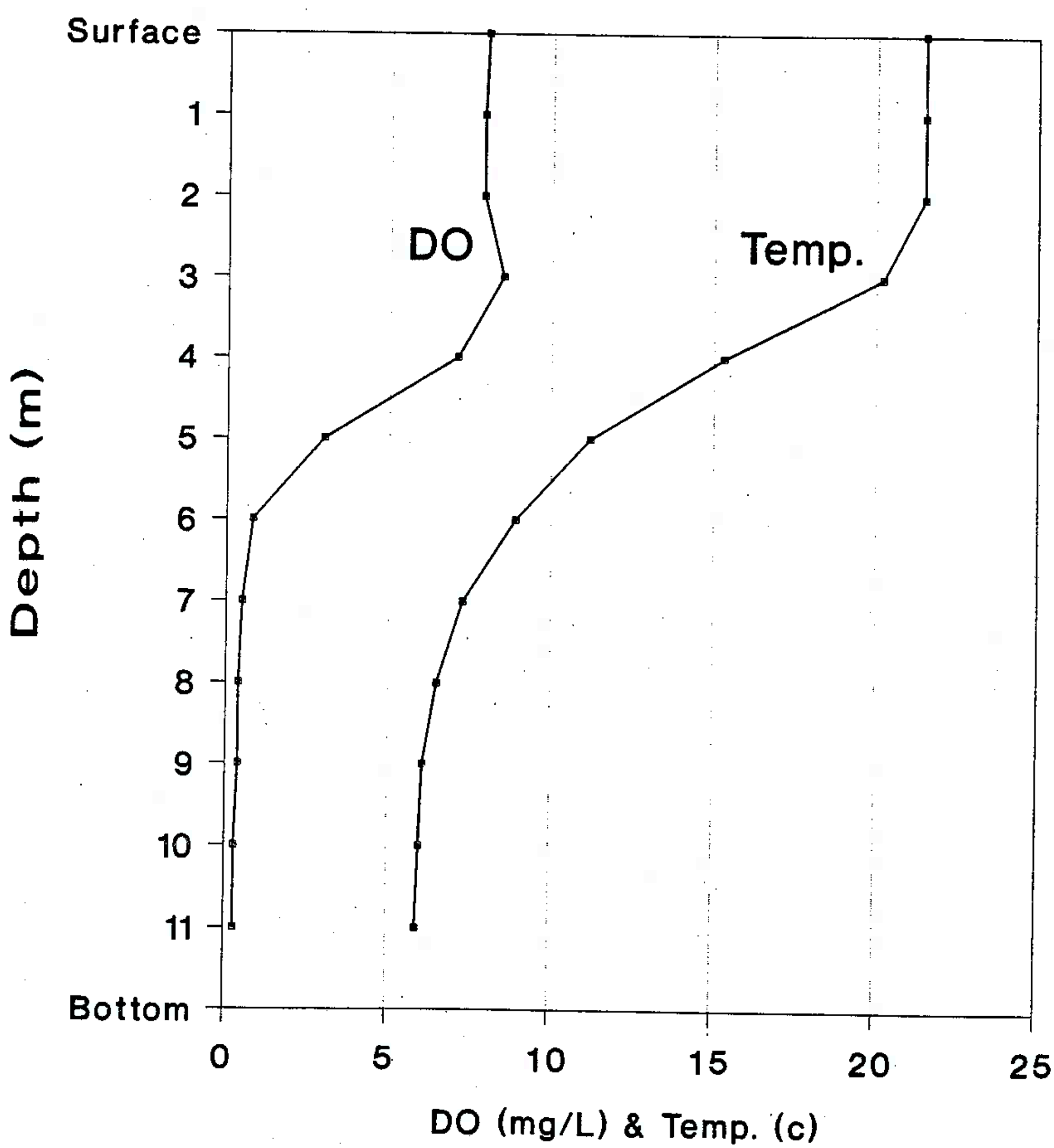


Table 34. LWQA dissolved oxygen/temperature profiles, specific conductivity and pH during summer thermal stratification for Kelso Lake on August 14, 1991.

Depth (meters)	Dissolved Oxygen (mg/L)	Temperature (°C)	Specific Conductance (umhos/cm)	pH
0.0	8.0	21.5	85.0	6.7
1.0	7.9	21.5	85.0	6.8
2.0	7.9	21.5	85.0	6.9
3.0	8.5	20.2	85.0	6.8
4.0	7.1	15.3	91.0	6.1
5.0	3.0	11.2	94.0	5.9
6.0	0.8	8.9	95.0	5.8
7.0	0.5	7.3	97.0	5.8
8.0	0.4	6.5	99.0	5.8
9.0	0.4	6.1	103.0	5.8
10.0	0.3	6.0	106.0	5.8
11.0	0.3	5.9	109.0	5.9

Table 35. 1990 Lake Water Quality Assessment (LWQA) water chemistry data for Kelso Lake. *

Date	5-22-90	5-22-90	6-26-90	6-26-90	8-6-90	8-6-90	9-19-90	9-19-90	9-19-90	0-30-90	0-30-90
Time	1245	1245	1200	1200	1200	1200	0930	0930	0930	1030	1030
Sample Depth	14.5	4	12	3	10	4	11	5	1	12	3.5
Total Depth	15.5	15.5	15	15	11.9	11.9	12.1	12.1	12.1	---	---
Secchi Depth	4.2	4.2	3	3	4.1	4.1	5	5	5	---	---
T. NH3-N	0.345	0.058	0.376	0.033	0.382	0.047	0.522	0.067	0.07	0.118	0.057
T. NO2+NO3-N	<.005	<.005	<.005	<.005	0.007	<.005	0.006	0.008	0.012	<.005	<.005
T. Kjeldahl-N	0.73	0.38	0.69	0.41	1	0.49	0.88	0.28	0.3	0.32	0.28
T. Phosphorus-P	0.032	0.015	0.078	0.015	0.12	0.014	0.15	0.013	0.006	0.013	0.01
Dissl. Phosphate-P	0.009	0.003	0.07	0.002	0.1	<.002	---	<.002	<.002	<.002	<.002
Ortho Phosphate-P	---	---	---	---	---	---	0.13	---	---	---	---
Hardness-CaCO3	48	32	48	28	44	40	48	44	40	40	40
T.Alkalinity-CaCO3	53	37	51	38	51	42	51	44	43	45	43

* Depth in meters and water chemistry data in mg/L.

UPPER TWIN LAKE:

General

Upper Twin Lake is located in Kootenai County, Idaho, and has 483 acres of surface water and 4.5 miles of shoreline with a maximum water depth of 16 feet (5 meters) (Figure 28). The forested watershed has been experiencing some clearcutting and there is extensive submergent macrophyte growth throughout the Lake (Plate 8).

Upper Twin Lake generally had poor water quality and was brown-stained with extensive algal blooms. A limited secchi disk reading of 3.0 meters was the result of both stained water and an algae bloom. Zooplankton were often found feeding on the algae bloom. Upper Twin Lake is relatively shallow and most likely continues to mix throughout the summer.

Potential siltation problems from logging can be avoided by implementing sound watershed management practices in the managed forest areas. This is essential to prevent further deterioration of water quality in the tributary streams and the Lake.

LWQA water sampling occurred once at one station in 1990. LWQA dissolved oxygen and temperature profiles, secchi depth and chlorophyll "a" and submergent macrophyte distribution were determined once in 1991. LWQA and CVMP water samples were taken at secchi depth. Citizen volunteer monitoring program (CVMP) water sampling occurred three times at one station in 1990 and four times at one station in 1991.

Beneficial Uses

The Idaho Water Quality Standards protect Twin Lakes for the following beneficial uses: domestic water supply, agricultural water supply, cold water biota, primary contact recreation and secondary contact recreation (Table 6). Twin Lakes is protected for future use for salmonid spawning. The eutrophic nature of Upper Twin Lake threatens the beneficial uses of domestic water supply, agricultural water supply, cold water biota and primary contact recreation.

Fishing, boating, water skiing, ski-doing, swimming, sightseeing and sunbathing are major recreational uses of Upper Twin Lake. The aesthetic and visual qualities of Upper Twin Lake are excellent. Extensive residential homes, private and religious camps and some commercial resort developments are found along the shoreline. A public access is located on the lake.

Sources of Pollution, Nutrients and Recommended Management Actions

Upper Twin Lake is very shallow and eutrophic. Cattle have been recently observed in the west end of the Lake. The presence of these cattle in and around the Lake may likely be contributing nutrients and sediment to the Lake. Timber harvesting in the south slope of the watershed may be contributing to sediment loading in the Lake. Extensive residential homes can be found on the north and east shoreline. The combination of phosphorus and sediment contributions from all of the potential sources mentioned above, may have a major impact on the deterioration of water quality in Upper Twin Lake.

Management action should include effective livestock grazing Best Management Practices near shoreline and stream riparian areas. Any timber management activities should consider water quality impacts on tributary streams and the Lake. Residential homes should be certain that drain fields are functional and have proper setbacks from the Lake. Siltation runoff from roads, improper logging practices and cattle grazing must be managed to protect the Lake from further eutrophication.

Limnological Characteristics of Upper Twin Lake:

Secchi Depth: 1991 LWQA range = 3.0 meters, average = 3.0 meters; 1991 CVMP range = 3.0-5.0 meters, average = 4.1 meters; 1990 CVMP range = 2.5-3.5 meters, average = 2.9 meters.

On August 12, 1991, Upper Twin Lake was brown-stained with limited visibility and an algal bloom.

Chlorophyll "a": 1991 LWQA range = 5.1-5.6 ug/L, average = 5.4 ug/L; 1991 CVMP range = 2.0-9.0 ug/L, average = 5.4 ug/L. 1990 CVMP range = 2.8-4.3 ug/L, average = 3.6 ug/L.

Chlorophyll "a" productivity is relatively high and indicative of late mesotrophic/early eutrophic conditions.

Total Phosphorus: 1990 LWQA range = 0.016-0.018 mg/L, average = 0.017 mg/L; 1991 CVMP range = 0.013-0.017 mg/L, average = 0.015 mg/L; 1990 CVMP range = 0.011-0.32 mg/L, average = 0.066 mg/L.

Phosphorus data were consistent at secchi depth across the dates sampled.

Dissolved Oxygen/Temperature Profiles

Dissolved oxygen/temperature profiles taken in August of 1990 and 1991, demonstrated that Upper Twin Lake was not thermally stratified and had completely mixed from the lake surface to the bottom (Tables 36-39, Figure 29). Dissolved oxygen ranged from 7.6

mg/L at the surface to 6.7 mg/L near the lake bottom at four meters.

Submergent Macrophytes

Upper Twin Lake has prolific submergent macrophyte growth, which consists primarily of robbins pondweed reaching across the entire lake bottom. The lake bottom at five meters consisted of detritus and robbin's pondweed with a strong hydrogen sulfide odor near the lake bottom.

There was not a balanced variety of submergent species. The dominant submergent plants found in Upper Twin Lake are dependent on water quality and water depth, as well as the type of lake bottom in which they were rooted (sand, rocks, organic soils, detritus, etc.). Species such as robbins pondweed, coontail, Elodea, Chara and yellow water lily were dominant in the detritus, organic bottoms at all water depths.

The only other submergent macrophyte species found in Upper Twin Lake occurred in trace amounts. The species included: largeleaf pondweed, needle rush and bushy pondweed. These species are more frequently associated with oligotrophic and mesotrophic lakes, and therefore, do not make up a significant part of any of the submergent plant communities of this eutrophic lake.

The following seven aquatic macrophyte species were found in Upper Twin Lake: Chara (muskgrass), Elodea spp., (waterweed), Eleocharis (needle rush), Potamogeton robbinsii (robbins pondweed), Ceratophyllum demersum (coontail), P. amplifolius (largeleaf pondweed), Najas flexilis (bushy pondweed) and Nuphar (yellow water lily).

Coontail and muskgrass were dominant in water less than 2 meters. At 3 meters and deeper, robbin's pondweed dominated in the highly-organic lake bottom. Needle rush and bushy pondweed were found only in trace amounts in a few areas of sandy lake bottom.

The continued delineation and study of the submergent macrophyte communities will help to provide information needed for further watershed management.

LWQA and CVMP Water Quality Data

LWQA and CVMP water chemistry data indicated that Upper Twin Lake was meso-eutrophic (Tables 36-39, Figure 29). Moderate to moderately-high levels of ammonia, nitrate and nitrite nitrogen, total kjehldahl nitrogen, total phosphorus and ortho-phosphate and chlorophyll "a" indicated the Lake is in transition and experiencing eutrophication More specific discussion of some of these and other parameters can be found under specific parameter subtitles in this report.

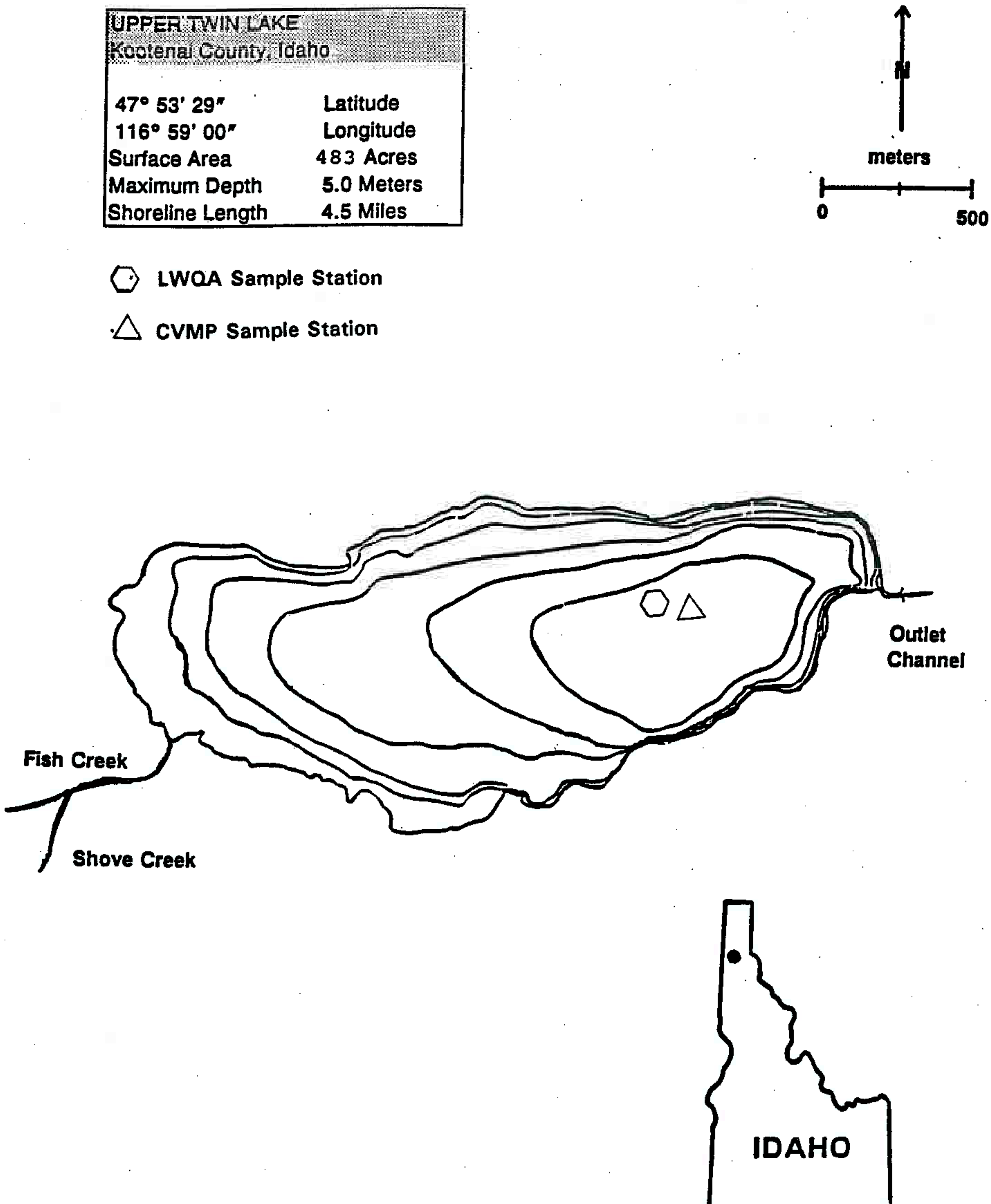


Figure 28. Map of Upper Twin Lake.

Plate 8. Upper Twin Lake photographs showing clearcuts in the forested watershed and floating-leaf and emergent vegetation of the littoral zone.

Figure 29. Dissolved oxygen and temperature profile for Upper Twin Lake, August 12, 1991.

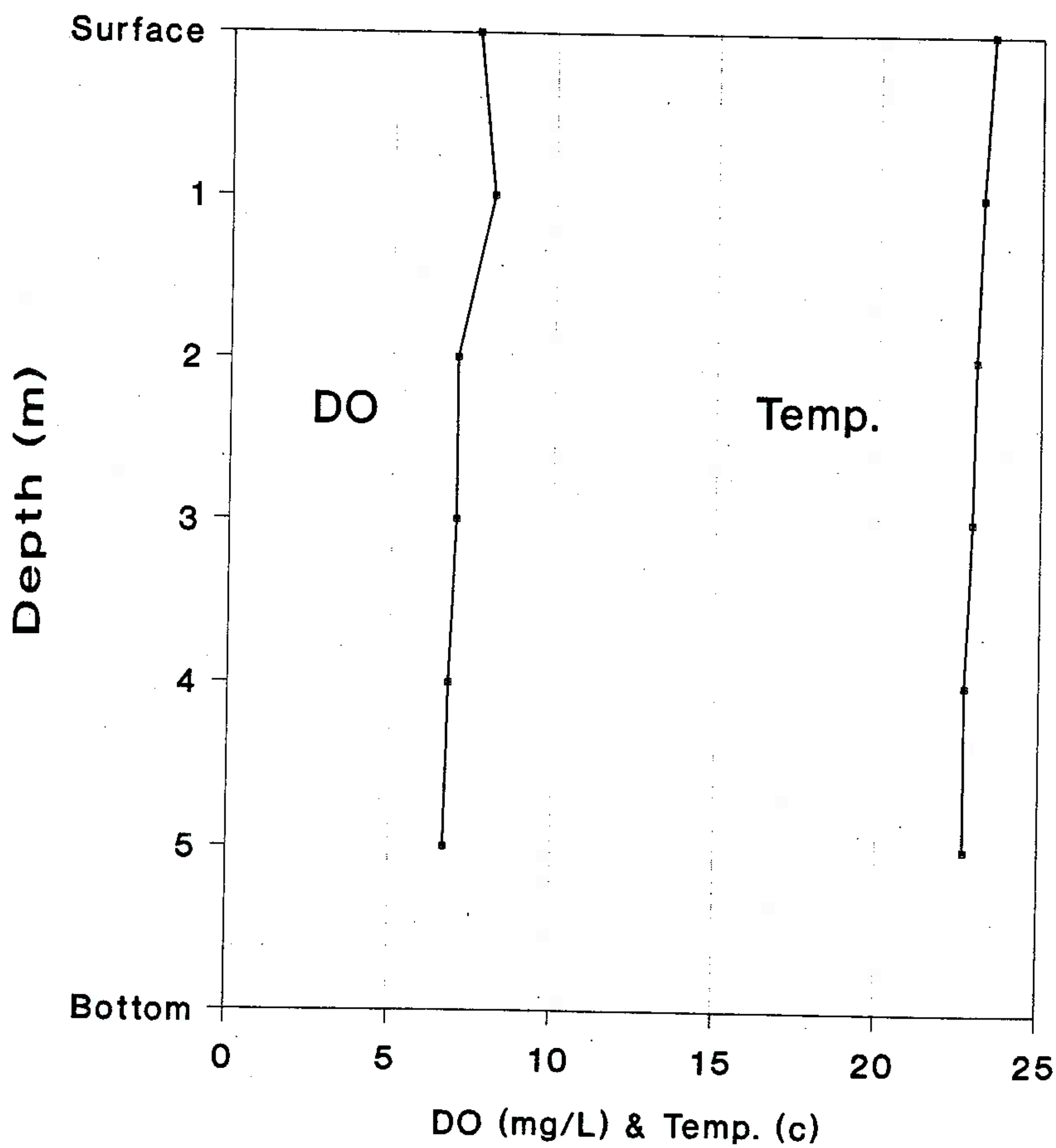


Table 36. LWQA dissolved oxygen/temperature profiles, specific conductivity and pH during summer thermal stratification for Upper Twin Lake on August 12, 1991.

Depth (meters)	Dissolved Oxygen (mg/L)	Temperature (°C)	Specific Conductance (umhos/cm)	pH
0.0	7.6	23.5	27.0	6.1
1.0	8.1	23.2	27.0	6.2
2.0	7.0	23.0	27.0	6.2
3.0	7.0	22.9	27.0	6.2
4.0	6.8	22.7	27.0	6.1
5.0	6.7	22.7	27.0	6.1

Table 37. 1990 Lake Water Quality Assessment (LWQA) water chemistry data for Upper Twin Lake.

Date	8-27-90	8-27-90
Time	0900	0915
Sample Depth	3.5	3
Total Depth	--	--
Secchi Depth	--	--
T. NH3-N	0.477	0.303
T. NO2+NO3-N	<.005	<.005
T. Kjeldahl-N	0.22	0.3
T. Phosphorus-P	0.018	0.016
Ortho Phosphate-P	<.001	--
Dissl. Phosphate-P	--	<.001
Hardness-CaCO3	--	12
T.Alkalinity-CaCO3	--	10

	8-27-90			
Meters	Temp.	pH	Cond.	D.O.
1	19.6	5.8	30	7.3
2	19.6	5.9	30	7.2
3	19.5	5.9	30	7.1
4	19.5	5.9	30	7.1
5	19.5	5.9	30	7

* Temperature in degrees Centigrade, conductivity in umhos/cm and water chemistry data in mg/L.

Table 38. 1990 Citizen Volunteer Monitoring Program (CVMP) water quality data for Upper Twin Lake.

Date of Sample *	CVMP 06/12/90	CVMP** 07/23/90	CVMP** 07/23/90	CVMP*** 08/27/90	DEQ/QA/QC**** 08/27/90
Secchi sample depth (meters):	---	2.5	2.5	3.5	3
T. Ammonia	---	0.015	0.026	0.477	0.303
T. NO2+NO3	---	0.005	0.007	0.005	0.005
T.K. Nitrogen	---	0.3	0.25	0.22	0.3
T. Phosphorus	---	0.011	0.011	0.018	0.016
Ortho Phosphate	---	0.001	0.001	0.001	0.001
Temperature (degrees Centigrade)	---	---	---	18	19.5
Dissolved Oxygen	---	---	---	6.8	7.1
Chlorophyll a (ug/L)	2.8	3.5	3.8	4.3	3.4
Deep sample depth: **	5	---	---	5	5
T. Ammonia	0.005	---	---	0.744	---
T. NO2+NO3	0.005	---	---	0.005	---
T.K. Nitrogen	0.2	---	---	0.9	---
T. Phosphorus	0.018	---	---	0.32	---
Ortho Phosphate	0.001	---	---	0.27	---
Temperature	---	---	---	18	19.5
Dissolved Oxygen	---	---	---	6.8	7

* mg/L unless otherwise indicated.

** Sample taken one meter above the lake bottom.

*** CVMP duplicate samples.

**** Idaho Division of Environmental Quality/Quality Assurance/Quality Control.

Table 39. 1991 Citizen Volunteer Monitoring Program (CVMP) water quality data for Upper Twin Lake.

Date of Sample *	CVMP** 05/20/91	CVMP** 05/20/91	CVMP 07/01/91	CVMP*** 08/12/91	DEQ/QA/QC*** 08/12/91	CVMP 09/16/91
Secchi sample depth (meters):	5	5	5	3	3	3.5
T. Ammonia	0.025	0.024	0.02	0.072	0.078	0.085
T. NO2+NO3	0.015	0.022	0.005	0.006	0.017	0.01
T.K. Nitrogen	0.2	0.08	0.43	0.62	0.35	0.38
T. Phosphorus	0.014	0.017	0.015	0.015	0.016	0.013
Ortho Phosphate	0.002	0.002	0.002	0.002	0.002	0.002
Temperature (degrees Centigrade)	10.7	10.7	15.2	21	22.9	15.7
Dissolved Oxygen	10.5	10.5	10.7	7	7	7.4
Chlorophyll a (ug/L)	2	2	9	7.6	6.4	5.3

* mg/L unless otherwise indicated.

** CVMP duplicate samples.

*** Idaho Division of Environmental Quality/Quality Assurance/Quality Control.

COCOLALLA LAKE:

General

Cocolalla Lake is located in Bonner County, Idaho, and has 806 acres of surface water and 6 miles of shoreline with a maximum water depth of 45 feet (13.7 meters) (Figure 30).

Cocolalla Lake is an eutrophic lake in the process of cultural eutrophication. The contribution of phosphorus and other nutrients to the watershed by agricultural activities in stream riparian zones of Cocolalla Creek and Fish Creek, and other tributaries have significantly reduced the water quality and hastened the eutrophication of Cocolalla Lake. Excessive filamentous strands of green algae (Spirogyra) were found at the outlet delta area of these two Creeks, indicating nutrients are entering Cocolalla Lake at the confluence of both Cocolalla and Fish Creek.

Dense algal blooms were present throughout the Lake, reducing the secchi depth to 2.5 meters. Water samples taken one meter off the lake bottom had a distinctive hydrogen sulfide odor, indicating anaerobic bacterial activity in the bottom detritus and water column. Further evidence of anaerobic decomposition was evident, when dissolved oxygen decreased from 7.8 mg/L at the surface to 0.5 mg/L at 8 meters near the lake bottom.

LWQA water samples were taken once at secchi depth and one meter off the bottom in 1990. LWQA dissolved oxygen and temperature profiles, secchi depth and chlorophyll "a" and submergent macrophyte distribution were determined once in 1991. Citizen volunteer monitoring program (CVMP) water sampling occurred four times at one station at secchi depth and one meter off the bottom in 1990.

Beneficial Uses

The Idaho Water Quality Standards protect Cocolalla Lake for the following beneficial uses: domestic water supply, agricultural water supply, cold water biota, primary contact recreation and secondary contact recreation (Table 6). An additional existing beneficial use for Cocolalla Lake is warm water biota. Threatened beneficial uses include: domestic water supply, agricultural water supply, cold water biota, and primary contact recreation.

Both public and private commercial boat accesses exist on Cocolalla Lake. Extensive residential homes and some commercial resort developments are located on the west and north sides of the lake. Fishing, swimming, water skiing and other boating activities are all prevalent. Aesthetic and visual qualities are apparent. Camping opportunities are limited. Tributary streams and riparian areas of many of the watersheds are used for grazing of horses and cattle, which contributes to streambank erosion and sediment, and nutrient input to Cocolalla Lake. Cocolalla Lake flows to Cocolalla Creek outlet, which is the primary source of water for Round Lake.

Sources of Pollution, Nutrients and Recommended Management Actions

An extensive Phase 1 Clean Lakes Study has just been completed on Cocolalla Lake. Numerous private residential homes can be found on the north and east side of this under-utilized, eutrophic recreational lake (Plate 9). Nonpoint sources of nutrients include: agricultural, grazing, forestry and road impacts. Considerable internal recycling of phosphorus occurs in Cocolalla Lake. Significant phosphorus and sediment enters the Lake via Fish and Cocolalla Creeks. A moderate amount of feedlots and grazing were found on the riparian zones of these tributary creeks. Logging activities have been adversely affecting critical riparian areas.

Management recommendations include the development of improved BMP's for manure and grazing activities in the riparian zone of Cocolalla Creek and improved sediment control from Fish Creek. Improved containment and reduction of septic tank and drainage field seepage from residential homes is also needed. Improved regulations for residential development throughout the watershed is also needed. Assessment of nutrient contamination from a sewage lagoon at Sandy Beach Resort is recommended. Implementation of cost-share agricultural BMP's would help to facilitate improvement in water quality.

Limnological Characteristics of Cocolalla Lake:

Secchi Depth: 1991 LWQA range = 2.5-2.5 meters, average = 2.5 meters; 1990 CVMP range = 1.0-2.0 meters, average = 1.7 meters.

Water clarity in Cocolalla Lake is limited due to frequent algal blooms throughout the summer.

Chlorophyll "a": 1991 LWQA range = 9.1-11.0 ug/L, average = 10.1 ug/L; 1990 CVMP range = 6.4-16.0 ug/L, average = 10.9 ug/L.

Phytoplankton production in Cocolalla Lake is relatively high. The Lake is eutrophic.

Total Phosphorus: 1990 LWQA range = 0.02-0.22 mg/L, average = 0.12 mg/L; 1990 CVMP range = 0.019-0.22 mg/L, average = 0.075 mg/L.

Total phosphorus data has been collected extensively in a recent Phase 1 Project and will provide data needed to evaluate phosphorus levels and phosphorus recycling in Cocolalla Lake. Internal recycling and tributary input of phosphorus is extensive for the Lake.

Dissolved Oxygen/Temperature Profiles

The dissolved oxygen in Cocolalla Lake dropped from 7.8 mg/L at the surface to less than 1.0 mg/L at 8 meters (Table 40, Figure 31). The depletion of dissolved oxygen was severe in the thermocline, and extended to 10 meters. Consequently, adequate dissolved oxygen to support aquatic life was found only in the epilimnion in the summer and was severely reduced in the thermocline. The dissolved oxygen dropped rapidly from 6 to 8 meters in the thermocline, rendering the hypolimnion nearly anaerobic. The upper 6 meters of the epilimnion was mixed and uniform in water temperature. These conditions indicated severe lake eutrophication and heavy nutrient loading was occurring throughout Cocolalla Lake.

Submergent Macrophytes

The submergent aquatic plant communities of Cocolalla Lake consisted of twelve different species. Each of these submerged plant communities were dominated by a few species that were highly dependent upon water quality, the lake bottom substrate in which they were rooted and the amount of available light.

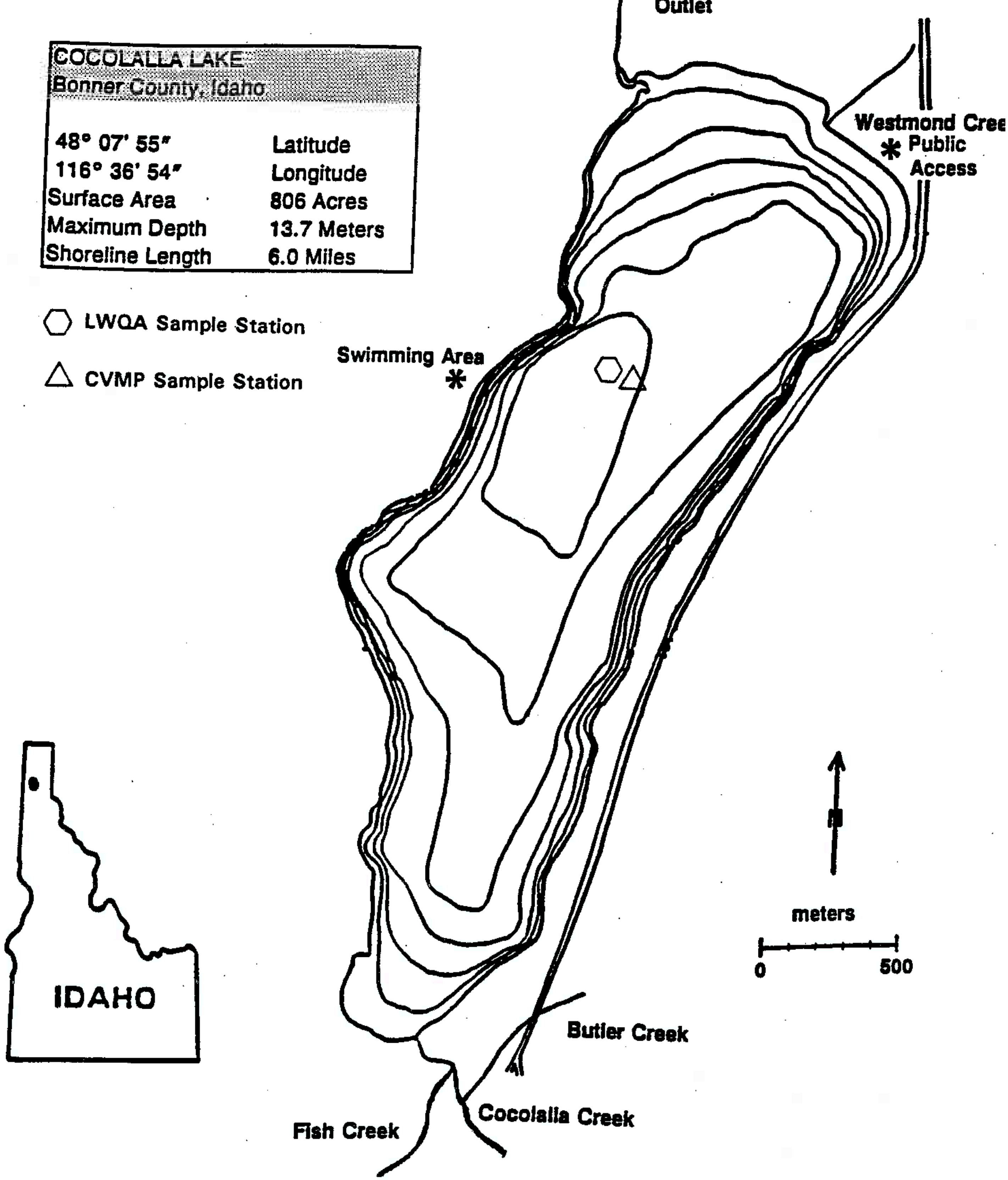
The predominant floating-leaf species included: yellow water lily (<u>Nuphar</u>) and water shield (<u>Brasenia</u>). Waterweed (<u>Elodea</u>) and robbins pondweed (<u>Potamogeton robbinsii</u>) were the two leading dominant submergent macrophytes found in organic bays and silt-ridden littoral areas. These species are somewhat ubiquitous in nature. However, the relative abundance of these two species may indicate that the lake is late-mesotrophic to eutrophic. Robbins pondweed is quite shade-tolerant and tends to grow profusely in lakes of high phosphorus and high nutrient content and low water clarity. The extensive development of yellow water lily communities and the absence of white water lily communities in the silt-ridden bay areas, further illustrated the eutrophic nature of Cocolalla Lake.

The maximum depth at which submergent vegetation grows ranged from 1.5 to 2.5 meters, depending on the degree of bottom slope of the littoral zone and the compositional makeup of the bottom substrate (i.e., sand, detritus, rock, clay, etc). The bottom substrate of the littoral zone is quite variable. The shallow water area of large rock and sand bottom adjacent to the mouth of Cocolalla Creek leaving Cocolalla Lake was remarkably, almost devoid of submergent macrophytes or emergent vegetation such as cattails. Only bulrushes were prevalent, which is typical for sand/rock/inorganic littoral lake bottoms of shallow water depth and areas subjected to strong wave action. The absence of any significant detritus on the lake bottom at the mouth of this outlet, may suggest that the sediment entering, and generated, in Cocolalla Lake has settled out in the deeper waters of the profundal zone.

LWQA and CVMP Water Quality Data

LWQA and CVMP water chemistry data indicated that Cocolalla Lake is eutrophic (Tables 40-42, Figure 31). Moderately-high to high levels of ammonia, nitrate and nitrite, and total kjehldahl nitrogen, total phosphorus and orthophosphate and chlorophyll "a" indicate the Lake is experiencing eutrophication. More specific discussion of some of these and other parameters can be found under parameter subtitles in this report.

Figure 30. Map of Cocolalla Lake.



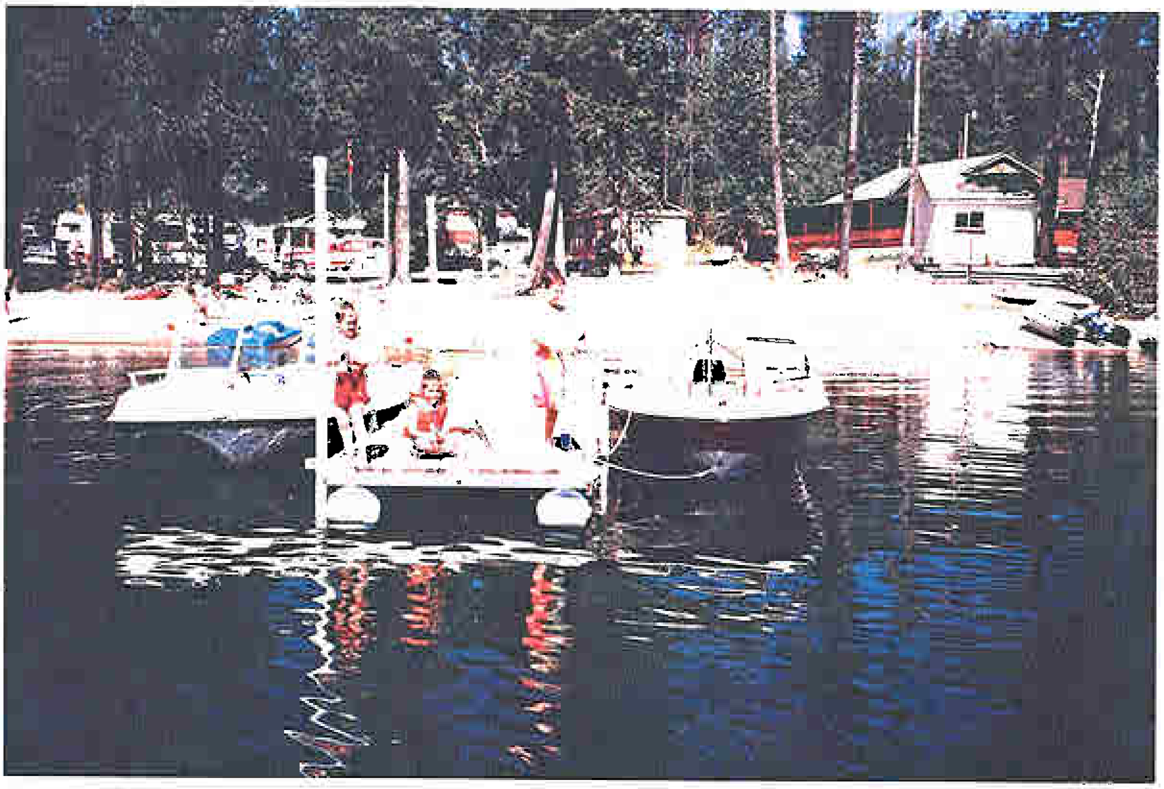


Plate 9. Cocolalla Lake photographs showing both undeveloped and developed lakeshore.

Figure 35. Dissolved oxygen and temperature profile for Round Lake, August 6, 1991.

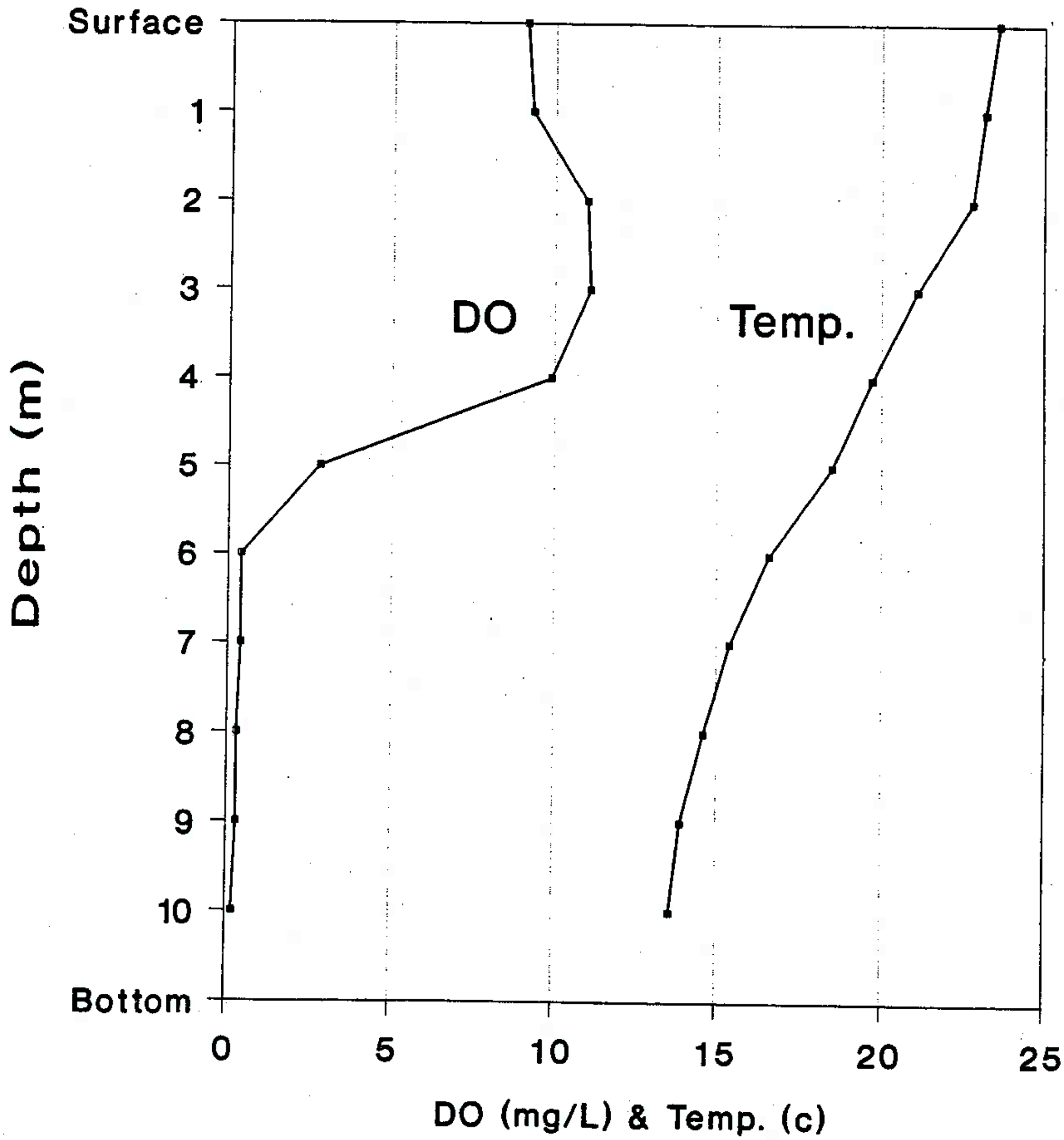


Table 46. LWQA dissolved oxygen/temperature profiles, specific conductivity and pH during summer thermal stratification for Round Lake on August 6, 1991.

Depth (meters)	Dissolved Oxygen (mg/L)	Temperature (°C)	Specific Conductance (umhos/cm)	pH
0.0	9.1	23.6	70.0	7.8
1.0	9.3	23.2	69.0	7.8
2.0	11.0	22.8	70.0	8.0
3.0	11.1	21.1	71.0	8.0
4.0	9.9	19.7	71.0	7.3
5.0	2.8	18.5	70.0	6.0
6.0	0.4	16.6	65.0	5.8
7.0	0.4	15.4	61.0	5.7
8.0	0.3	14.6	78.0	5.8
9.0	0.3	13.9	93.0	5.9
10.0	0.2	13.6	101.0	5.9

Table 47. 1990 Lake Water Quality Assessment (LWQA) water chemistry data for Round Lake. *

Date	5-21-90	5-21-90	6-26-90	6-26-90	8-8-90	8-8-90	10-23-90	10-23-90
Time	1300	1300	0845	0845	1000	1000	1000	1000
Sample Depth	9.5	1	9	3	9	2	9	2
Total Depth	10.5	10.5	10.5	10.5	10.3	10.3	10.2	10.2
Secchi Depth	2.1	2.1	2.8	2.8	2.3	2.3	2.3	2.3
T. NH3-N	0.065	0.059	0.164	0.038	0.921	0.051	0.316	0.27
T. NO2+NO3-N	<.005	<.005	0.006	<.005	<.005	<.005	0.046	0.03
T. Kjeldahl-N	0.42	0.26	0.49	0.38	0.367	0.98	0.97	0.8
T. Phosphorus-P	0.029	0.027	0.079	0.029	0.38	0.02	0.046	0.043
Dissl. Phosphate-P	0.001	0.001	0.026	0.002	0.3	<.002	0.005	0.002
Hardness-CaCO3	24	24	28	24	32	28	32	36
T.Alkalinity-CaCO3	23	23	27	24	37	29	37	36

* Depth in meters and water chemistry data in mg/L.

Table 48. 1990 Lake Water Quality Assessment (LWQA) dissolved oxygen, temperature, conductivity and pH for Round Lake. *

	5-21				6-26				8-8				9-19				10-23			
Meters	Temp	pH	Cond.	D.O.	Temp.	pH	Cond.	D.O.	Temp.	pH	Cond	D.O	Temp	pH	Cond.	D.O.	Temp.	pH	Cond.	D.O.
1	12.8	6.3	64	9.6	20.6	6.9	66	10.1	23.5	8.1	78	9.3	18.4	6.8	82	8.9	10.2	6	90	7.4
2	12.2	6.4	65	9.3	20	7	67	9.8	23.4	8.1	78	9.4	18.1	7	81	9	10.1	6.1	90	7
3	12	6.4	65	9.1	19.4	6.8	67	9.4	22.1	7.9	78	9.6	18	7.1	81	9.2	10	6.1	90	6.9
4	12	6.4	65	9.1	18.4	6.7	67	9.3	20.4	7	79	7.6	17.8	7.2	81	9.1	10	6.1	90	6.8
5	12	6.4	64	9	17.4	6.6	66	9	19.1	6.3	79	2.6	17.2	6.2	82	5.9	10	6.2	89	6.9
6	12	6.4	65	9	16.5	6.3	66	7.8	18	5.9	73	0.3	16.9	6.2	82	6	10	6.2	90	6.8
7	12	6.4	65	9	15.5	6.2	66	6.8	16.6	5.8	71	0.3	16.5	6	81	4.9	9.9	6.2	91	6.6
8	11.9	6.5	65	9	14.6	6.1	66	5.6	14.6	5.8	85	0.2	14.7	6	108	0.4	9.9	6.2	91	6.5
9	11.9	6.5	65	9	13.6	5.9	67	2.7	13.7	5.9	101	0.2	13.5	6.1	152	0.3	9.8	6.1	92	6.4

* Temperature in degrees Centigrade, conductivity in umhos/cm and dissolved oxygen in mg/L.

GRANITE LAKE:

General

Granite Lake is located in Bonner County, Idaho, and has 20 acres of surface water and 0.9 miles of shoreline with a maximum water depth of 79 feet (24 meters) (Figure 36). Granite Lake has variable watershed topography, no residential shoreline development and brown-stained water (Plate 12).

Granite Lake appears to be sort of an anomally in the spectrum of lake types found in North Idaho. Most likely, Granite Lake never fully mixes and remains thermally stratified in the summer. Preliminary data indicated that it is a meromictic lake of relatively high total dissolved solids with a specific conductivity ranging from 86 umhos at the surface to 296 umhos near the lake bottom at 21 meters. The dissolved oxygen is rapidly depleted from 7.1 mg/L at the surface to 0.6 mg/L at 5 meters. The dissolved oxygen continued to be less than 1 mg/L from the 5 meter depth to the lake bottom. The brown-stained water contributed to the absorption of light and may have accounted for the extremely narrow epilimnion/thermocline and the extreme cold water found at five meters during summer thermal stratification. Secchi depth readings of four meters were primarily a result of brown-stained colored water, since algae blooms were not evident during the sample period.

The thick, grey-black cold, lake bottom sediment was many feet deep. Undoubtedly, this was a major factor in the recycling of high phosphorus, iron and manganese minerals throughout the Lake. Undoubtedly, the meromictic nature of Granite Lake has been maintained by these large, thick reserves of bottom muds laden with nutrients and minerals.

LWQA dissolved oxygen and temperature profiles and secchi depth were determined four times in 1990. LWQA water samples were taken five times in 1990 and analyzed for nutrients and metals. LWQA dissolved oxygen and temperature profiles, secchi depth, chlorophyll "a" and submergent macrophyte distribution were determined once in 1991. No CVMP exists for Granite Lake.

Beneficial Uses

The Idaho Water Quality Standards do not address beneficial uses for Granite Lake. Existing beneficial uses of Granite Lake are: cold water biota, warm water biota, and secondary contact recreation (Table 6). The limited data base for Granite Lake prevents designation of additional beneficial uses.

Based on the eutrophic nature of Granite Lake, the cold water biota use is <u>impaired</u>. The majority of the water column in Granite Lake is anaerobic in late August. Also, total hypolimnetic ammonia concentrations (4.8 mg/L) exceeded the DEQ Water Quality Standard of 2.2 mg/L. The narrow littoral zone in Granite Lake, along with low dissolved oxygen at the bottom (0.3 mg/L) threaten the warm water biota.

With a narrow littoral zone, steep drop-off and anoxic hypolimnion, it is unlikely that a cold-water fisheries would be productive in this lake. Largemouth bass and other warm-water fisheries may do well in these stained waters. Fishing is limited due to extremely low dissolved oxygen levels in most of the Lake. One undeveloped boat access is available at the northwest end of the lake. Aesthetic and visual quality is apparent. There were limited camping opportunities with no facilities.

Sources of Pollution, Nutrients and Recommended Management Actions

Granite Lake is an additional eutrophic, meromictic lake with coffee-stained water. Very high iron and manganese levels, along with high tannins and lignins, most likely account for the coffee-colored water. There are no known sources of nutrients from the watershed. Very little additional limnological data or background information exists for Granite Lake. No management action is recommended at this time.

Limnological Characteristics of Granite Lake:

Secchi Depth: 1991 LWQA range = 4.0-4.0 meters, average = 4.0 meters; 1990 LWQA range = 3.6-5.5 meters, average = 4.9 meters.

Granite Lake is highly brown-water stained. Consequently, water clarity is limited to 4 meters. A zooplankton bloom was evident at the surface of the Lake.

Chlorophyll "a": 1991 LWQA range = 9.0-9.0 ug/L, average = 9.0 ug/L.

Phytoplankton production in August for Granite Lake was relatively high (9.0 ug/L).

Total Phosphorus: 1990 LWQA range = 0.01-0.97 mg/L, average = 0.33 mg/L.

Phosphorus levels were highly variable throughout the seasons sampled. However, relatively high phosphorus levels were found for all water samples taken approximately one meter off the lake bottom. This indicated that, most likely, considerable internal phosphorus recycling has been occurring in Granite Lake.

Dissolved Oxygen/Temperature Profiles

Both dissolved oxygen and water temperature dropped very rapidly between two and five meters water depth (Table 49, Figure 37). The extreme changes in dissolved oxygen from the surface to five meters indicated excessive nutrient loading and oxygen consumption. There was virtually no oxygen in the Lake from 5 meters to the lake bottom. Undoubtedly, the high organic and mineral-rich lake bottom sediment have contributed significantly to oxygen depletion in Granite Lake.

Total ammonia and total Kjeldahl-nitrogen were excessively high, further indicating that most of the deep water is consuming most of the oxygen in the near-anoxic water column.

Total iron and total manganese levels were extremely high in Granite lake. Total iron levels were as high as 32,500 ug/L and manganese was as high as 1,860 ug/L.

Granite Lake is eutrophic and meromictic. The odoriferous, rich organic lake bottom muds, accompanied by a narrow littoral zone, all contributed to the severe oxygen depletion that occurs from 5 meters to the lake bottom. The dissolved oxygen profile is classic for a late eutrophic lake with rapid oxygen depletion in the thermocline, and anoxic conditions, not only throughout the hypolimnion, but in the lower thermocline as well. Consequently, there is very little area in Granite lake that has ample oxygen to support fish life.

Submergent Macrophytes

The submergent macrophyte communities of Granite Lake were comprised of eleven species and were distributed in a very narrow littoral band along the shoreline. A combination of steep drop-offs and highly stained water contributed to the narrow band of submergent aquatic plant growth. There were only two large, shallow water bays that had an expansive submergent plant community.

The submergent plant community was dominated by largeleaf floating pondweed (*Potamogeton amplifolius*), coontail (*Ceratophyllum demersum*) and water milfoil (*Myriophyllum exalbescens*). The floating-leaf community was dominated by water shield (*Brasenia*) and yellow water lily (*Nuphar*). These dominant submergent macrophytes were typically indicative of late mesotrophic/eutrophic lake trophic conditions.

LWQA Water Quality Data

LWQA water chemistry data indicated that Granite Lake is eutrophic, and most likely meromictic Tables 49-51, Figure 37). High levels of ammonia, nitrate and nitrite, and total kjehldahl nitrogen, total phosphorus and ortho-phosphate, chlorophyll "a" and specific conductivity indicated the Lake is eutrophic. More specific discussion of some of these and other parameters can be found under specific parameter subtitles in this report.

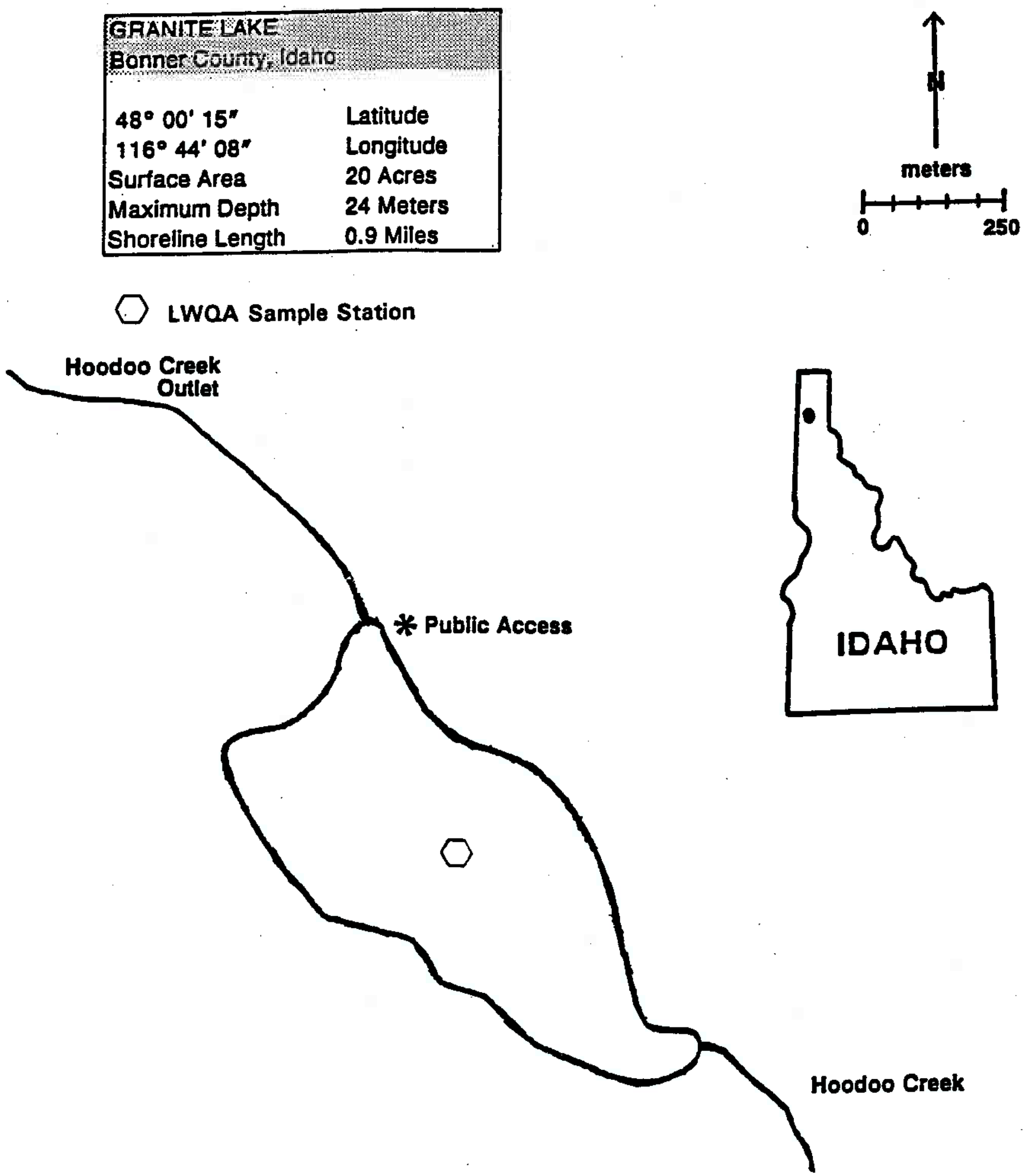


Figure 36. Map of Granite Lake.

Figure 31. Dissolved oxygen and temperature profile for Cocolalla Lake, August, 1991.

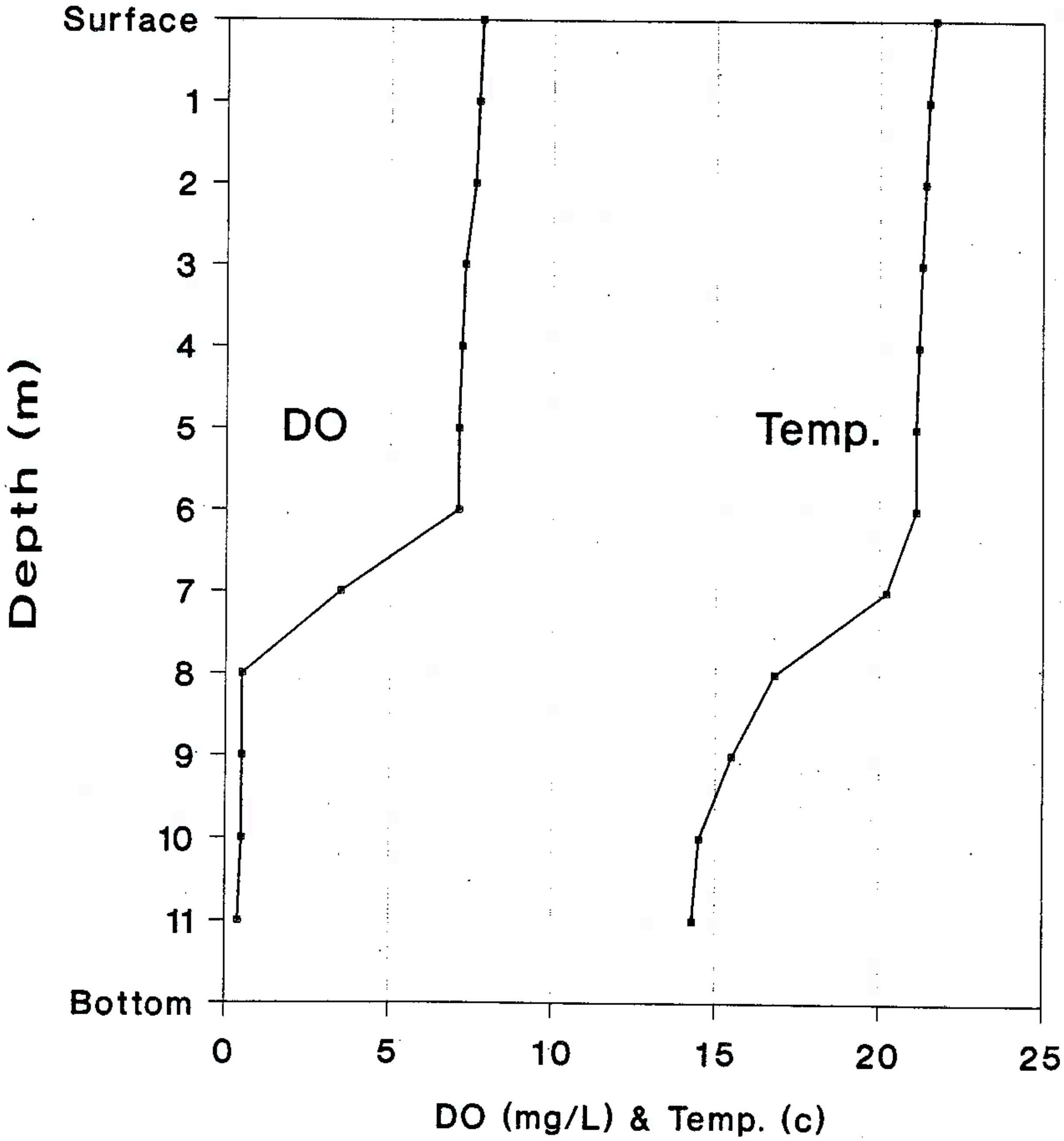


Table 40. LWQA dissolved oxygen/temperature profiles, specific conductivity and pH during summer thermal stratification for Cocolalla Lake on August 26, 1991.

Depth (meters)	Dissolved Oxygen (mg/L)	Temperature (°C)	Specific Conductance (umhos/cm)	pH
0.0	7.8	21.7	61.0	7.7
1.0	7.7	21.5	61.0	7.8
2.0	7.6	21.4	62.0	7.7
3.0	7.3	21.3	62.0	7.5
4.0	7.2	21.2	62.0	7.3
5.0	7.1	21.1	62.0	7.3
6.0	7.1	21.1	62.0	7.2
7.0	3.5	20.2	61.0	6.3
8.0	0.5	16.8	73.0	6.0
9.0	0.5	15.5	77.0	6.0
10.0	0.5	14.5	85.0	6.0
11.0	0.4	14.3	87.0	6.0

Table 41. 1990 Lake Water Quality Assessment (LWQA) water chemistry data for Cocolalla Lake. *

Date	8-28-90	8-28-90
Time	1400	1400
Sample Depth	11	2
Total Depth	11.5	11.5
Secchi Depth	2.3	2.3
T. NH3-N	0.688	0.139
T. NO2+NO3-N	<.005	0.031
T. Kjeldahl-N	0.79	0.38
T. Phosphorus-P	0.22	0.02
Ortho Phosphate-P	--	--
Dissl.Phosphate-P	0.19	0.002
Hardness-CaCO3	32	24
T.Alkalinity-CaCO3	36	26
Chlorophyll a (ug/L)	2.8	11.5

		8-28-90		
Meters	Temp.	pH	Cond.	D.O.
1	21.5	8.5	72.0	8.8
2	20.7	8.6	72.0	9.0
3	20.4	8.5	71.0	8.6
4	20.2	8.5	71.0	8.4
5	20.1	8.4	71.0	8.3
6	20.0	8.0	69.0	6.9
7	17.9	6.6	68.0	0.3
8	15.6	6.2	79.0	0.3
9	13.9	6.2	88.0	0.2
10	12.9	6.3	99.0	0.2
11	12.7	6.3	100.0	0.2

* Temperature in degrees Centigrade, conductivity in umhos/cm and water chemistry in mg/L.

Table 42. 1990 Citizen Volunteer Monitoring Program (CVMP) water quality data for Cocolalla Lake.

	CVMP	CVMP	CVMP	CVMP**	CVMP***	DEQ****
Date of Sample *	05/01/90	06/12/90	07/24/90	08/28/90	08/28/90	08/28/90
Secchi sample depth (meters):	1.75	1	1.3	2	2	2
T. Ammonia	0.016	0.016	0.007	0.132	0.291	0.139
T. NO2+NO3	0.001	0.026	0.005	0.005	0.019	0.031
T. K. Nitrogen	0.42	0.4	0.5	0.36	0.37	0.38
T. Phosphorus	0.025	0.038	0.019	0.019	0.02	0.02
Ortho Phosphate	0.002	0.006	0.005	0.001	0.001	0.002
Temperature (degrees Centigrade)	9	12.5	---	19	---	20.7
Dissolved Oxygen	14.5	10.4	---	9.2	---	9
Chlorophyll a (ug/L)	6.4	9.8	16	---	---	11.5
Deep sample depth: **	10.5	12	---	11	11	11
T. Ammonia	0.024	0.009	---	0.41	0.514	0.688
T. NO2+NO3	0.001	0.02	---	0.069	0.037	0.005
T.K. Nitrogen	0.66	0.116	---	0.72	0.76	0.79
T. Phosphorus	0.03	0.04	---	0.2	0.19	0.22
Ortho Phosphate	0.002	0.007	---	0.19	0.17	0.19
Temperature	8	12.4	---	---	---	12.7
Dissolved Oxygen	13.5	9.8	---	---	---	0.2

* mg/L unless otherwise indicated.

** depth in meters.

*** CVMP duplicate samples.

**** Idaho Division of Environmental Quality/Quality Assurance/Quality Control Sample.

HAUSER LAKE:

General

Hauser Lake is located in Kootenai County, Idaho, and has 604 acres of surface water and 4 miles of shoreline with a maximum water depth of 40 feet (12.2 meters) (Figure 32). The entire littoral zone is inhabited by submergent macrophytes, except for a public swimming beach area (Plate 10).

Hauser Lake is an eutrophic lake in the process of cultural eutrophication. The contribution of phosphorus and other nutrients to the watershed from septic tanks of residential homes, runoff from roads and agricultural activities such as livestock grazing and farming have all significantly contributed to the deterioration of water quality and eutrophication in Hauser Lake.

Most of the lake bottom is silt/detritus. There are some sandy shore areas near the public swimming beach. Despite the rich organic bottom muds, there were no odors from water samples taken one meter off the lake bottom. Algal blooms were often prevalent throughout Hauser Lake in late summer.

LWQA dissolved oxygen and temperature profiles, secchi depth and chlorophyll "a" and submergent macrophyte distribution were determined once at one station in 1991. Citizen volunteer monitors (CVMP) collected water samples five times and four times, at secchi depth and one meter off the lake bottom in 1990 and 1991, respectively.

Beneficial Uses

According to Idaho Water Quality Standards, the beneficial uses of Hauser Lake are protected for: domestic water supply, agricultural water supply, cold water biota, primary contact recreation and secondary contact recreation (Table 6). The Standards protect Hauser Lake for future use as salmonid spawning. Warm water biota is an existing beneficial use not designated for Hauser Lake.

Based on the eutrophic conditions found at Hauser Lake, the following beneficial uses are threatened: domestic water supply, cold water biota, salmonid spawning, and primary contact recreation.

Both public and private commercial boat accesses exist on Hauser Lake. Residential homes and some commercial resorts are sparsely distributed on the lakeshore. Fishing, swimming, water skiing, boating, sailing and sunbathing are all intensively-used recreational opportunities on Hauser Lake. Wildlife and fisheries habitat are important. Camping opportunities are limited. A public swimming and sun-bathing beach is used extensively at the south end of the Lake.

Sources of Pollution, Nutrients and Recommended Management Actions

A number of different limnological studies have been conducted on Hauser Lake. A Phase 1 Diagnostic and Feasibility Analysis from the Clean Lakes Program was completed in 1990.

Private residential homes can be found on most of the shoreline of this heavily-used recreational Lake. Nonpoint sources of nutrients include: agricultural, grazing, drainage fields and forestry activities. Considerable internal recycling of phosphorus occurred in eutrophic Hauser Lake.

Limnological Characteristics of Hauser Lake:

Secchi Depth: 1991 LWQA range = 2.5-2.5 meters, average = 2.5 meters; 1991 CVMP range = 2.5-4.5 meters, average = 3.6 meters; 1990 CVMP range = 3.0-5.0 meters, average = 4.0 meters.

Water clarity in Hauser Lake is limited due to algal blooms throughout the summer.

Chlorophyll "a": 1991 LWQA range = 16.7-17.0 ug/L, average = 16.9 ug/L; 1991 CVMP range = 2.2-6.1 ug/L, average = 4.0 ug/L. 1990 CVMP range = 2.4-11.0 ug/L, average = 5.0 ug/L.

Phytoplankton production in Hauser Lake is extremely high. The lake is eutrophic.

Total Phosphorus: 1991 CVMP range = 0.012-0.35 mg/L, average = 0.088 mg/L; 1990 CVMP range = 0.004-0.7 mg/L, average = 0.181 mg/L.

Total phosphorus was highly variable throughout the sample period.

Dissolved Oxygen/Temperature Profiles

On July 29, 1991, the dissolved oxygen in Hauser Lake dropped from 11.5 mg/L at the surface to 0.7 mg/L at 11 meters near the lake bottom (Table 43, Figure 33). Dissolved oxygen depletion occurred in the thermocline, which extended to 9 meters. Adequate dissolved oxygen for fish in the summer was found only in the epilimnion and upper thermocline, and was severely reduced at a water depth of 7 meters and deeper. The entire hypolimnion was severely depleted of dissolved oxygen, a condition that indicated severe lake eutrophication and heavy nutrient loading in Hauser Lake.

Submergent Macrophytes

The submergent plant communities of Hauser Lake consisted of 12 different species. Each community was dominated by a few species. These species are highly dependent on water quality, the lake bottom substrate and the amount of available light. The predominant floating-leaf species was yellow water lily (Nuphar). No white water lilies were found.

Waterweed (Elodea) and robbins pondweed (Potamogeton robbinsii) were the two leading dominant submergent macrophytes found in organic bays and silt-ridden littoral areas. These species are somewhat ubiquitous in nature. However, the relative abundance of these two species may indicate that the lake is eutrophic. Robbins pondweed is quite shade-tolerant and tends to grow profusely in lakes of high phosphorus and nutrient content and low water clarity. Robbins pondweed is dominant in water of 3 and 4 meters water depth, while Elodea is dominant at water depths of 2 meters and less.

Generally, the extensive development of yellow water lily communities, and the absence of white water lily in the silt-ridden bay areas, may further illustrate the eutrophic nature of Hauser Lake. Surprisingly, water milfoil (Myriophyllum) was not found in Hauser Lake. Bladderwort (Utricularia) was found in very shallow water of less than 0.5 meters. Eleocharis (needlerush) and Isoetes (quillwort) were found in shallow, sandy littoral areas only. At five and six meters, there was a silt-ridden lake bottom of decomposing robbins pondweed.

The type of soil bottom is critical in determining the species composition of submergent plant communities. The lack of submergent plant diversity (9 species) and the domination of the submergent plant communities by waterweed and robbins pondweed, tends to indicate that Hauser Lake is highly eutrophic. These two dominant species were restricted to shallow water depth in Hauser Lake.

The submergent plant communities were consistently homogeneous in species composition. The maximum depth at which submergent macrophytes grew ranged from 4 to 5 meters. The submergent plant community makeup and the water depths at which they were found was highly dependent on the compositional makeup of the bottom substrate (i.e., sand, detritus, rock, clay, etc.), as well as the water depth and light intensity.

CVMP Water Quality Data

CVMP water chemistry data indicated that Hauser Lake is eutrophic (Tables 43-45, Figure 33). Relatively high levels of ammonia, nitrate and nitrite, and total kjehldahl nitrogen, total phosphorus and ortho-phosphate and chlorophyll "a" indicated the Lake is eutrophying. More specific discussion of some of these and other parameters can be found under specific parameter subtitles in this report.

Figure 32. Map of Hauser Lake.

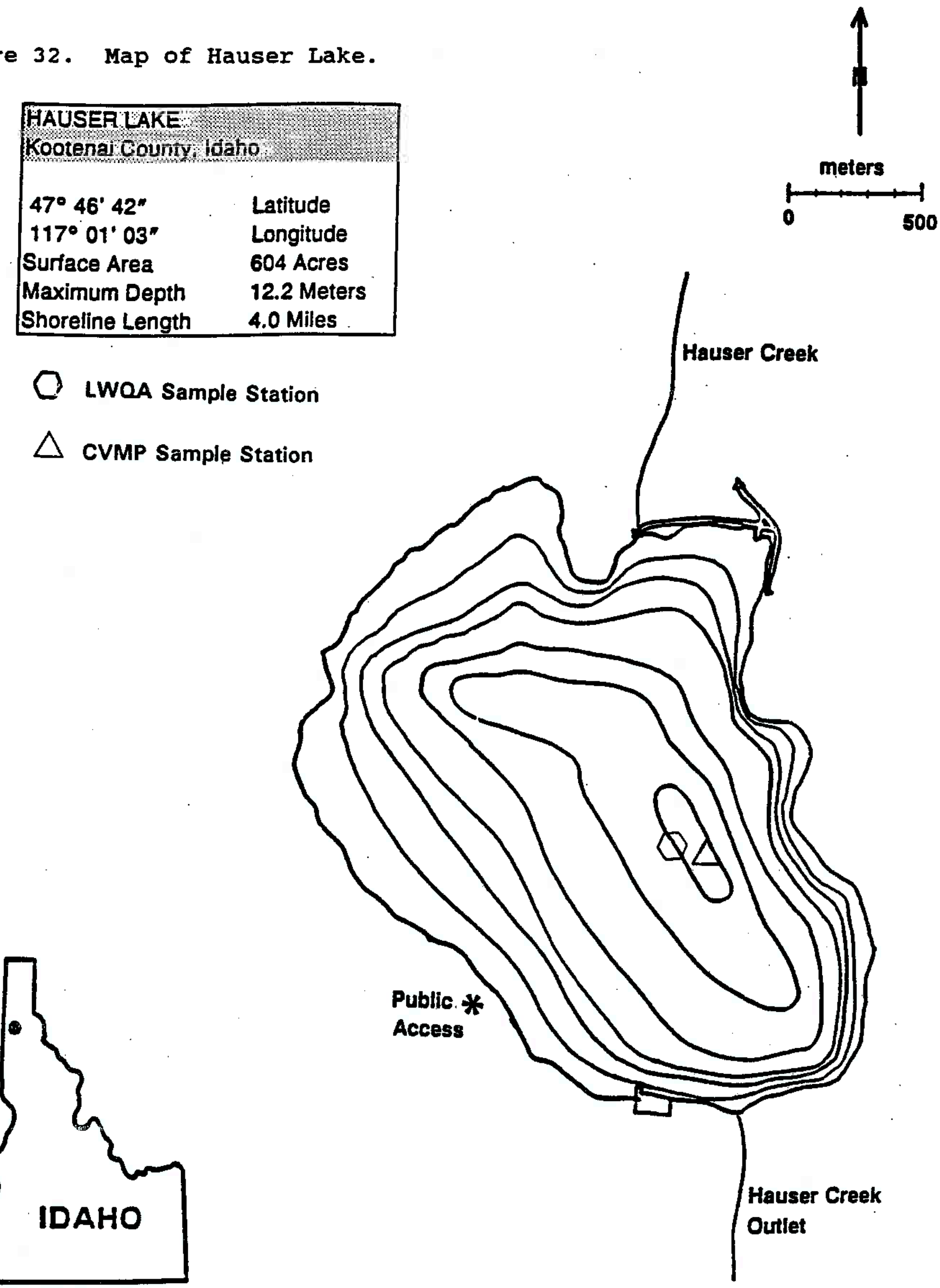


Plate 10. Hauser Lake photographs showing a public swimming beach and fishing activity among the floating-leaf vegetation.

Figure 33. Dissolved oxygen and temperature profile for Hauser Lake, July 29, 1991.

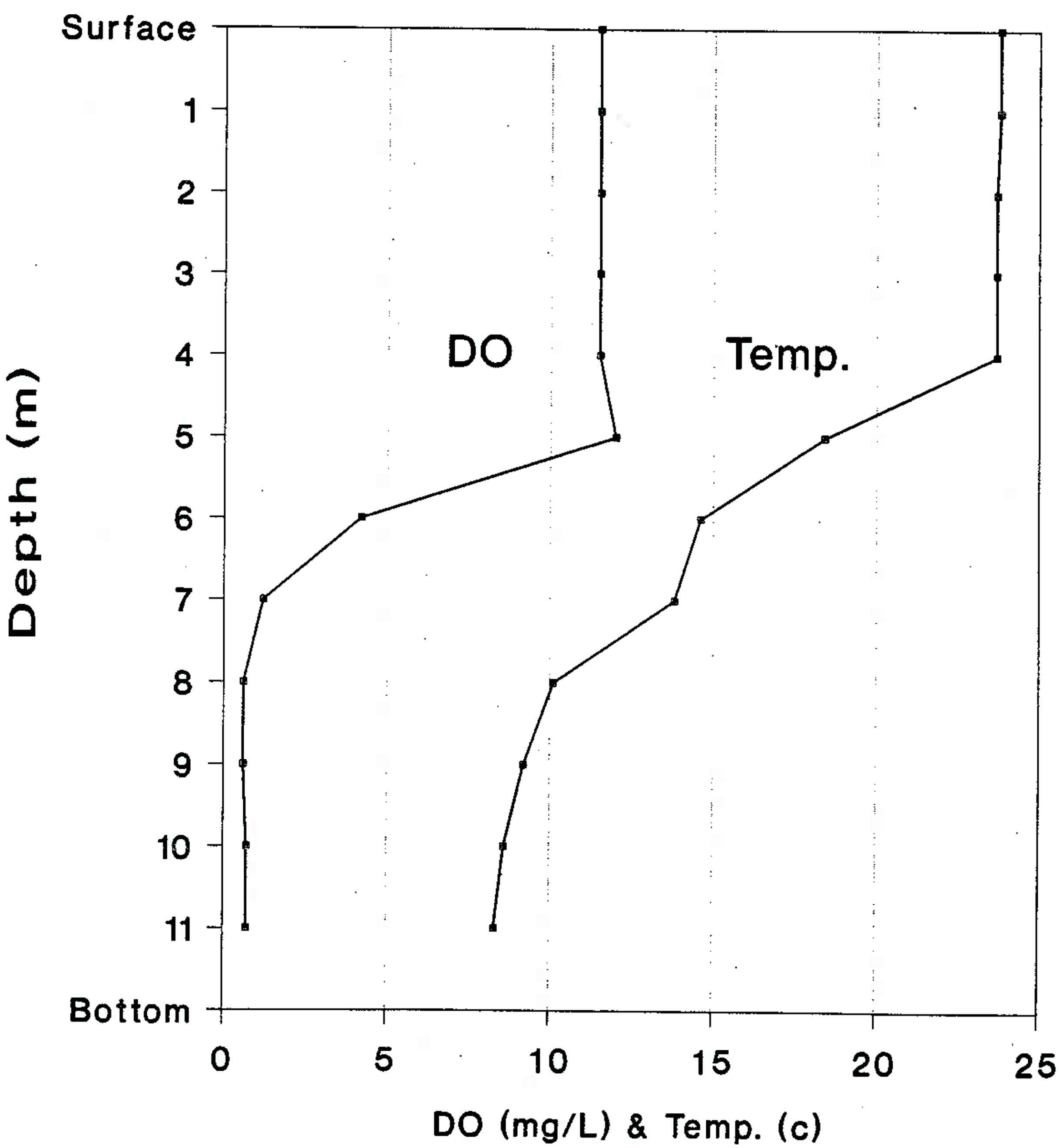


Table 43. LWQA dissolved oxygen/temperature profiles during summer thermal stratification for Hauser Lake on July 29, 1991.

Depth (meters)	Dissolved Oxygen (mg/L)	Temperature (°C)
0.0	11.5	23.8
1.0	11.5	23.8
2.0	11.5	23.7
3.0	11.5	23.7
4.0	11.5	23.7
5.0	12.0	18.4
6.0	4.2	14.6
7.0	1.2	13.8
8.0	0.6	10.1
9.0	0.6	9.2
10.0	0.7	8.6
11.0	0.7	8.3

Table 44. 1990 Citizen Volunteer Monitoring Program (CVMP) water quality data for Hauser Lake.

Date of Sample *	CVMP 04/30/90	CVMP 06/11/90	CVMP 07/21/90	CVMP 08/26/90	CVMP*** 10/14/90	CVMP*** 10/14/90
Secchi sample depth (meters):	3.5	3	5	4.75	4	4
T. Ammonia	0.032	0.005	0.047	0.371	0.03	0.048
T. NO2+NO3	0.001	0.005	0.005	0.005	0.005	0.005
T.K. Nitrogen	0.16	0.39	0.37	0.42	0.14	0.16
T. Phosphorus	0.017	0.023	0.019	0.004	0.018	0.019
Ortho phosphate	0.001	0.001	0.001	0.001	0.007	0.008
Temperature (degrees Centigrade)	11	14	18	19.5	11	11
Dissolved Oxygen	5	8	8	4	9	5
Chlorophyll a (ug/L)	2.4	4.1	11	2.9	5.3	4.2
Deep sample depth: **	11.5	12	11.5	10.5	12	12
T. Ammonia	0.15	0.323	0.44	0.66	1.14	0.982
T. NO2+NO3	0.001	0.051	0.005	0.078	0.005	0.005
T.K. Nitrogen	0.65	0.78	0.86	1.18	2.12	1.73
T. Phosphorus	0.023	0.113	0.23	0.404	0.7	0.6
Ortho phosphate	0.006	0.085	0.16	0.3	0.003	0.003
Temperature	7	8.5	14	10	10	10
Dissolved Oxygen	8	1.4	0.8	0.8	1	1

* mg/L unless otherwise indicated.
** Sample taken one meter above the lake bottom.
*** CVMP duplicate samples.

Table 45. 1991 Citizen Volunteer Monitoring Program (CVMP) water quality data for Hauser Lake.

Date of Sample *	CVMP 06/02/91	CVMP 07/03/91	CVMP 09/16/91	CVMP 10/21/91	DEQ*** 10/21/91
Secchi sample depth (meters):	4	4.5	4.5	2.5	2.5
T. Ammonia	0.037	0.031	0.054	0.086	0.068
T. NO2+NO3	0.015	0.005	0.016	0.02	0.012
T.K. Nitrogen	0.67	0.41	0.33	0.05	0.25
T. Phosphorus	0.018	0.021	0.012	0.077	0.068
Ortho phosphate	0.002	0.002	0.004	0.016	0.016
Temperature (degrees Centigrade)	--	18	18	--	7.3
Dissolved Oxygen	12	12	14	--	12.2
Chlorophyll a (ug/L)	3.4	5.1	6.1	2.2	3
Deep sample depth: **	11.5	9	10.25	9	9
T. Ammonia	0.204	0.107	0.514	0.064	0.062
T. NO2+NO3	0.005	0.01	0.012	0.007	0.015
T.K. Nitrogen	0.67	0.51	1.49	0.1	0.08
T. Phosphorus	0.16	0.109	0.35	0.03	0.033
Ortho phosphate	0.13	0.082	0.26	0.016	0.016
Temperature	10	13	12	--	12.1
Dissolved Oxygen	2	8	5	--	7

* mg/L unless otherwise indicated.

** Sample taken one meter above the lake bottom.

*** Idaho Division of Environmental Quality/Quality Assurance/Quality Control.

ROUND LAKE:

General

Round Lake is located in Bonner County, Idaho, and has 46 acres of surface water and 1.2 miles of shoreline with a maximum water depth of 34 feet (10.4 meters) (Figure 34). The shoreline of Round Lake is undeveloped except for the public swimming beach of Round Lake State Park (Plate 11).

Round Lake is eutrophic and receives its primary water source from Cocolalla Lake via Cocolalla Creek. The primary contribution of phosphorus and other nutrients to the watershed originate from septic tanks of residential homes, runoff from roads, logging and livestock grazing and farming in the Cocolalla Lake watershed. All of these activities have significantly contributed to the deterioration of water quality and eutrophication in Round Lake. The lakeshore and watershed of Round Lake is heavily forested and undeveloped. Most of the lake bottom is silt and detritus. However, there are some shore areas that have a sandy bottom such as the Round Lake State Park swimming beach area. Despite the rich organic bottom muds, there was no odor in the water sample taken near the lake bottom. A fine-grain algal bloom was prevalent throughout the lake in August.

LWQA dissolved oxygen and temperature profiles, secchi depth and other water quality data were determined five times in 1990. LWQA chlorophyll "a", dissolved oxygen and temperature profiles, secchi depth and submergent macrophyte distribution were determined once in 1991. There is no CVMP for Round Lake.

Beneficial Uses

The Idaho Water Quality Standards do not designate beneficial uses for Round Lake. The Idaho DEQ recognizes the following existing beneficial uses to Round Lake: cold water biota, warm water biota, primary contact recreation and secondary contact recreation (Table 6). Based on LWQA information, background information and best professional judgement, cold water biota and primary contact recreation are <u>threatened.</u>

Round Lake State Park is located on the north side of the Lake. A public boat access, camping and picnic areas are located at the Park. No residential homes and commercial resorts are on the Lake. Fishing, swimming, hiking and sun-bathing are all recreational opportunities. Wildlife and fisheries habitat are important.

Sources of Pollution, Nutrients and Recommended Management Actions

Very little limnological data and background information exists for Round Lake. The only lakeshore development is an Idaho State Park Campground, beach and public boat access at the north shore. This facility is well managed and maintained and presents little pollution threat to the lake at this time. Gas-powered motors are not allowed on the lake. The primary water source for Round Lake is Cocolalla Lake, another eutrophic lake. Any important management plan for maintaining or reducing phosphorus levels in Round Lake will be closely dependent on a comprehensive, watershed nutrient management plan for Cocolalla Lake. A Phase 1 Study of the Clean Water Act is just being completed for Cocolalla Lake.

Limnological Characteristics of Round Lake:

Secchi Depth: 1991 LWQA range = 3.0-3.0 meters, average = 3.0 meters; 1990 LWQA range = 2.1-2.8 meters, average = 2.4 meters.

Water clarity in Round Lake is limited due to brown-stained water and algal blooms.

Chlorophyll "a": 1991 LWQA range = 13.0-13.8 ug/L, average = 13.4 ug/L.

Phytoplankton production in Round Lake is extremely high. The lake is eutrophic.

Total Phosphorus: 1990 LWQA range = 0.020-0.380 mg/L, average = 0.082 mg/L.

During the first week in August, total phosphorus was extremely high (0.38 mg/L) near the bottom. Total ammonia (0.92 mg/L) also was high, indicating anaerobic decomposition and oxygen depletion has occurred near the bottom of the lake.

Dissolved Oxygen/Temperature Profiles

On August 6, 1991, the dissolved oxygen in Round Lake plummeted from 9.1 mg/L at the surface to 0.2 mg/L at 10 meters near the lake bottom (Table 46, Figure 35). Dissolved oxygen depletion occurred in the lower thermocline and the hypolimnion extending to 10 meters. Sufficient dissolved oxygen for fish in the summer was found only at four meters and above. The dissolved oxygen increased slightly in the thermocline, and reached near anaerobic conditions at 6 meters and throughout the remainder of the hypolimnion, a condition that indicated severe lake eutrophication and heavy nutrient loading in Round Lake.

Submergent Macrophytes

The submergent and floating-leaf aquatic plant communities of Round Lake consisted of 13 different species. Each community was dominated by a few species. These species are highly dependent on water quality, the lake bottom substrate and the amount of available light. The dominant species throughout the entire littoral zone of the Lake were: robbins pondweed, waterweed and largeleaf pondweed. The predominant floating-leaf species were Brasenia (water shield) and yellow water lily (Nuphar).

Waterweed (Elodea) and robbins pondweed (Potamogeton robbinsii) were the two leading dominant submergent macrophytes found in organic bays and silt-ridden littoral areas. These species are somewhat ubiquitous. However, the relative abundance of these two species (robbins pondweed = 90 per cent and waterweed = 70 per cent) indicated that the Lake is eutrophic. Robbins pondweed is quite shade-tolerant and tends to grow profusely in lakes of high phosphorus and nutrient content and low water clarity. While Robbins pondweed and waterweed were dominant, the maximum depth at which they grew was 2 meters.

Generally, the extensive development of water shield and yellow water lily communities, and the absence of white water lily in the silt-ridden bay areas, further illustrated the eutrophic nature of Round Lake. Eleocharis (needlerush) and Isoetes (quillwort) were not found in shallow, sandy, littoral areas. These two species are most often associated with oligotrophic lakes.

The 13 species of submergent and floating-leaf aquatic plants found in Round Lake were: Potamogeton robbinsii (robbins pondweed), Elodea (waterweed), Brasenia (water shield), Nuphar variegatum (yellow water lily), P. amplifolius (largeleaf pondweed), P. filiformis (fineleaf pondweed), P. natans (floating brownleaf pondweed), Myriophyllum verticillatum (green milfoil), P. zosteriformis (flatstem pondweed), Ceratophyllum demersum (coontail), Najas flexilis (bushy pondweed), P. epihydrus (leafy pondweed), P. Oaksianis and Zizania aquaticus. (wild rice).

The submergent plant communities were consistently homogeneous in species composition. The maximum depth at which submergent macrophytes grew ranged from 1.5 to 2.0 meters. The slightly brown-stained water and limited water clarity (secchi depth = 3.0 meters) contributed to the limited depth at which submergent aquatic plants were found in Round Lake.

LWQA Water Quality Data

LWQA water chemistry data indicated that Round Lake is eutrophic (Tables 46-48, Figure 35). Relatively high levels of ammonia, nitrate and nitrite, and total kjehldahl nitrogen, total phosphorus and ortho-phosphate and chlorophyll "a" indicate the Lake is eutrophying. More specific discussion of some of these and other parameters can be found under specific parameter subtitles in this report.

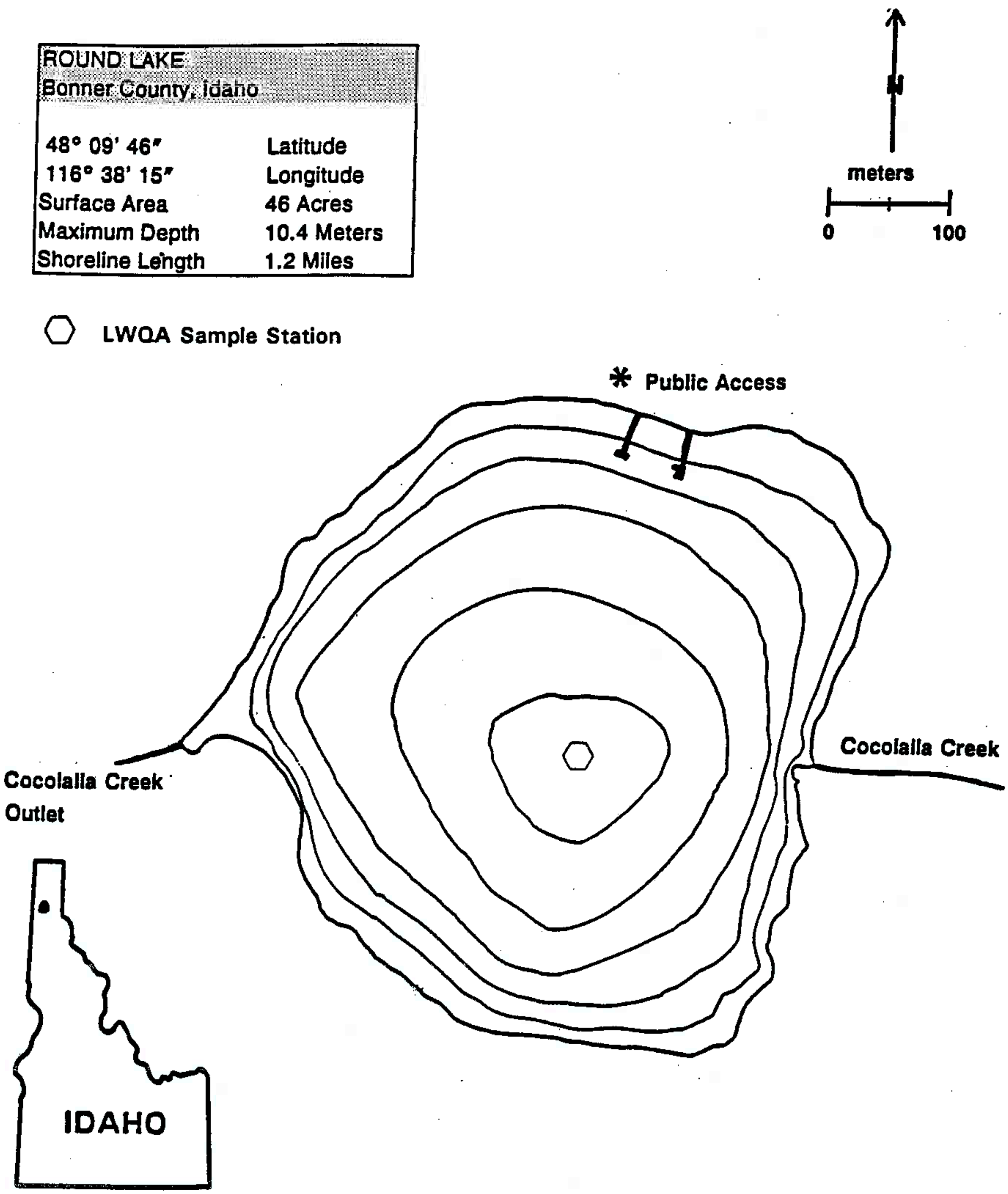


Figure 34. Map of Round Lake.

Plate 11. Round Lake photographs showing undeveloped lakeshore and Round Lake State Park swimming beach and non-motorized boat access.

Figure 35. Dissolved oxygen and temperature profile for Round Lake, August 6, 1991.

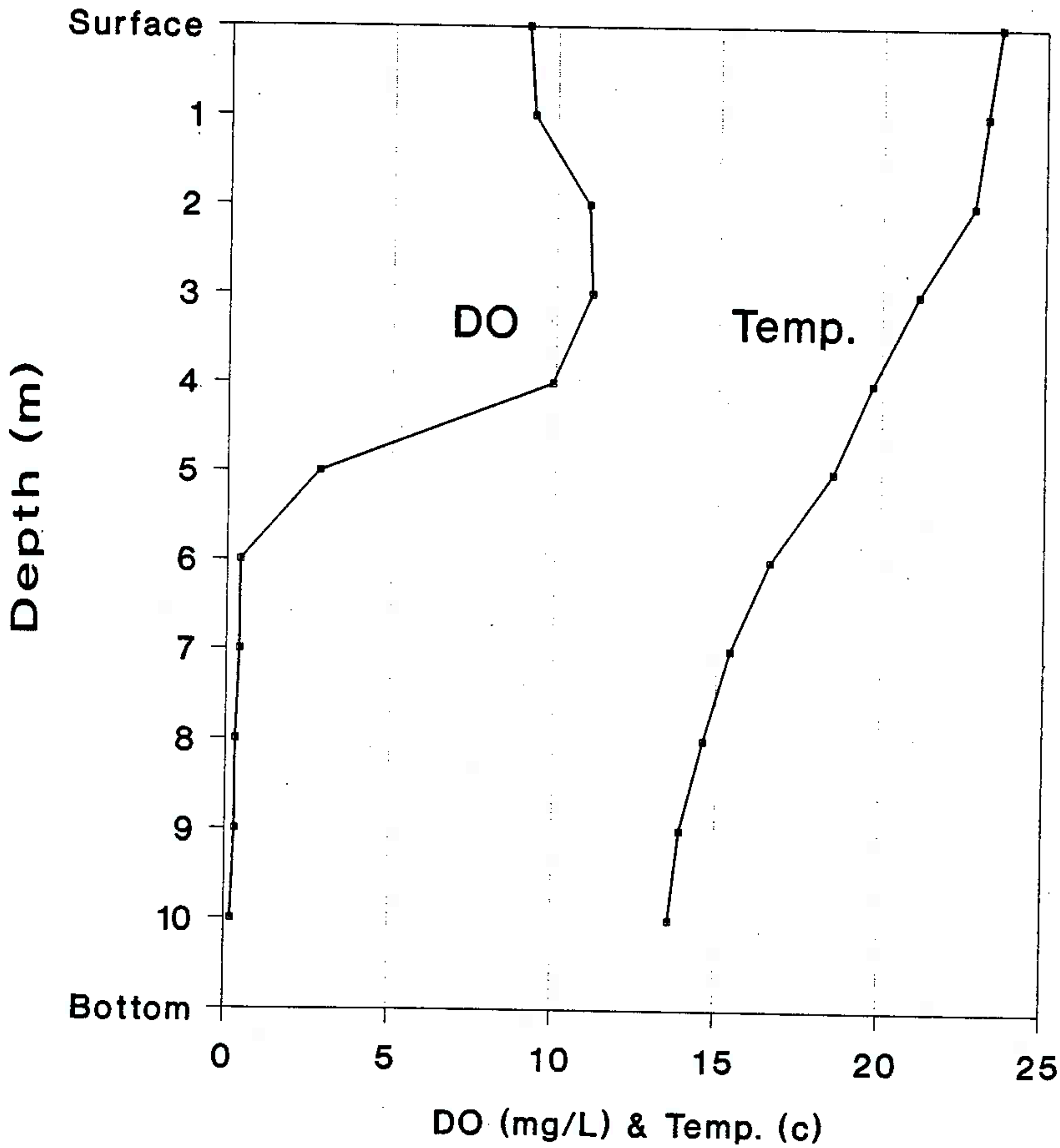


Table 46. LWQA dissolved oxygen/temperature profiles, specific conductivity and pH during summer thermal stratification for Round Lake on August 6, 1991.

Depth (meters)	Dissolved Oxygen (mg/L)	Temperature (°C)	Specific Conductance (umhos/cm)	pH
0.0	9.1	23.6	70.0	7.8
1.0	9.3	23.2	69.0	7.8
2.0	11.0	22.8	70.0	8.0
3.0	11.1	21.1	71.0	8.0
4.0	9.9	19.7	71.0	7.3
5.0	2.8	18.5	70.0	6.0
6.0	0.4	16.6	65.0	5.8
7.0	0.4	15.4	61.0	5.7
8.0	0.3	14.6	78.0	5.8
9.0	0.3	13.9	93.0	5.9
10.0	0.2	13.6	101.0	5.9

Table 47. 1990 Lake Water Quality Assessment (LWQA) water chemistry data for Round Lake. *

Date	5-21-90	5-21-90	6-26-90	6-26-90	8-8-90	8-8-90	10-23-90	10-23-90
Time	1300	1300	0845	0845	1000	1000	1000	1000
Sample Depth	9.5	1	9	3	9	2	9	2
Total Depth	10.5	10.5	10.5	10.5	10.3	10.3	10.2	10.2
Secchi Depth	2.1	2.1	2.8	2.8	2.3	2.3	2.3	2.3
T. NH3-N	0.065	0.059	0.164	0.038	0.921	0.051	0.316	0.27
T. NO2+NO3-N	<.005	<.005	0.006	<.005	<.005	<.005	0.046	0.03
T. Kjeldahl-N	0.42	0.26	0.49	0.38	0.367	0.98	0.97	0.8
T. Phosphorus-P	0.029	0.027	0.079	0.029	0.38	0.02	0.046	0.043
Dissl. Phosphate-P	0.001	0.001	0.026	0.002	0.3	<.002	0.005	0.002
Hardness-CaCO3	24	24	28	24	32	28	32	36
T.Alkalinity-CaCO3	23	23	27	24	37	29	37	36

* Depth in meters and water chemistry data in mg/L.

Table 48. 1990 Lake Water Quality Assessment (LWQA) dissolved oxygen, temperature, conductivity and pH for Round Lake. *

	5-21				6-26				8-8				9-19				10-23			
Meters	Temp	pH	Cond.	D.O.	Temp.	pH	Cond.	D.O.	Temp.	pH	Cond	D.O	Temp	pH	Cond.	D.O.	Temp.	pH	Cond.	D.O.
1	12.8	6.3	64	9.6	20.6	6.9	66	10.1	23.5	8.1	78	9.3	18.4	6.8	82	8.9	10.2	6	90	7.4
2	12.2	6.4	65	9.3	20	7	67	9.8	23.4	8.1	78	9.4	18.1	7	81	9	10.1	6.1	90	7
3	12	6.4	65	9.1	19.4	6.8	67	9.4	22.1	7.9	78	9.6	18	7.1	81	9.2	10	6.1	90	6.9
4	12	6.4	65	9.1	18.4	6.7	67	9.3	20.4	7	79	7.6	17.8	7.2	81	9.1	10	6.1	90	6.8
5	12	6.4	64	9	17.4	6.6	66	9	19.1	6.3	79	2.6	17.2	6.2	82	5.9	10	6.2	89	6.9
6	12	6.4	65	9	16.5	6.3	66	7.8	18	5.9	73	0.3	16.9	6.2	82	6	10	6.2	90	6.8
7	12	6.4	65	9	15.5	6.2	66	6.8	16.6	5.8	71	0.3	16.5	6	81	4.9	9.9	6.2	91	6.6
8	11.9	6.5	65	9	14.6	6.1	66	5.6	14.6	5.8	85	0.2	14.7	6	108	0.4	9.9	6.2	91	6.5
9	11.9	6.5	65	9	13.6	5.9	67	2.7	13.7	5.9	101	0.2	13.5	6.1	152	0.3	9.8	6.1	92	6.4

* Temperature in degrees Centigrade, conductivity in umhos/cm and dissolved oxygen in mg/L.

GRANITE LAKE:

General

Granite Lake is located in Bonner County, Idaho, and has 20 acres of surface water and 0.9 miles of shoreline with a maximum water depth of 79 feet (24 meters) (Figure 36). Granite Lake has variable watershed topography, no residential shoreline development and brown-stained water (Plate 12).

Granite Lake appears to be sort of an anomally in the spectrum of lake types found in North Idaho. Most likely, Granite Lake never fully mixes and remains thermally stratified in the summer. Preliminary data indicated that it is a meromictic lake of relatively high total dissolved solids with a specific conductivity ranging from 86 umhos at the surface to 296 umhos near the lake bottom at 21 meters. The dissolved oxygen is rapidly depleted from 7.1 mg/L at the surface to 0.6 mg/L at 5 meters. The dissolved oxygen continued to be less than 1 mg/L from the 5 meter depth to the lake bottom. The brown-stained water contributed to the absorption of light and may have accounted for the extremely narrow epilimnion/thermocline and the extreme cold water found at five meters during summer thermal stratification. Secchi depth readings of four meters were primarily a result of brown-stained colored water, since algae blooms were not evident during the sample period.

The thick, grey-black cold, lake bottom sediment was many feet deep. Undoubtedly, this was a major factor in the recycling of high phosphorus, iron and manganese minerals throughout the Lake. Undoubtedly, the meromictic nature of Granite Lake has been maintained by these large, thick reserves of bottom muds laden with nutrients and minerals.

LWQA dissolved oxygen and temperature profiles and secchi depth were determined four times in 1990. LWQA water samples were taken five times in 1990 and analyzed for nutrients and metals. LWQA dissolved oxygen and temperature profiles, secchi depth, chlorophyll "a" and submergent macrophyte distribution were determined once in 1991. No CVMP exists for Granite Lake.

Beneficial Uses

The Idaho Water Quality Standards do not address beneficial uses for Granite Lake. Existing beneficial uses of Granite Lake are: cold water biota, warm water biota, and secondary contact recreation (Table 6). The limited data base for Granite Lake prevents designation of additional beneficial uses.

Based on the eutrophic nature of Granite Lake, the cold water biota use is <u>impaired</u>. The majority of the water column in Granite Lake is anaerobic in late August. Also, total hypolimnetic ammonia concentrations (4.8 mg/L) exceeded the DEQ Water Quality Standard of 2.2 mg/L. The narrow littoral zone in Granite Lake, along with low dissolved oxygen at the bottom (0.3 mg/L) <u>threaten</u> the warm water biota.

With a narrow littoral zone, steep drop-off and anoxic hypolimnion, it is unlikely that a cold-water fisheries would be productive in this lake. Largemouth bass and other warm-water fisheries may do well in these stained waters. Fishing is limited due to extremely low dissolved oxygen levels in most of the Lake. One undeveloped boat access is available at the northwest end of the lake. Aesthetic and visual quality is apparent. There were limited camping opportunities with no facilities.

Sources of Pollution, Nutrients and Recommended Management Actions

Granite Lake is an additional eutrophic, meromictic lake with coffee-stained water. Very high iron and manganese levels, along with high tannins and lignins, most likely account for the coffee-colored water. There are no known sources of nutrients from the watershed. Very little additional limnological data or background information exists for Granite Lake. No management action is recommended at this time.

Limnological Characteristics of Granite Lake:

Secchi Depth: 1991 LWQA range = 4.0-4.0 meters, average = 4.0 meters; 1990 LWQA range = 3.6-5.5 meters, average = 4.9 meters.

Granite Lake is highly brown-water stained. Consequently, water clarity is limited to 4 meters. A zooplankton bloom was evident at the surface of the Lake.

Chlorophyll "a": 1991 LWQA range = 9.0-9.0 ug/L, average = 9.0 ug/L.

Phytoplankton production in August for Granite Lake was relatively high (9.0 ug/L).

Total Phosphorus: 1990 LWQA range = 0.01-0.97 mg/L, average = 0.33 mg/L.

Phosphorus levels were highly variable throughout the seasons sampled. However, relatively high phosphorus levels were found for all water samples taken approximately one meter off the lake bottom. This indicated that, most likely, considerable internal phosphorus recycling has been occurring in Granite Lake.

Dissolved Oxygen/Temperature Profiles

Both dissolved oxygen and water temperature dropped very rapidly between two and five meters water depth (Table 49, Figure 37). The extreme changes in dissolved oxygen from the surface to five meters indicated excessive nutrient loading and oxygen consumption. There was virtually no oxygen in the Lake from 5 meters to the lake bottom. Undoubtedly, the high organic and mineral-rich lake bottom sediment have contributed significantly to oxygen depletion in Granite Lake.

Total ammonia and total Kjeldahl-nitrogen were excessively high, further indicating that most of the deep water is consuming most of the oxygen in the near-anoxic water column.

Total iron and total manganese levels were extremely high in Granite lake. Total iron levels were as high as 32,500 ug/L and manganese was as high as 1,860 ug/L.

Granite Lake is eutrophic and meromictic. The odoriferous, rich organic lake bottom muds, accompanied by a narrow littoral zone, all contributed to the severe oxygen depletion that occurs from 5 meters to the lake bottom. The dissolved oxygen profile is classic for a late eutrophic lake with rapid oxygen depletion in the thermocline, and anoxic conditions, not only throughout the hypolimnion, but in the lower thermocline as well. Consequently, there is very little area in Granite lake that has ample oxygen to support fish life.

Submergent Macrophytes

The submergent macrophyte communities of Granite Lake were comprised of eleven species and were distributed in a very narrow littoral band along the shoreline. A combination of steep drop-offs and highly stained water contributed to the narrow band of submergent aquatic plant growth. There were only two large, shallow water bays that had an expansive submergent plant community.

The submergent plant community was dominated by largeleaf floating pondweed (*Potamogeton amplifolius*), coontail (*Ceratophyllum demersum*) and water milfoil (*Myriophyllum exalbescens*). The floating-leaf community was dominated by water shield (*Brasenia*) and yellow water lily (*Nuphar*). These dominant submergent macrophytes were typically indicative of late mesotrophic/eutrophic lake trophic conditions.

LWQA Water Quality Data

LWQA water chemistry data indicated that Granite Lake is eutrophic, and most likely meromictic Tables 49-51, Figure 37). High levels of ammonia, nitrate and nitrite, and total kjehldahl nitrogen, total phosphorus and ortho-phosphate, chlorophyll "a" and specific conductivity indicated the Lake is eutrophic. More specific discussion of some of these and other parameters can be found under specific parameter subtitles in this report.

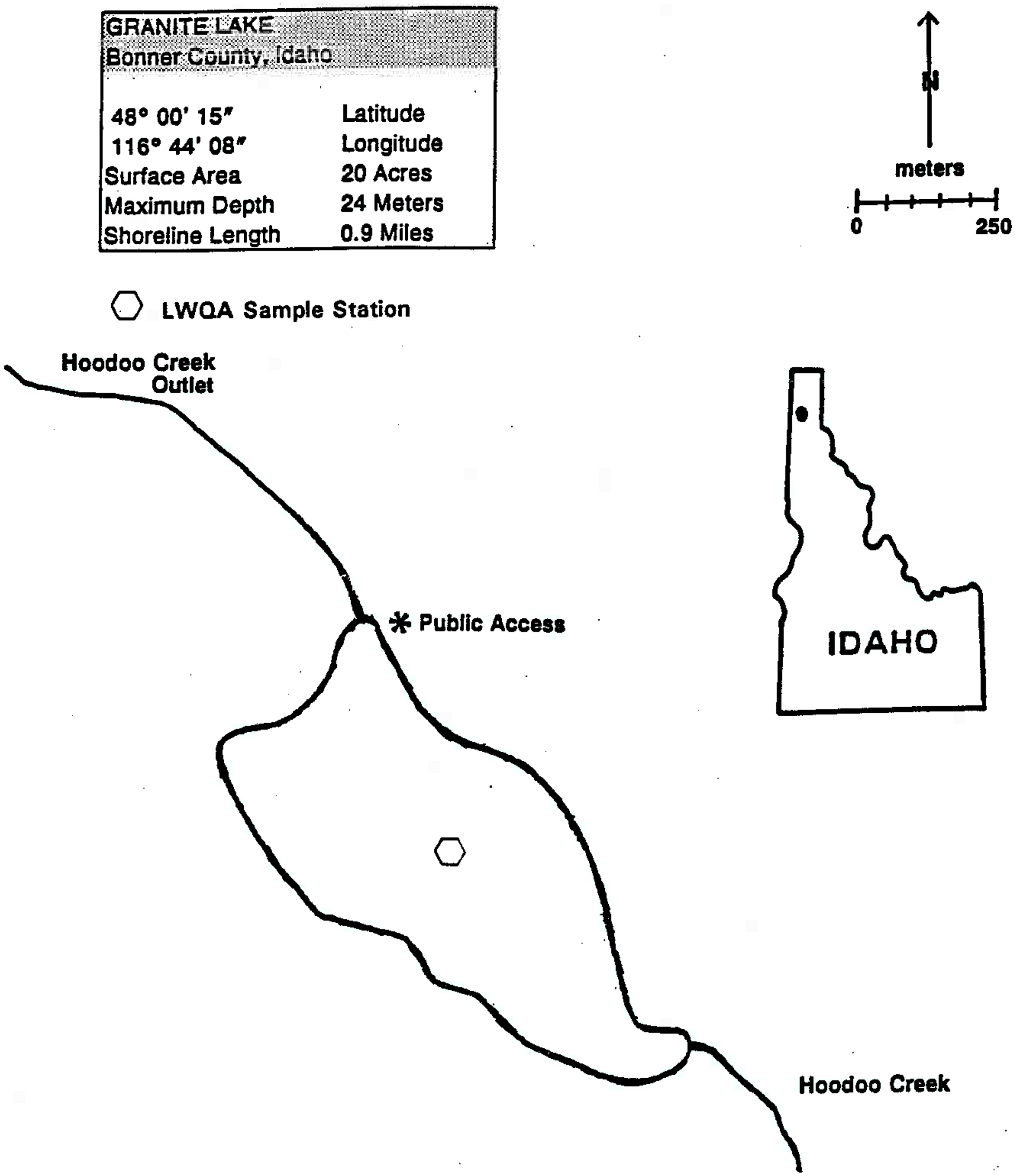


Figure 36. Map of Granite Lake.

Plate 12. Granite Lake photographs showing the public access, both flat and steep terrain and the narrow littoral zone of dark-stained Granite Lake.

Figure 37. Dissolved oxygen and temperature profile for Granite Lake, August 5, 1991.

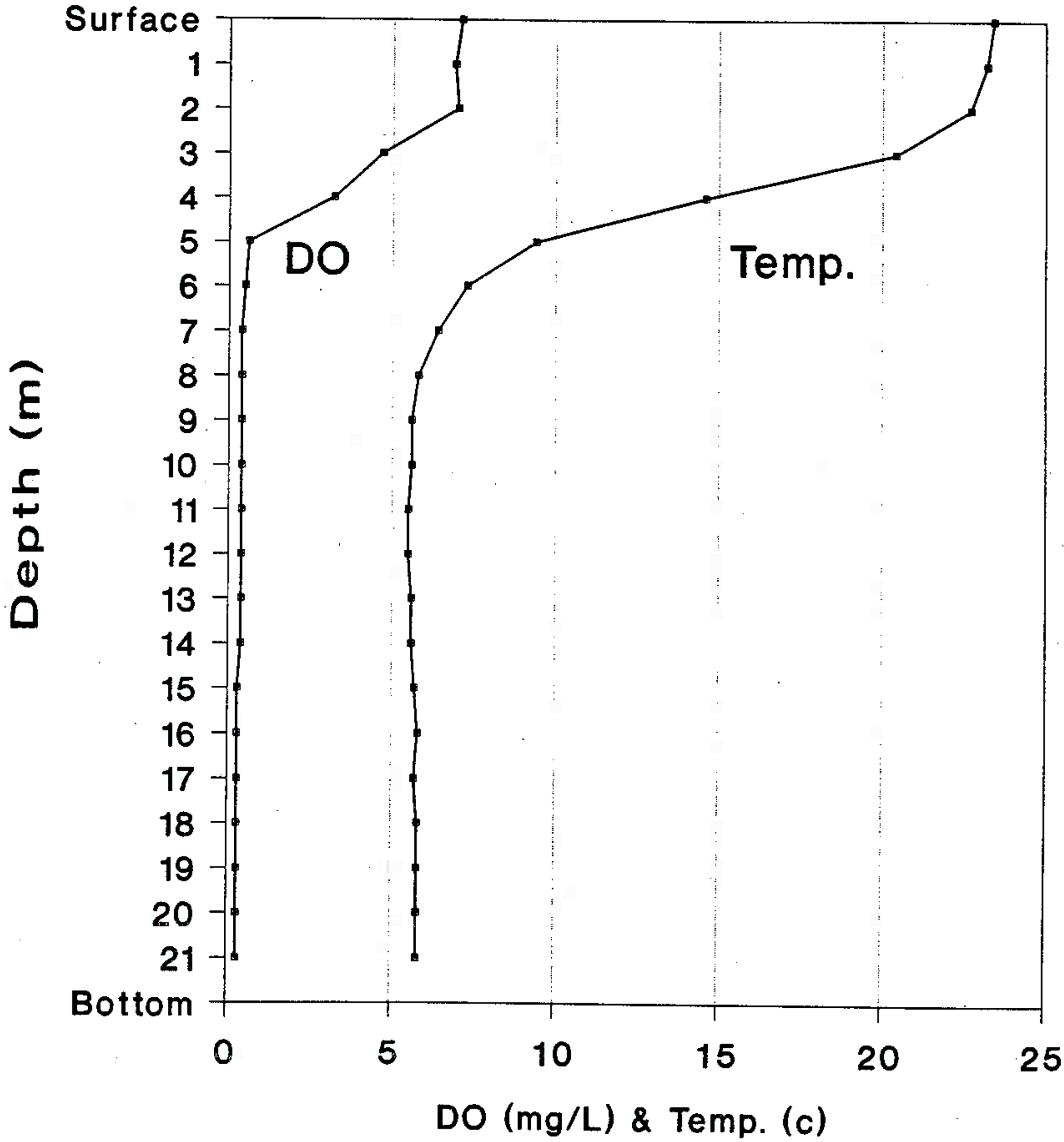


Table 49. LWQA dissolved oxygen/temperature profiles, specific conductivity and pH during summer thermal stratification for Granite Lake on August 5, 1991.

Depth (meters)	Dissolved Oxygen (mg/L)	Temperature (°C)	Specific Conductance (umhos/cm)	pH
0.0	7.1	23.4	86.0	6.6
1.0	6.9	23.2	85.0	6.6
2.0	7.0	22.7	85.0	6.6
3.0	4.7	20.4	85.0	6.1
4.0	3.2	14.6	100.0	6.0
5.0	0.6	9.4	113.0	5.9
6.0	0.5	7.3	118.0	5.9
7.0	0.4	6.4	122.0	5.9
8.0	0.4	5.8	131.0	5.9
9.0	0.4	5.6	139.0	5.9
10.0	0.4	5.6	154.0	6.0
11.0	0.4	5.5	192.0	6.1
12.0	0.4	5.5	236.0	6.2
13.0	0.4	5.6	264.0	6.3
14.0	0.4	5.6	272.0	6.3
15.0	0.3	5.7	278.0	6.3
16.0	0.3	5.8	284.0	6.3
17.0	0.3	5.7	288.0	6.3
18.0	0.3	5.8	290.0	6.3
19.0	0.3	5.8	292.0	6.3
20.0	0.3	5.8	294.0	6.3
21.0	0.3	5.8	296.0	6.3

Table 50. 1990 Lake Water Quality Assessment (LWQA) water chemistry for Granite Lake.

Date	5-22	5-22	6-26	6-26	8-6	8-6	8-6	8-6	9-17	9-17	9-17	9-17	9-17	9-17	10-30	10-30	10-30
Time	1100	1100	1040	1040	1400	1400	1400	1400	1000	1000	1000	1000	1000	1000	0845	0845	0845
Sample Depth (meters)	30	3	33	4	30	15	6	3	30	21	12	9.5	5	2	32	8	4.5
Total Depth	--	--	36.9	36.9	32.6	32.6	32.6	32.6	34.1	34.1	34.1	34.1	34.1	34.1	--	--	--
Secchi Depth	3.6	3.6	3.7	3.7	5.5	5.5	5.5	5.5	5.4	5.4	5.4	5.4	5.4	5.4	--	--	--
T. NH3-N (mg/L)	4.05	0.061	3.45	0.037	4.78	3.62	0.036	0.067	3.94	3.81	1.74	0.88	0.056	0.049	27.7	0.071	0.099
T. NO2+NO3-N	<.005	0.008	<.005	0.008	0.008	0.018	0.039	<.005	<.005	<.005	<.005	<.005	<.005	<.005	<.005	0.01	<.005
T. Kjeldahl-N	5.27	0.49	3.94	0.36	5.02	6.68	0.87	0.51	4.3	3.98	2.46	1.47	0.32	0.33	0.96	0.27	0.36
T. Phosphorus-P	0.86	0.015	0.67	0.013	0.8	0.4	0.014	0.012	0.94	0.72	0.17	0.037	0.009	0.013	0.97	0.01	0.011
Dissl. Phosphate-P	0.8	0.003	0.46	0.002	0.8	0.37	<.002	<.002	0.87	0.69	0.15	0.003	<.001	<.001	0.88	<.002	<.002
Conductivity	--	--	217	97	253	247	125	99	--	--	--	--	--	--	--	--	--
Hardness-CaCO3	88	36	112	40	99	97	48	40	--	--	--	--	--	--	120	48	48
T.Alkalinity-CaCO3	102	39	106	43	126	120	54	41	--	--	--	--	--	--	132	52	50
Calcium	27	10	25	11	33	32	15	10	33	33	30	23	14	11	--	--	--
Magnesium	3	2	3.5	2.2	4	4.1	2.6	2.3	3.9	3.9	3.6	3.1	2.2	2.1	--	--	--
Sodium	5	4	5	4.2	5.4	5.4	4.6	4.2	5.2	5.3	5.1	4.9	4.3	4.6	--	--	--
Potassium	2	2	2.2	1.7	2.4	2.7	2	1.5	2.1	2.5	2	2	1.9	1.6	--	--	--
Chloride	4	1	2	0.9	1.5	1.5	1.8	0.9	2	2	2	1	1	1	--	--	--
Fluoride	0.23	0.35	--	--	0.18	0.16	0.16	0.16	0.15	0.18	0.15	0.18	0.19	0.27	--	--	--
Sulphate-SO4	<5	<5	17	<1	25	17	<5	<5	--	--	--	--	--	--	--	--	--
Silica-SiO2	30	24	34	23	32	30	20	20	35	34	29	26	22	24	--	--	--
Turbidity(NTU)	--	--	26	0.39	44	26	7	0.3	--	--	--	--	--	--	--	--	--
pH(SU)	--	--	6.9	6.9	7	7	6.7	6.9	--	--	--	--	--	--	6.9	7.2	7.1
Total Arsenic (ug/L)	--	--	--	--	11	6	<10	<10	13	12	5	<5	<5	<5	15	<5	<5
Total Boron (ug/L)	--	--	--	--	--	--	--	--	--	--	--	--	--	--	<100	<100	<100
Total Cadmium (ug/L)	--	--	--	--	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5
Total Chromium (ug/L)	--	--	--	--	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Total Copper (ug/L)	--	--	--	--	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	7	6	7
Total Iron (ug/L)	--	--	--	--	--	--	--	--	32800	25200	13700	7200	360	220	29000	215	295
Total Lead (ug/L)	--	--	--	--	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Total Manganese (ug/L)	--	--	--	--	1840	1640	270	50	1860	1840	1560	1480	320	30	1780	250	170
Total Mercury (ug/L)	--	--	--	--	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5
Total Nickel (ug/L)	--	--	--	--	20	20	<10	<10	<20	<20	<20	<20	<20	<20	<20	<20	<20
Total Silver (ug/L)	--	--	--	--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total Zinc (ug/L)	--	--	--	--	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chlorophylla (ug/L)	--	--	--	--	--	--	--	--	--	--	--	55	1.2	1.2	--	--	7.9

Table 51. 1990 Lake Water Quality Assessment (LWQA) dissolved oxygen, temperature, conductivity and pH for Granite Lake. *

	6-26-90				9-17-90				9-24-90				10-30-90			
Meters	Temp	Ph	Cond	D.O.	Temp	Ph	Cond	D.O.	Temp	Ph	Cond	D.O.	Temp	Ph	Cond	D.O.
1	22.2	6.1	91	6	17	6.4	102	7.4	16.4	6.6	104	8.1	7.8	6.5	114	7.8
3	17.4	6.1	90	4.7	16.9	6.4	102	7.3	15.8	6.5	103	7.9	7.8	6.5	114	7.6
6	6.8	6.1	115	0.9	8.4	5.9	132	0.3	9.4	6	132	0.6	7.7	6.5	114	7.6
9	5.4	6.4	148	0.3	5.9	5.9	169	0.2	6.1	6	168	0.5	6.3	6.2	174	0.5
12	5.4	6.4	245	0.3	5.5	6.3	269	0.2	5.7	6.3	278	0.4	5.6	6.5	279	0.3
15	5.7	6.4	303	0.3	5.6	6.3	313	0.2	5.8	6.4	312	0.3	5.7	6.5	314	0.3
18	5.9	6.4	329	0.3	5.8	6.4	330	0.2	5.8	6.4	328	0.3	5.7	6.6	330	0.3
21	5.9	6.4	333	0.3	5.8	6.4	336	0.2	5.9	6.4	336	0.3	5.8	6.5	338	0.3
24	6	6.4	339	0.3	5.8	6.4	346	0.2	5.9	6.4	341	0.3	5.8	6.5	341	0.3
27	6	6.5	382	0.3	--	--	--	--	5.9	6.4	344	0.3	5.8	6.5	343	0.3
30	6	6.5	344	0.4	--	--	--	--	5.9	6.4	349	0.3	5.8	6.5	348	0.3
33	6.1	6.5	343	0.4	--	--	--	--	5.9	6.4	348	0.3	5.9	6.5	348	0.3
36	6.1	6.5	347	0.5	--	--	--	--	5.9	6.4	352	0.3	5.9	6.5	351	0.3

* Temperature in degrees Centigrade, conductivity in μmhos/cm and dissolved oxygen in mg/L.

SOLDIER'S MEADOW RESERVOIR:

General

Soldier's Meadow Reservoir is located in Nez Perce County, Idaho, and has 120 acres of surface water and 2.6 miles of shoreline with a maximum water depth of 46 feet (14 meters) (Figure 38). Soldier's Meadow has extremely fluctuating water levels and is used as an agricultural water source (Plate 13).

Soldier's Meadow Reservoir on August 20, 1991, had an extensive, fine/granular, blue-green algal bloom and only one submergent macrophyte species, Nitella at 1.5 meters maximum depth growing from a clay lake bottom. The red clay shoreline and banks showed extensive and obvious steps or terraces (Plate 13) from the drawdown of water for irrigation of crops in the watershed or downstream. Many windfall lodgepole pine are down and dead on the shoreline.

LWQA dissolved oxygen and temperature profiles and secchi depth were determined four times in 1990. LWQA water samples were taken four times in 1990. LWQA dissolved oxygen and temperature profile, secchi depth, chlorophyll "a" and submergent macrophyte distribution were determined once in 1991. No CVMP exists for Soldiers Meadow Reservoir.

Beneficial Uses

There are no beneficial use designations in the Idaho Water Quality Standards for Soldiers Meadow Reservoir. Existing beneficial uses include: agricultural water supply, cold water biota, primary contact recreation, and secondary contact recreation (Table 6).

Cold water biota beneficial use in Soldier's Meadow Reservoir appears to be threatened. The presence of dead trout in the lake and significant dissolved oxygen depletion in the hypolimnion (1.4 mg/L) was indicative of a stressed lake.

Additional uses of the Reservoir include: camping, fishing, boating, swimming, irrigation, waterfowl and fisheries habitat. A boat access is located at the north end of the Lake. Camping facilities are at the northwest and southeast end of the Reservoir.

Sources of Pollution, Nutrients and Recommended Management Actions

Nonpoint source nutrient pollution of Soldier's Meadow Reservoir originates from soil erosion in the watershed and shoreline. Extreme drawdown and water level fluctuation to supply irrigation water for agricultural cropland account for intensive shoreline bank erosion of clay and silt into the Lake.

Recommended management action is to implement agricultural BMP's in Soldier's Meadow watershed, thereby reducing nutrient and sediment loading to the Lake. The extreme drawdown and accompanying variation in water level have prevented the development of a submergent aquatic plant community. These fluctuations in water level prevent the development of a productive fishery that is dependent on aquatic plants for cover, food and reproduction. Maintenance of a more consistent water level in Soldier's Meadow would allow for a more stable and diverse biological system.

Limnological Characteristics of Soldier's Meadow Reservoir:

Secchi Depth: 1991 LWQA range = 2.1-2.1 meters, average = 2.1 meters; 1990 LWQA range = 1.5-2.6 meters, average = 2.0 meters.

Water clarity and visibility is poor, most likely, due to a combination of suspended sediments and algae.

Chlorophyll "a": 1991 LWQA range = 6.7-7.7 ug/L, average = 7.2 ug/L.

Phytoplankton production is relatively high for this fertile lake.

Total Phosphorus: 1990 LWQA range = 0.050-0.108 mg/L, average = 0.05 mg/L.

Phosphorus levels are relatively high.

Dissolved Oxygen/Temperature Profiles

Soldier's Meadow was thermally stratified in August and showed significant progressive oxygen depletion from the surface through the hypolimnion, ranging from 9.1 mg/L to 1.4 mg/L at 11 meters (Table 52, Figure 39). This depletion of oxygen was the result of plankton die-offs and bacteria activity breaking down the organic materials in the hypolimnion. Once the Lake turned over in the fall, the dissolved oxygen level was relatively uniform and restored throughout the water column (8.8 mg/L).

Submergent Macrophytes

Only sparse stands of Nitella were found.

LWQA Water Quality Data

LWQA water chemistry data indicated that Soldier's Meadow Reservoir is eutrophic (Tables 52-54, Figure 39). Relatively high levels of ammonia, nitrate and nitrite, and total kjehldahl nitrogen, total phosphorus and ortho-phosphate, chlorophyll "a" indicated the Lake is eutrophic. More specific discussion of some of these and other parameters can be found under specific parameter subtitles in this report.

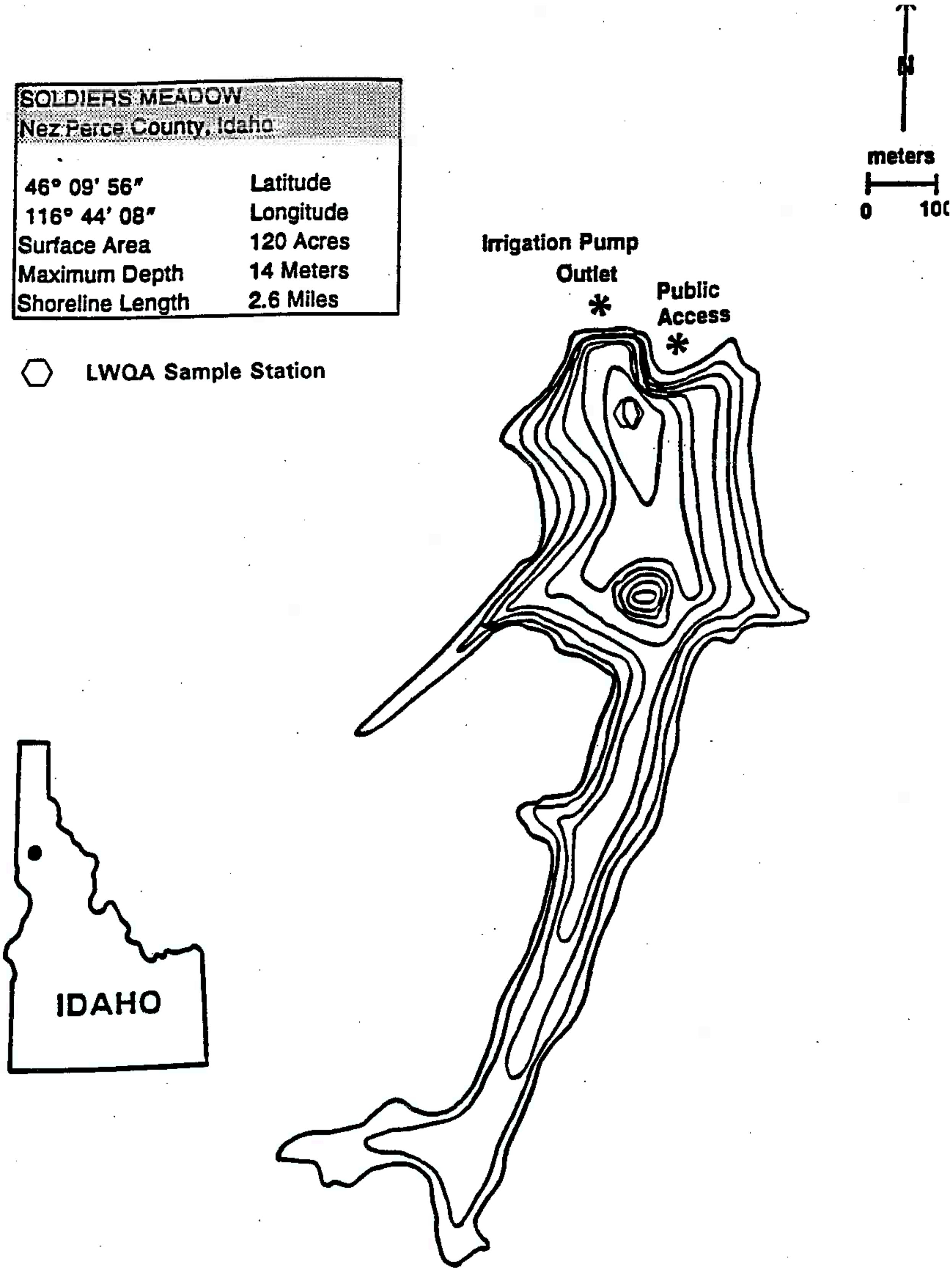


Figure 38. Map of Soldier's Meadow Reservoir.

Plate 13. Soldier's Meadow Reservoir photographs showing public access and dike road and characteristic "stepped shoreline layers" from rapid, periodic water drawdown. Note lack of submergent aquatic vegetation.

Figure 39. Dissolved oxygen and temperature profile for Soldier's Meadow Reservoir, August 20, 1991.

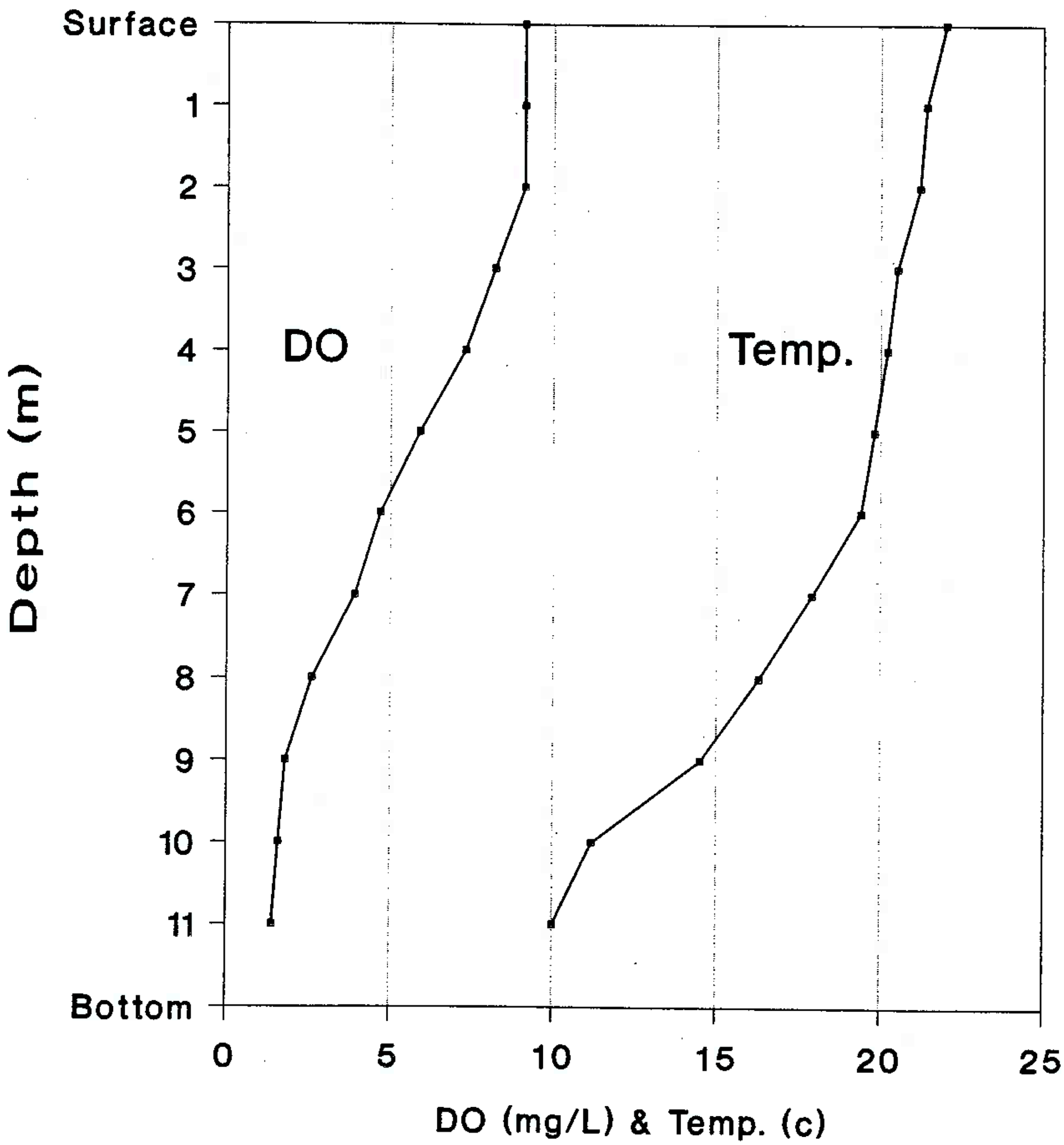


Table 52. LWQA dissolved oxygen/temperature profiles, specific conductivity and pH during summer thermal stratification for Soldiers Meadow Lake on August 20, 1991.

Depth (meters)	Dissolved Oxygen (mg/L)	Temperature (°C)	Specific Conductance (umhos/cm)	pH
0.0	9.1	22.0	54.0	8.1
1.0	9.1	21.4	55.0	8.1
2.0	9.1	21.2	54.0	8.1
3.0	8.2	20.5	54.0	7.7
4.0	7.3	20.2	54.0	7.2
5.0	5.9	19.8	54.0	6.6
6.0	4.7	19.4	55.0	6.4
7.0	3.9	17.9	56.0	5.9
8.0	2.6	16.3	58.0	5.8
9.0	1.8	14.5	65.0	5.8
10.0	1.6	11.2	82.0	5.9
11.0	1.4	10.0	92.0	5.9

Table 53. 1990 Lake Water Quality Assessment (LWQA) dissolved oxygen, temperature, conductivity and pH for Soldiers Meadow Lake. *

	6–20				8–1				9–13				10–24			
Meters	Temp.	pH	Cond.	D.O.	Temp.	pH	Cond.	D.O.	Temp.	pH	Cond.	D.O.	Temp.	pH	Cond.	D.O.
1	16	6.7	57	9	21.2	7.2	61	7.8	17.8	8	63	9.6	7.3	6.3	63	8.9
2	15.5	6.5	61	9	20.9	7.2	60	7.9	17.8	8.1	62	9.6	7.1	6.4	63	8.8
3	12.8	6.1	57	8	19.7	7	60	7.9	17.7	8.1	62	9.7	7.1	6.4	63	8.8
4	11.1	5.8	58	7.3	18.7	6.7	61	7.2	17.6	8.1	62	9.7	6.9	6.4	63	8.8
5	10.1	5.7	58	6.9	15.9	6.1	61	5	17.1	7.5	63	8.2	6.9	6.4	63	8.8
6	9.8	5.6	58	6.8	13.5	6	60	3.2	16.1	6.6	62	4.8	6.8	6.4	63	8.7
7	8.9	5.6	57	6.4	11.5	5.8	61	2.5	15.2	6	64	1.9	6.8	6.5	63	8.6
8	8.3	5.5	59	5.8	10.6	5.8	60	2.6	12.5	5.9	77	0.6	6.8	6.5	62	8.6
9	7.6	5.4	58	4.9	9.7	5.7	59	2.9	11.1	5.9	92	0.4	6.7	6.5	63	8.6
10	6.9	5.3	58	3.7	8.7	5.7	60	2.2	9.9	5.9	101	0.3	—	—	—	—
11	6.4	5.3	60	2.3	7.8	5.6	64	0.9	—	—	—	—	—	—	—	—
12	6.3	5.3	65	1.9	—	—	—	—	—	—	—	—	—	—	—	—

* Temperature in degrees Centigrade, conductivity in umhos/cm and dissolved oxygen in mg/L.

Table 54. 1990 Lake Water Quality Assessment (LWQA) water chemistry for Soldiers Meadow Lake. *

Date	6-20-90	6-20-90	8-1-90	8-1-90	9-13-90	10-24-90	10-24-90
Time	1130	1130	1130	1130	1100	1400	1400
Sample Depth	13	1.5	11	2	2.5	8.5	2
Total Depth	13.25	13.25	12	12	10.5	9.5	9.5
Secchi Depth	1.5	1.5	1.9	1.9	2.6	2.2	2.2
T. NH3-N	0.145	0.061	0.126	0.032	0.022	0.228	0.224
T. NO2+NO3-N	0.013	0.005	0.03	<.005	0.008	0.011	0.019
T. Kjeldahl-N	0.46	0.42	0.46	0.43	0.38	0.45	0.63
T. Phosphorus-P	0.043	0.021	0.108	0.028	<.05	<.05	<.05
Dissl. Phosphate-P	0.01	0.008	0.04	0.007	0.016	0.018	0.013
Hardness-CaCO3	28	32	20	28	20	32	28
T.Alkalinity-CaCO3	27	26	28	27	33	29	30

* Depth in meters and water chemistry data in mg/L.

WAHA LAKE:

General

Waha Lake is located in Nez Perce County, Idaho, and has 93 acres of surface water and 1.6 miles of shoreline with a maximum water depth of 100 feet (30.6 meters) (Figure 40). The watershed is picturesque, mountainous and forested (Plate 14).

Most of the shoreline has a rapid dropoff and the Lake is surrounded by steep, forested cliffs. No submergent vegetation was found anywhere in the Lake. A fine sand/clay colloidal sediment with a slight greenish tinge was apparent throughout the lake. The Idaho Fish & Game reports that the fisheries has never done well and that water clarity is low throughout the seasons.

The combination of low phosphorus levels and high suspended solids of Waha Lake contributed to the low phytoplankton production and to some extent, the total absence of submergent macrophytes. The erodible, clay shorelines showed layering above the high water marks as drawdown occured for irrigation. This is a similar phenomenon as was found in Soldier's Meadow Reservoir and Mann Lake.

Water is drawn from Waha Lake for irrigation from a pumphouse located at the north end of the Lake. A boat access is located at the northwest end of the lake. Primary uses are fishing, swimming and water for irrigation. The aesthetic and visual quality of surrounding forested watershed is exceptionally beautiful.

LWQA dissolved oxygen and temperature profiles and secchi depth were determined three times in 1990. LWQA water samples were taken at secchi depth three times in 1990. LWQA dissolved oxygen and temperature, secchi depth, chlorophyll "a" and submergent macrophyte distribution were sampled once in 1991. No CVMP exists for Waha Lake.

Beneficial Uses

The Idaho Water Quality Standards do not designate beneficial uses for Waha Lake. DEQ recognizes existing beneficial uses of Waha Lake based on background information, LWQA surveys, and best professional judgement. Existing beneficial uses of Waha Lake include: domestic water supply, agricultural water supply, cold water biota, warm water biota, primary contact recreation, and secondary contact recreation (Table 6). Cold water biota uses are threatened. Historically, Waha Lake has had a poor fishery according to knowledgeable sources.

Sources of Pollution, Nutrients and Recommended Management Actions

Nonpoint nutrient pollution of Waha Lake originated from agricultural fertilizers and soil erosion from past and present farming activities and cattle grazing. Extreme drawdown and water level fluctuation for agricultural use accounted for intensive shoreline erosion of clay and silt into the Lake.

Recommended management action is to implement agricultural BMP's in Waha Lake watershed, thereby reducing nutrient and sediment loading to the Lake. The extreme drawdown and accompanying variation in water level have prevented the development of a submergent aquatic plant community. These fluctuations in water level have prevented the development of a productive fishery. Maintenance of a more consistent water level in Waha Lake would allow for a more stable and diverse biological system.

Limnological Characteristics of Waha Lake:

Secchi Depth: 1991 LWQA range = 1.5-1.5 meters, average = 1.5 meters; 1990 LWQA range = 0.8-2.0 meters, average = 1.3 meters.

Water clarity and visibility is poor.

Chlorophyll "a": 1991 LWQA range = 1.4-1.8 ug/L, average = 1.6 ug/L.

Phytoplankton production is low.

Total Phosphorus: 1990 LWQA range = 0.028-0.108 mg/L, average = 0.066 mg/L.

Phosphorus levels are relatively low and most likely, a limiting factor for both phytoplankton and submergent macrophyte growth.

Dissolved Oxygen/Temperature Profiles

Water temperature dropped very rapidly after 3 meters, resulting in a relatively narrow epilimnion and thermocline and an extensive hypolimnion. The dissolved oxygen remained relatively high down to a depth of 22 meters despite the rapid temperature drop with the same descent. The lack of organics and low productivity of phytoplankton probably contributed to this uniform dissolved oxygen distribution throughout the water column. Only at the interphase of the deep hypolimnion and lake bottom does one find significantly reduced oxygen. The conductivity and pH changed very little from the surface to the lake bottom at 27 meters, further illustrating the lack of organic production and organic loading in Waha Lake.

Waha Lake is eutrophic. Waha Lake was thermally stratified in August and showed a somewhat radical departure from typical dissolved oxygen/temperature profiles found in eutrophic lakes

(Table 55, Figure 41). Dissolved oxygen dropped quickly in the thermocline and increased momentarily in the upper hypolimnion, followed by a sharp decline in the deep hypolimnion. A large irrigation pumping system located at the north end of the lake may account for some of these fluctuations in dissolved oxygen in the water column, where currents and seiche may be created, by pumping large volumes of water from the Lake.

Submergent macrophytes

No submergent macrophytes were found in Waha Lake.

LWQA Water Quality Data

LWQA water chemistry data indicated that Waha Lake is eutrophic (Tables 55-56, Figure 41). Moderately high levels of ammonia, nitrate and nitrite, and total kjehldahl nitrogen, total phosphorus and orthophosphate and specific conductivity indicated the Lake is eutrophic. More specific discussion of some of these and other parameters can be found under specific parameter subtitles in this report.

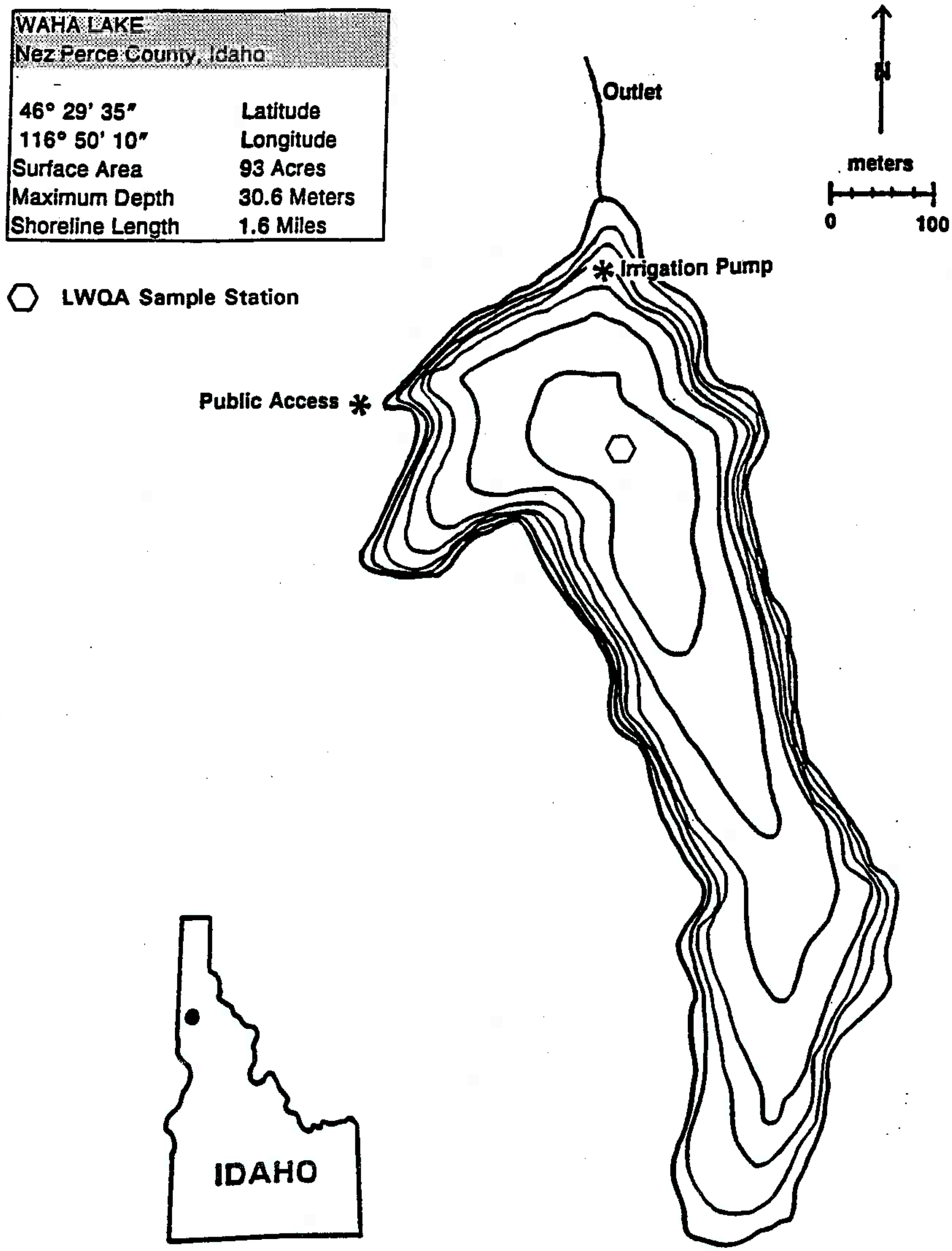


Figure 40. Map of Waha Lake.

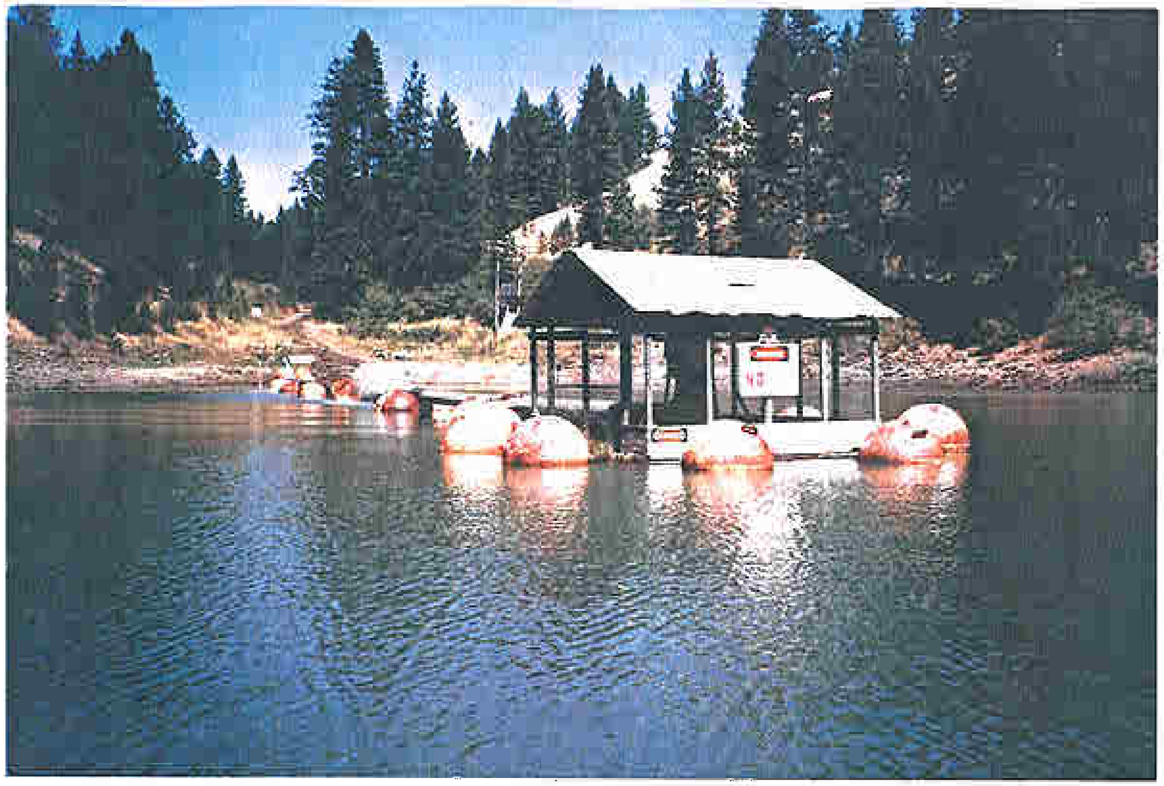


Plate 14. Waha Lake photographs showing the picturesque forested watershed and an irrigation pumping station.

Figure 41. Dissolved oxygen and temperature profile for Waha Lake, August 20, 1991.

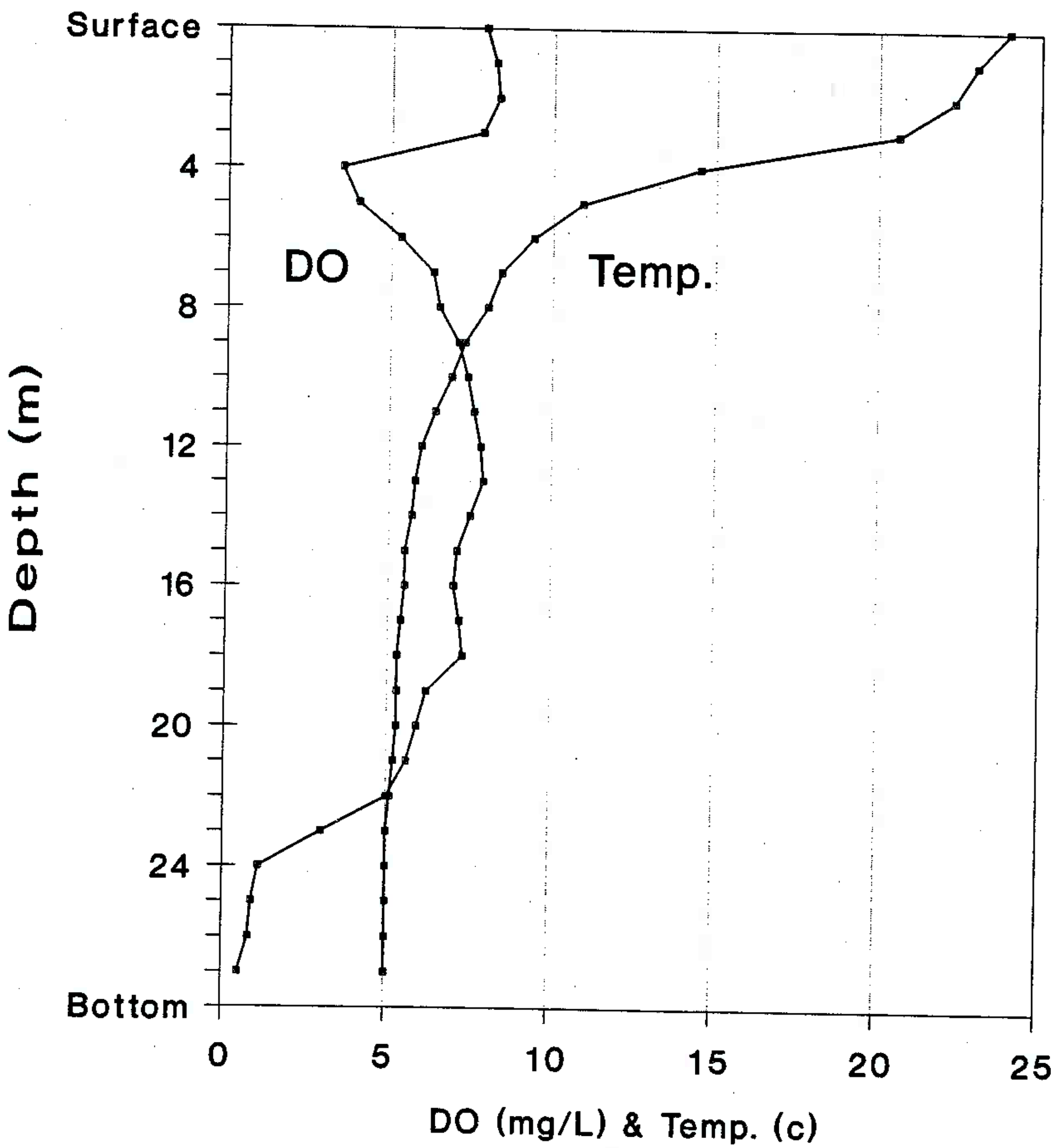


Table 55. LWQA dissolved oxygen/temperature profiles, specific conductivity and pH during summer thermal stratification for Waha Lake on August 20, 1991.

Depth (meters)	Dissolved Oxygen (mg/L)	Temperature (°C)	Specific Conductance (umhos/cm)	pH
0.0	7.9	24.0	67.0	8.0
1.0	8.2	23.0	67.0	8.1
2.0	8.3	22.3	67.0	8.1
3.0	7.8	20.6	67.0	7.9
4.0	3.5	14.5	65.0	6.2
5.0	4.0	10.9	64.0	5.9
6.0	5.3	9.4	64.0	5.9
7.0	6.3	8.4	62.0	6.0
8.0	6.5	8.0	63.0	6.0
9.0	7.1	7.3	63.0	6.0
10.0	7.4	6.9	63.0	6.0
11.0	7.6	6.4	63.0	6.0
12.0	7.8	6.0	63.0	6.0
13.0	7.9	5.8	64.0	6.0
14.0	7.5	5.7	65.0	6.0
15.0	7.1	5.5	66.0	6.0
16.0	7.0	5.5	64.0	6.0
17.0	7.2	5.4	64.0	6.0
18.0	7.3	5.3	64.0	6.0
19.0	6.2	5.3	66.0	5.9
20.0	5.9	5.3	65.0	5.9
21.0	5.6	5.2	67.0	5.9
22.0	5.0	5.1	67.0	5.8
23.0	3.0	5.0	68.0	5.8
24.0	1.1	5.0	70.0	5.7
25.0	0.9	5.0	72.0	5.7
26.0	0.8	5.0	73.0	5.7
27.0	0.5	5.0	77.0	5.7

Table 56. 1990 Lake Water Quality Assessment (LWQA) water chemistry data for Waha Lake. *

Date	5–15	5–15	6–20	6–20	8–1	8–1	9–13
Time	1030	1030	1430	1430	—	—	—
Sample Depth	27.5	1	30	1	—	—	—
Total Depth	—	—	—	—	—	—	—
Secchi Depth	1.2	1.2	0.8	0.8	2	2	—
T. NH3–N	0.053	0.05	0.117	0.075	—	—	—
T. NO2+NO3–N	0.175	<.005	0.241	<.005	—	—	—
T. Kjeldahl–N	0.295	0.253	0.38	1.34	—	—	—
T. Phosphorus–P	0.108	0.042	0.087	0.028	—	—	—
Dissl. Phosphate–P	0.029	0.012	0.053	0.013	—	—	—
Hardness–CaCO3	40	24	40	40	—	—	—
T.Alkalinity–CaCO3	32	32	32	31	—	—	—

5–15					6–20					8–1				
Meters	Temp.	pH	Cond.	D.O.	Meters	Temp.	pH	Cond.	D.O.	Meters	Temp.	pH	Cond.	D.O.
1	11	7.1	71	10.3	1	18.1	8.2	73	11	1	22.1	7.7	75	7.6
5	11	7.2	71	10.2	3	13.4	8	72	10.5	3	18.4	7.2	75	6.6
7.5	7.2	6.6	72	10	6	10.1	6.5	71	9.5	6	10.6	6.2	72	6.9
10	6.4	6.7	72	10.3	9	9	6.3	72	9.4	9	9.1	6.1	72	7.5
15	4.6	6.6	73	10.4	12	7.8	6.2	71	9.3	12	7.2	6.1	72	7.9
20	4.12	6.5	73	10.4	13	6.8	6.1	72	9.3	15	5.7	6.1	73	7.7
22.5	4.1	6.4	73	10.1	14	6.4	6.1	72	9.4	18	5.2	6	73	7.4
25	4.1	6.3	72	8.4	15	5.8	6.1	72	9.5	21	5	6	75	5.9
27.5	4	6.2	74	5.9	18	5.1	6	73	9.5	24	4.7	5.9	77	4.3
29	4.1	6.2	72	4.4	21	4.8	6	73	9.2	27	4.5	5.9	99	0.4
					24	4.6	6	73	9.3					
					27	4.3	5.9	75	6					
					30	4.3	5.8	77	4					

* Depth in meters, water chemistry in mg/L, temperature in degrees Centigrade and conductivity in umhos/cm.

ROSE LAKE:

General

Rose Lake is located in Kootenai County, Idaho, and has 320 acres of surface water and 3.7 miles of shoreline with a maximum water depth of 17 feet (5.2 meters) (Figure 42). Rose Lake has extensive submergent and floating-leaf macrophyte growth in the entire littoral zone (Plate 15).

Rose Lake is shallow and eutrophic. The secchi depth reading is 1.4 meters. Even in late August, the Lake does not thermally stratify due to its shallow depth. The dissolved oxygen in Rose Lake is low, ranging from 5.7 mg/L at the surface to 1.6 mg/L near the bottom at 5.3 meters.

An extensive blue-green (Aphanizomenon) algal bloom is prevalent throughout the seasons. Zooplankton blooms are common and feed on these extensive algal blooms.

The contribution of phosphorus and other nutrients to the watershed from septic tanks of residential homes, livestock grazing, and farming have contributed to the deterioration of water quality and eutrophication in Rose Lake. Heavy metals from a century of mining discharges to the Coeur d'Alene River have contaminated both the bottom sediments and water quality of the Coeur d'Alene Lake basin lateral Lakes, including Rose Lake. Most of the lake bottom is organic silt and detritus.

LWQA dissolved oxygen and temperature profiles, secchi depth and chlorophyll "a" and submergent macrophyte distribution were determined once in 1991. Citizen volunteer monitors (CVMP) collected water samples from one station three times and five times, at secchi depth in 1990 and 1991, respectively.

Beneficial Uses

The Idaho Water Quality Standards (1985) do not designate beneficial uses for Rose Lake. DEQ recognizes existing beneficial uses for Rose Lake based on background information, LWQA surveys, and best professional judgement. Existing beneficial uses include: agricultural water supply, cold water biota, warm water biota, primary contact recreation and secondary contact recreation (Table 6).

The low dissolved oxygen observed August 29, 1991 violates the criteria for (1.6 mg/L) the cold water biota, which states that dissolved oxygen is to exceed 6.0 mg/L at all times. Extensive Aphanizomenon flos-aqua (blue-green algal) blooms threaten Rose Lake for use as primary contact recreation.

Sources of Pollution, Nutrients and Recommended Management Actions

Rose Lake has been impacted during the last century by heavy metal contamination from upstream mining waste disposal into the Coeur d'Alene River. Rose Lake is a lateral lake of the CDA River and has been less contaminated than some of the other lateral lakes due to a dam at the lake outlet and extensive vegetation in adjacent marsh areas. The dam has helped to prevent backwater flows from the Coeur d'Alene River from reaching the Lake.

Rose Lake has some limited residential home development on the south side, which most likely contributes some nutrients from drain fields to the watershed. Most of the shoreline is undeveloped and forested. The lake is shallow (4 meters) and internal recycling of phosphorus contributes to its eutrophic nature. Management recommendations include using the appropriate BMP's for livestock grazing and farming, maintenance of drain fields, control of runoff from home or road building near the lake's watershed.

Limnological Characteristics of Rose Lake:

Secchi Depth: 1991 LWQA range = 1.4-1.4 meters, average = 1.4 meters; 1991 CVMP range = 0.75-2.0 meters, average = 1.4 meters. 1990 CVMP range = 2.0-2.0 meters, average = 2.0 meters.

Water clarity in Rose Lake is limited due to both brown-stained water and algal blooms.

Chlorophyll "a": 1991 LWQA range = 11.5-12.0 ug/L, average = 11.8 ug/L. 1991 CVMP range = 3.4-15.7 ug/L, average = 11.4 ug/L. 1990 CVMP range = 3.0-4.3 ug/L, average = 3.5 ug/L.

Phytoplankton production in eutrophic Rose Lake is high. Blue-green algal blooms are common.

Total Phosphorus: 1991 CVMP range = 0.009-0.4 mg/L, average = 0.031 mg/L. 1990 CVMP range = 0.015-0.025 mg/L, average = 0.019 mg/L.

Total phosphorus in Rose Lake is variable and appears to change with blue-green algae bloom periods.

Dissolved Oxygen/Temperature Profiles

On August 29, 1991, the dissolved oxygen in Rose Lake was very low. It dropped from 5.7 mg/L at the surface to 1.6 mg/L at approximately 5 meters near the lake bottom (Table 57, Figure 43). Water temperature, pH and conductivity, however, remained relatively constant for all depths. Dissolved oxygen depletion occurred near the lake bottom, a condition that indicated lake eutrophication and heavy nutrient loading.

Submergent Macrophytes

Only four species of submergent macrophytes make up the extensive submerged plant communities of Rose Lake which formed a nearly continuous weed bed along the lakeshore in the littoral zone. Each of the submergent plant communities are dominated by a few species. These species are highly dependent upon water quality, the composition of the lake bottom substrate and the amount of available light. The predominant floating-leaf species are water shield (Brasenia) and yellow water lily (Nuphar). Robbin's pondweed (Potamogeton robbinsii) is the dominant submergent species in Rose Lake. Largeleaf pondweed (Potamogeton amplifolius) and waterweed (Elodea) are two significant submergent macrophytes distributed along the silt-ridden littoral areas. These species are somewhat ubiquitous in nature. However, the relative abundance of these aforementioned species indicated that the lake is eutrophic.

Robbin's pondweed is quite shade-tolerant and tends to grow profusely in lakes of high phosphorus and nutrient content and low water clarity. The submergent Robbin's pondweed was dominant under extensive, shaded canopies of floating water shield. Elodea was dominant only in areas that were located outside the extensive floating weed mats of water shield. However, Elodea was common under dense, floating mats of yellow water lily. The extensive development of yellow water lily communities and the absence of white water lily communities in the littoral zone, may also indicate eutrophic lake conditions.

The type of lake bottom soil is extremely critical in determining the species composition of submergent plant communities. The lack of submergent plant diversity (4 species) and the domination of the submergent plant communities by three eutrophic-associated species, further indicated that Rose Lake is eutrophic. Surprisingly, water milfoil (Myriophyllum) was not found in Rose Lake. The growth of submergent macrophytes in Rose Lake is restricted to a maximum depth of 1.5 meters, a result of the lack of light and water clarity. In late August, Bryozoan colonies were found on some of the submergent aquatic plants.

CVMP Water Quality Data

CVMP water chemistry data indicated that Rose Lake is eutrophic (Tables 57-59, Figure 43). Relatively high and variable levels of ammonia, total kjehldahl nitrogen, total phosphorus, orthophosphate and chlorophyll "a" indicated the Lake is eutrophic. More specific discussion of some of these and other parameters can be found under specific parameter subtitles in this report.

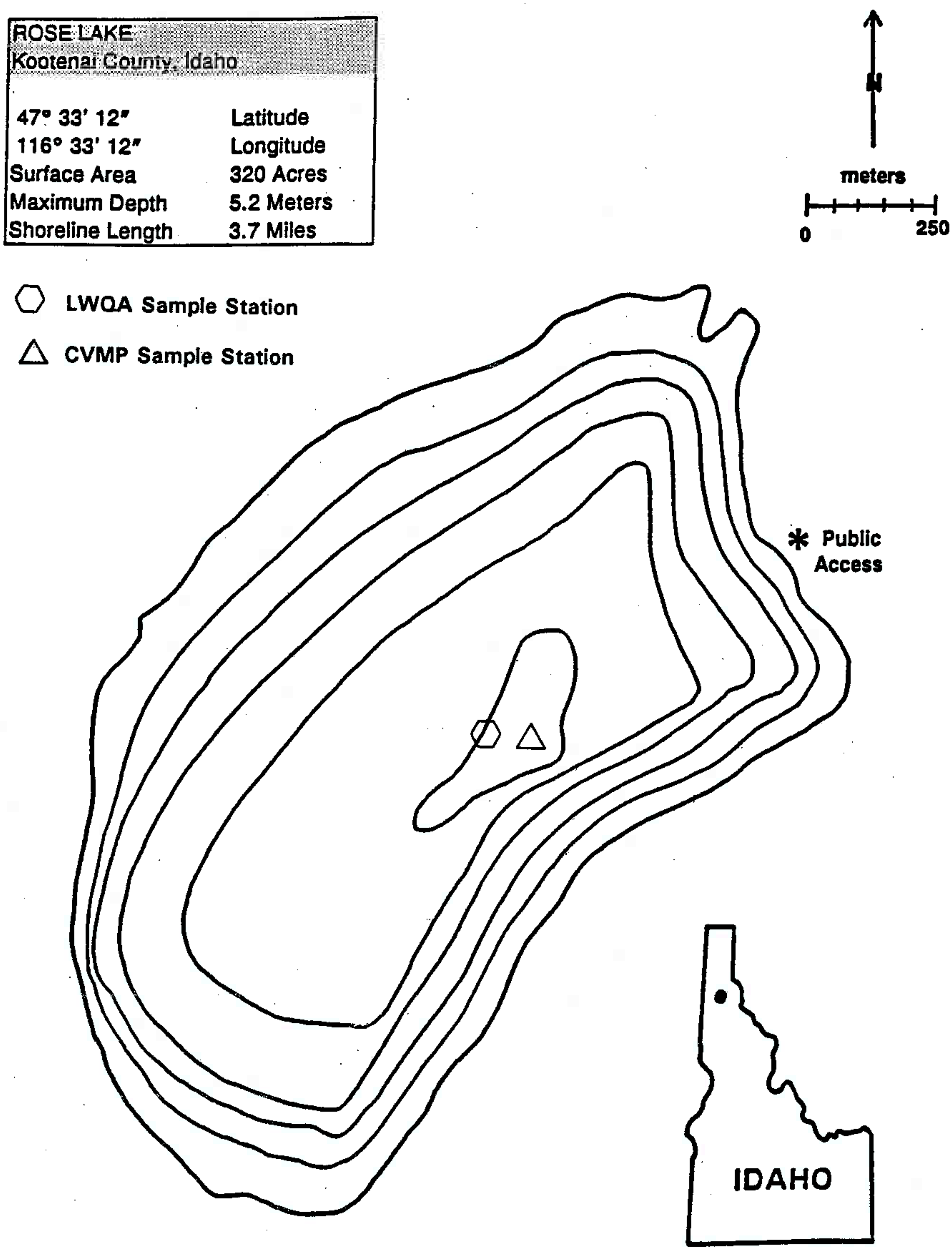


Figure 42. Map of Rose Lake.

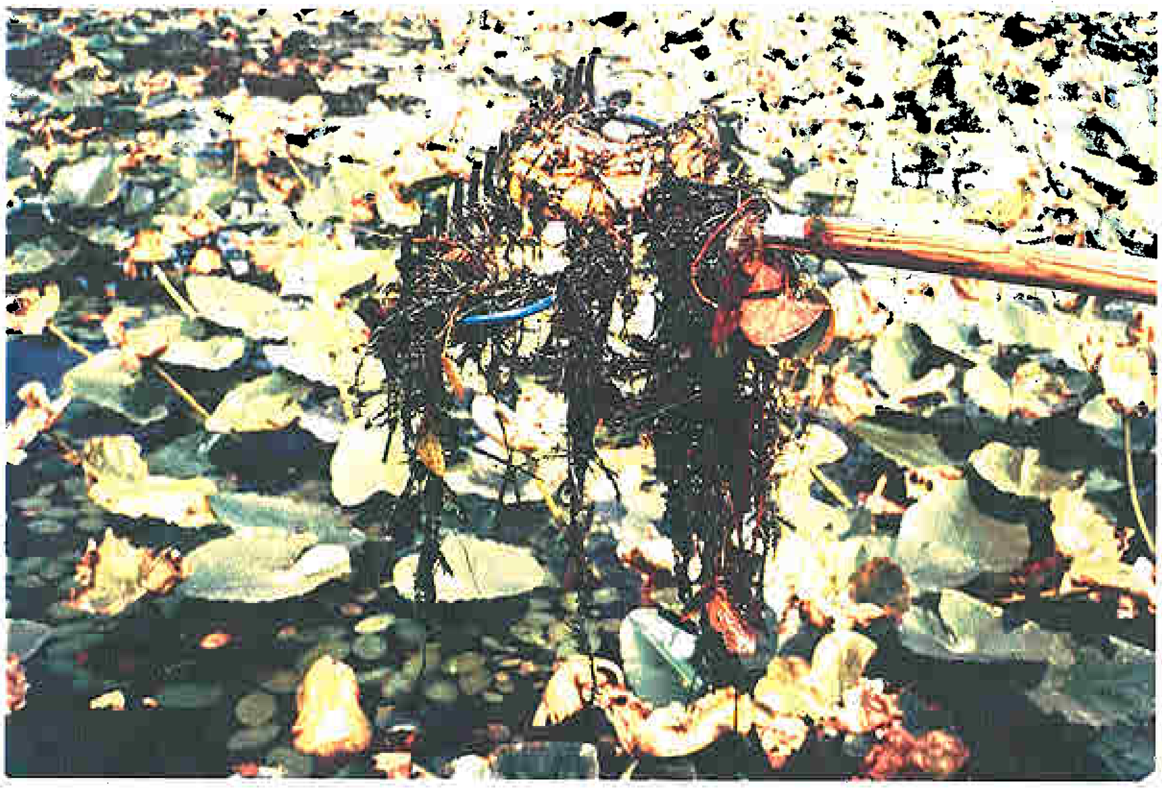


Plate 15. Rose Lake photographs showing a bryozoan colony (lower photo) and extensive aquatic plant growth in the littoral zone.

Figure 43. Dissolved oxygen and temperature profile for Rose Lake, August 29,1991.

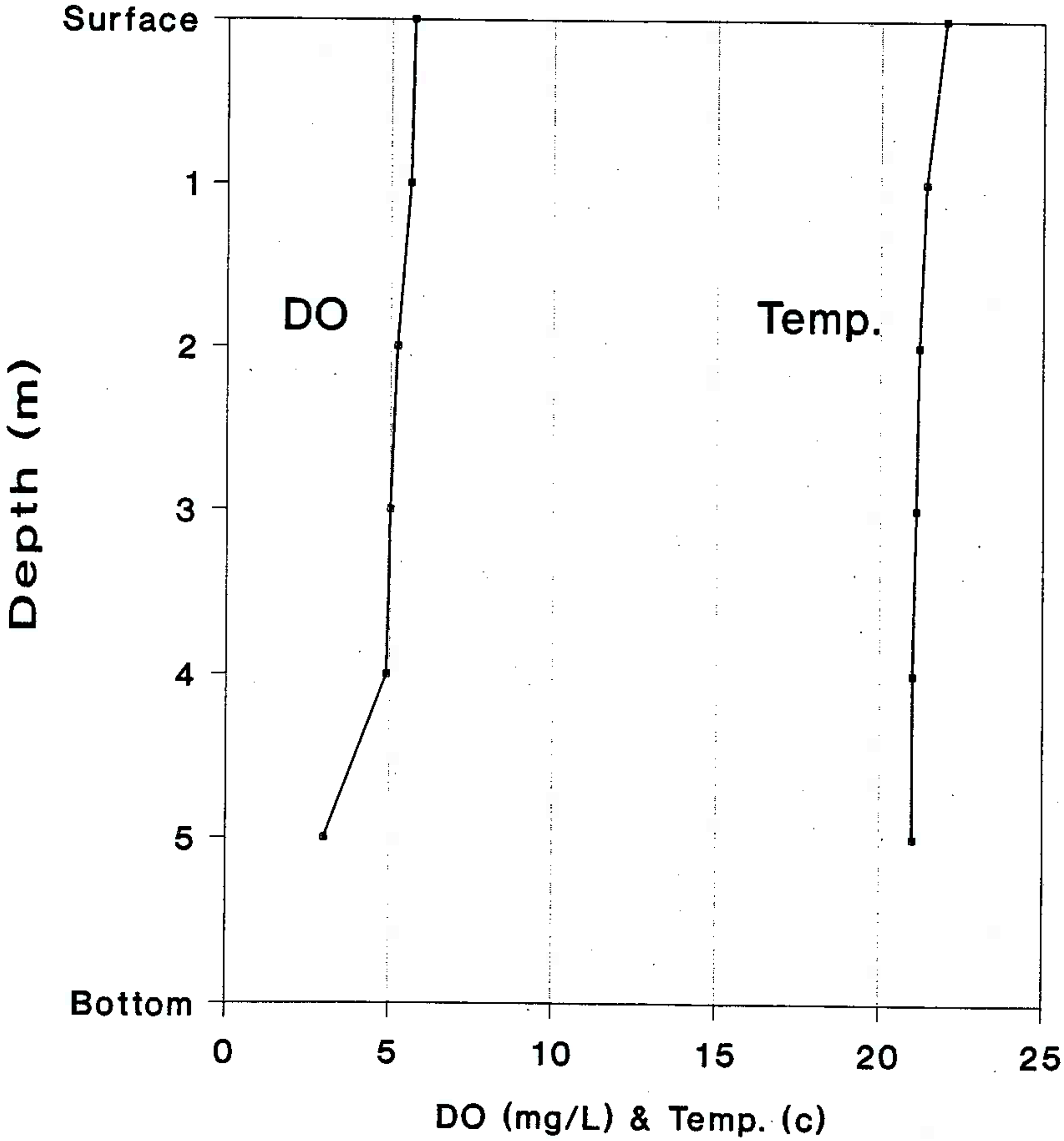


Table 57. LWQA dissolved oxygen/temperature profiles, specific conductivity and pH during summer thermal stratification for Rose Lake on August 29, 1991.

Depth (meters)	Dissolved Oxygen (mg/L)	Temperature (°C)	Specific Conductance (umhos/cm)	pH
0.0	5.7	22.0	46.0	6.2
1.0	5.6	21.4	46.0	6.0
2.0	5.2	21.2	46.0	6.0
3.0	5.0	21.1	46.0	6.0
4.0	4.9	21.0	46.0	6.0
5.0	3.0	21.0	49.0	5.9
5.3	1.6	20.8	55.0	5.8

Table 59. 1991 Citizen Volunteer Monitoring Program (CVMP) water quality data for Rose Lake, Idaho.

Date of Sample *	CVMP 05/21/91	CVMP** 06/30/91	CVMP** 06/30/91	CVMP 08/11/91	CVMP 09/15/91	CVMP 10/22/91	DEQ*** 10/22/91
Secchi sample depth (meters):	2	0.75	0.75	1.5	1	2	2
T. Ammonia	0.124	0.092	0.029	0.128	0.325	0.15	0.128
T. NO2+NO3	0.019	0.009	0.005	—	0.019	0.042	—
T.K. Nitrogen	0.23	1.64	1.55	—	0.86	0.26	—
T. Phosphorus	0.029	0.045	0.042	0.009	0.031	0.03	0.4
Ortho Phosphate	0.002	0.002	0.002	1.07	0.003	0.005	—
Temperature (degrees Centigrade)	17	19	19	0.026	21	10	10.7
Dissolved Oxygen	9	8	8	0.002	8	6	10.7
Chlorophyll a (ug/L)	3.4	15.2	15.7	13	13	9.5	9.8

* mg/L unless otherwise indicated.

** CVMP duplicate samples.

*** Idaho Division of Environmental Quality/Quality Assurance/Quality Control.

Table 58. 1990 Citizen Volunteer Monitoring Program (CVMP) water quality data for Rose Lake, Idaho.

Date of Sample *	CVMP** 06/11/90	CVMP** 06/11/90	CVMP 07/24/90	CVMP 08/27/90
Secchi sample depth (meters):	2	2	2	2
T. Ammonia	0.005	0.02	0.027	0.166
T. NO2+NO3	0.005	0.005	0.005	0.005
T.K. Nitrogen	0.35	0.36	0.46	0.39
T. Phosphorus	0.015	0.016	0.02	0.025
Ortho Phosphate	0.001	0.001	0.001	0.001
Temperature (degrees Centigrade)	14	14	24	24
Dissolved Oxygen	9	10	9	10
Zinc (ug/L)	10	10	2.5	2.5
Chlorophyll a (ug/L)	3.3	3	3.2	4.3

* mg/L unless otherwise indicated.

** CVMP duplicate samples.

MANN LAKE:

General

Mann Lake is located in Nez Perce County, Idaho, and has 130 acres of surface water and 1.6 miles of shoreline with a maximum water depth of 39 feet (12 meters) (Figure 44). Mann Lake is a reservoir used as a waterfowl refuge and as a source of water for irrigation (Plate 16).

Mann Lake is surrounded by open fields and flat prairie land. In August, a fine sand/clay, colloidal sediment with a slight greenish tinge was apparent throughout the Lake. The entire lake bottom consisted of mud and clay with a brown-black coloration, most likely containing goose excrement.

LWQA dissolved oxygen and temperature profiles and secchi depth were determined two times in 1990. LWQA water samples were taken two times in 1990. LWQA dissolved oxygen and temperature, secchi depth, chlorophyll "a" and submergent macrophyte distribution were determined once in 1991. No CVMP exists for Mann Lake.

Beneficial Uses

The Idaho Water Quality Standards do not designate beneficial uses in Mann Lake. The reservior is primarily used for an agricultural water supply and as a waterfowl refuge (Table 6). An additional existing beneficial use recognized by DEQ for Mann Lake is secondary contact recreation. The limited data on Mann Lake prevents further beneficial use designations at this time.

Extensive fecal deposits from large flocks of Canada Geese, threaten the use of Mann lake for livestock watering and secondary contact recreation.

Sources of Pollution, Nutrients and Recommended Management Actions

Nonpoint source nutrient pollution originated from excessive accumulation of geese excrement, and fertilizers and soil erosion from past and present farming activities and cattle grazing.

Recommended management action is to implement agricultural BMP's in Mann Lake watershed, thereby reducing nutrient and sediment loading to the Lake. The use of BMP's would help to alleviate internal nutrient recycling and enhance dissolved oxygen levels in the hypolimnion. The extreme drawdown and accompanying variation in water levels have prevented the development of a submergent aquatic plant community. These fluctuations in water level also prevent the development of a productive fishery so dependent on aquatic plants. Maintenance of a more consistent water level in Mann Lake would allow for a more stable and diverse biological system.

Limnological Characteristics of Mann Lake:

Secchi Depth: 1991 LWQA range = 1.3-1.3 meters, average = 1.3 meters; 1990 LWQA range = 0.7-1.25 meters, average = 1.1 meters.

Water clarity and visibility are poor as a result of suspended colloidal material.

Chlorophyll "a": 1991 LWQA range = 1.8-1.9 ug/L, average = 1.9 ug/L.

Phytoplankton production is low which is possibly a result of suspended colloidal material reducing the light available for photosynthesis.

Total Phosphorus: 1990 LWQA range = 0.034-0.064 mg/L, average = 0.053 mg/L.

Phosphorus levels were moderate in eutrophic Mann Lake.

Dissolved Oxygen/Temperature Profiles

The dissolved oxygen dropped from 7.8 mg/L at the surface to 3.3 mg/L near the bottom at 9 meters on August 21, 1991, despite little temperature change from the top to the bottom of the Lake (Tables 60-61, Figure 45).

Submergent Macrophytes

No submergent macrophytes were found at any water depth in Mann Lake, a result of drawdown and fluctuating water levels. Also, the lack of water clarity (secchi disk = 1.3 meters) limited the light available for submergent plant growth.

LWQA Water Quality Data

LWQA water chemistry data indicated that Mann Lake is eutrophic (Table 60-61, Figure 45). Relatively high levels of total kjehldahl nitrogen, total phosphorus and orthophosphate indicated the Lake is eutrophic. More specific discussion of some of these and other parameters can be found under specific parameter subtitles in this report.

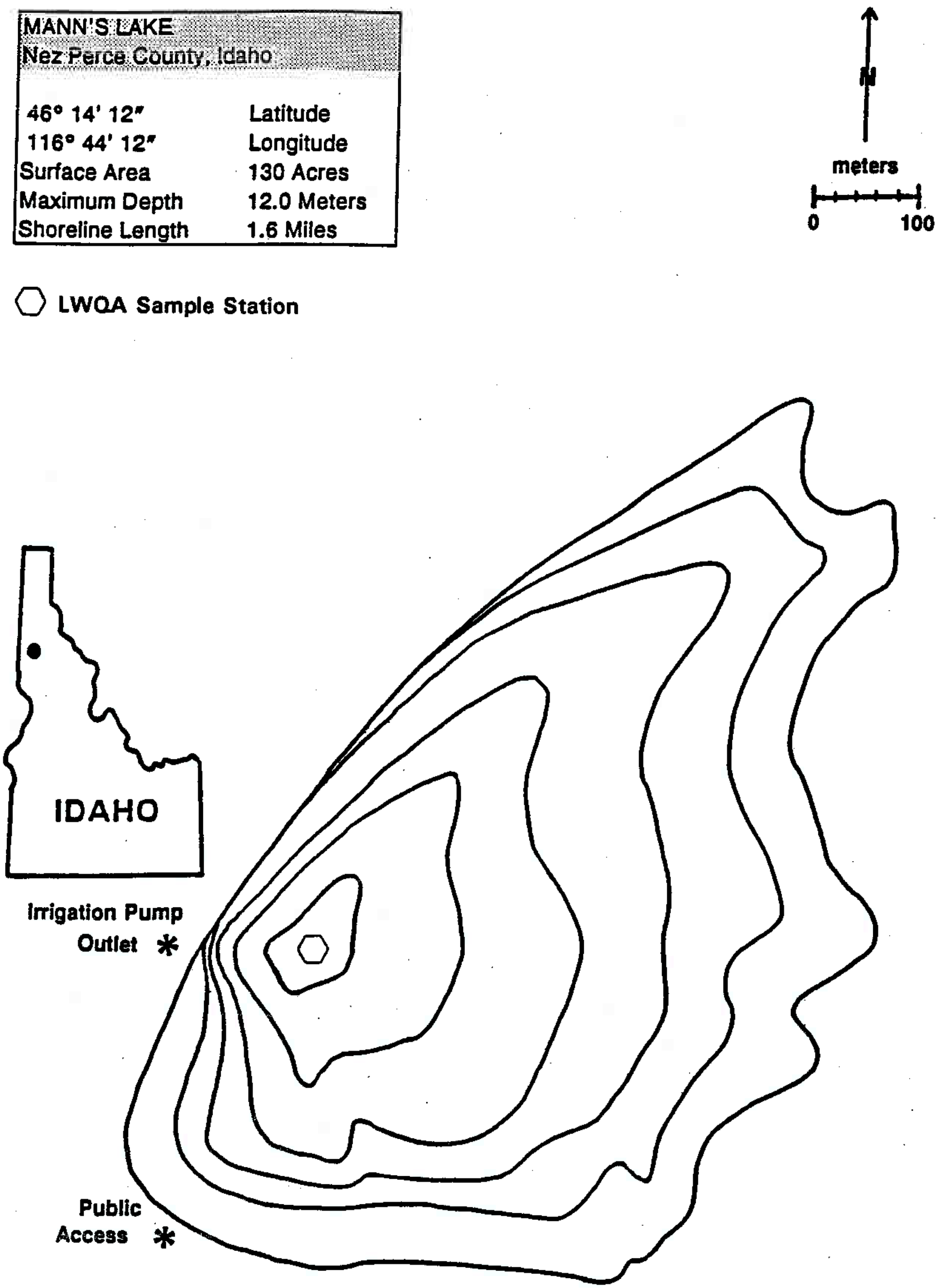


Figure 44. Map of Mann's Lake.

Plate 16. Mann Lake photographs showing extensive farmland and flocks of canada geese. This reservoir is used almost exclusively for irrigation and as a waterfowl refuge.

Figure 45. Dissolved oxygen and Temperature profile for Mann Lake, August 21, 1991.

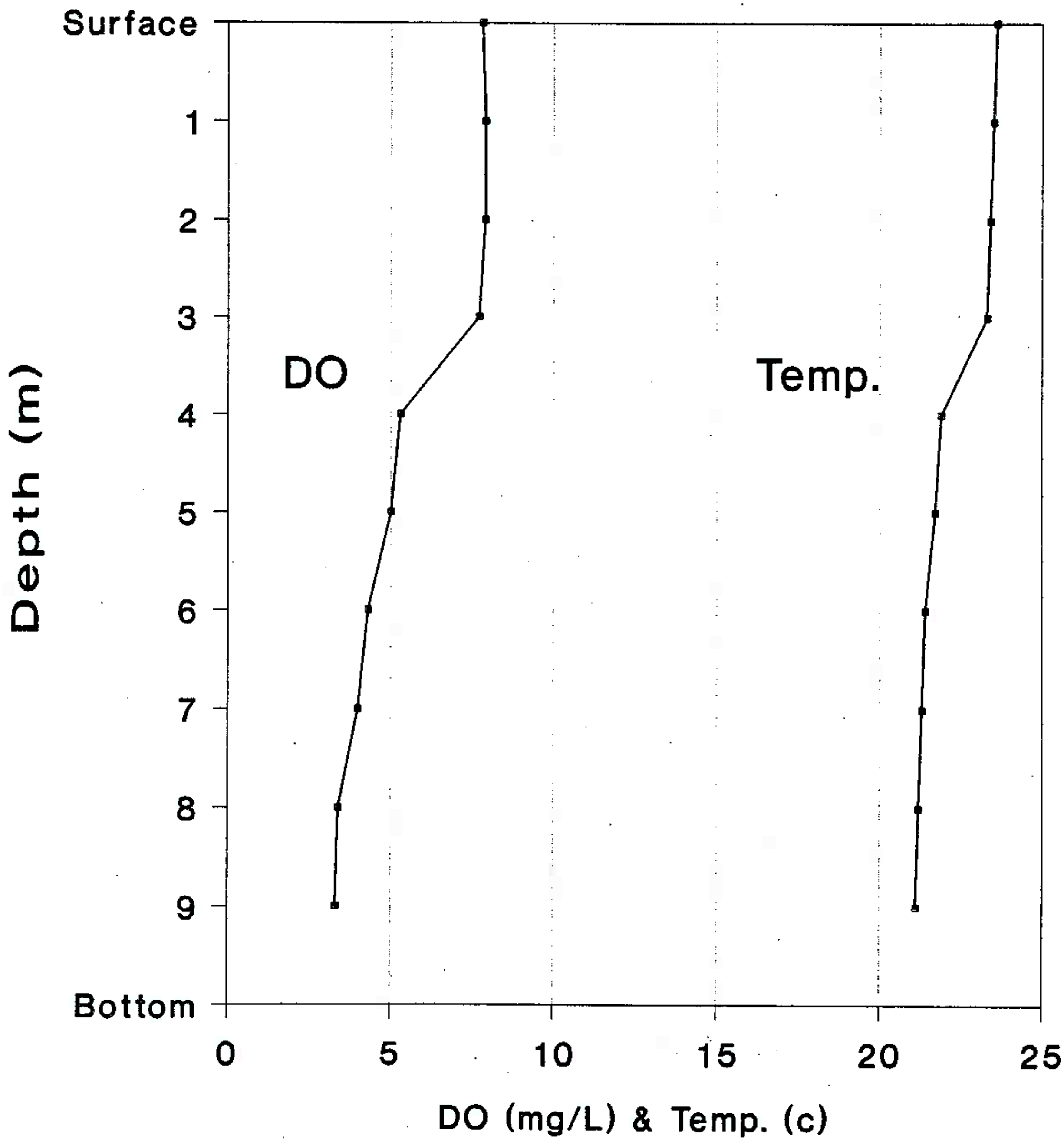


Table 60. LWQA dissolved oxygen/temperature profiles, specific conductivity and pH during summer thermal stratification for Mann Lake on August 21, 1991.

Depth (meters)	Dissolved Oxygen (mg/L)	Temperature (°C)	Specific Conductance (umhos/cm)	pH
0.0	7.8	23.6	86.0	7.7
1.0	7.9	23.5	85.0	7.7
2.0	7.9	23.4	85.0	7.7
3.0	7.7	23.3	85.0	7.7
4.0	5.3	21.9	86.0	6.8
5.0	5.0	21.7	85.0	6.8
6.0	4.3	21.4	85.0	6.6
7.0	4.0	21.3	87.0	6.6
8.0	3.4	21.2	86.0	6.5
8.5	3.3	21.1	87.0	6.5

Table 61. 1990 Lake Water Quality Assessment (LWQA) water chemistry data for Mann Lake. *

Date	5-14-90	5-14-90	6-20-90
Time	1215	1215	1645
Sample Depth	12	1	10
Total Depth	13	13	11.2
Secchi Depth	1.25	1.25	0.7
T. NH3-N	0.08	0.062	0.093
T. NO2+NO3-N	<.005	<.005	0.04
T. Kjeldahl-N	0.29	0.312	0.2
T. Phosphorus-P	0.064	0.062	0.034
Dissl. Phosphate-P	0.016	0.007	0.031
Hardness-CaCO3	40	44	44
T.Alkalinity-CaCO3	44	43	44

	5-14-90				6-20-90			
Meters	Temp.	pH	Cond.	D.O.	Temp.	pH	Cond.	D.O.
1	14.5	7.1	99	9.4	23.5	8.3	103	11.8
2	14.5	7.2	99	9.3	18.6	7.6	103	8.9
3	14.5	7.2	99	9.2	16.8	7	103	7.8
4	14.5	7.2	99	9.2	15.5	6.8	101	7.4
5	12.2	7	100	8.3	14.9	6.7	102	6.9
6	10.9	6.8	100	7.8	14.3	6.5	102	6.4
7	10.6	6.7	99	7.7	13.1	6.4	101	5.1
8	10.1	6.6	99	7.4	12.3	6.2	102	4.3
9	9.7	6.6	99	7.1	11.9	6.2	102	4
10	9.4	6.6	99	6.9	11.5	6.1	101	3.7
11	9.1	6.5	99	6.8	--	--	--	--
12	9.1	6.5	99	6.7	--	--	--	--

* Depth in meters, water chemistry in mg/L, temperature in degrees Centigrade and conductivity in umhos/cm.

WINCHESTER LAKE:

General

Winchester Lake is located in Nez Perce County, Idaho, and has 94 acres of surface water and 3.5 miles of shoreline with a maximum water depth of 33 feet (10 meters) (Figure 46). Winchester Lake has extensive blue-green algal blooms of Aphanizomenon (Plate 17).

Winchester Lake is a very eutrophic lake. Thick, viscous mats of irridescent Aphanizomenon were found floating at the surface in some bays. The filamentous blue-green algae was so dense in bays and open water that it appeared like a supernatant from a centrifuge sample, with the upper four inches clear, and a thick filamentous layer formed below.

Originally, Winchester Lake was used as an old mill pond for log storage and a water source for agriculture. Today, it is a non-motorized lake used for rainbow trout fishing and camping. Agriculture has heavily-impacted the entire watershed and has significantly increased phosphorus levels.

Winchester Lake has an offensive hydrogen sulfide odor which originates from bacterial activity in the anaerobic lake bottom. The extreme algal production and die-off followed by bacterial breakdown of these excessive Aphanizomenon blooms, results in the production of offensive hydrogen sulfide and methane gas. Bacterial activity also causes a rapid consumption and depletion of dissolved oxygen in waters deeper than four meters.

LWQA dissolved oxygen and temperature profiles and secchi depth were determined five times in 1990. LWQA water samples were taken five times in 1990. LWQA dissolved oxygen and temperature profiles, secchi depth, chlorophyll "a" and submergent macrophyte distribution were determined once in 1991. No CVMP exists for Winchester Lake.

Beneficial Uses

The Idaho Water Quality Standards protect the following beneficial uses for Winchester Lake: domestic water supply, agricultural water supply, cold water biota, primary contact recreation, secondary contact recreation and a special resource water (Table 6). It is protected for future use as salmonid spawning. An additional existing beneficial use of Winchester Lake is warm water biota.

Hyper-eutrophic conditions (i.e. low hypolimnetic dissolved oxygen, elevated temperatures, high total phosphorus, high hypolimnetic total ammonia, high bacteria levels and extensive blue-green algae blooms) in Winchester Lake impair the following beneficial uses: domestic water supply, cold water biota, salmonid spawning, and primary contact recreation. Threatened beneficial uses include: agricultural water supply, warm water biota and secondary contact recreation.

Sources of Pollution, Nutrients and Recommended Management Actions

Nonpoint pollution originates primarily from nitrogen and phophorus fertilizers and soil erosion from past and present farming activities and cattle grazing. Earlier years of millpond log storage also contributed to the water quality degradation of Winchester Lake.

Recommended management action is to implement agricultural BMP's in Winchester Lake watershed, thereby reducing nutrient and sediment loading to the Lake. Implementing BMP's may alleviate internal nutrient recycling and enhance dissolved oxygen levels in the hypolimnion. This will allow for long-term enhancement of the put-and-take rainbow trout fishery, and reduce the threatened and impaired conditions for present beneficial use designations of Winchester Lake.

Limnological Characteristics of Winchester Lake:

Secchi Depth: 1991 LWQA range = 1.0-1.0 meter, average = 1.0 meter; 1990 LWQA range = 0.8-2.5 meters, average = 1.3 meters.

Lack of water clarity is due almost entirely to excessive Aphanizomenon blooms.

Chlorophyll "a": 1991 LWQA range = 21.2-26.9 ug/L, average = 24.1 ug/L.

Phytoplankton production is excessive and extreme, resulting in odors, water quality, dissolved oxygen and aesthetic problems.

Total Phosphorus: 1990 LWQA range = 0.08-1.2 mg/L, average = 0.40 mg/L.

Total phosphorus levels are extremely high in the deep anoxic hypolimnion, where internal recycling of phosphorus from the lake bottom mud is prevalent.

Dissolved Oxygen/Temperature Profiles

The dissolved oxygen dropped from 13.7 mg/L at the surface to 0.5 mg/L one meter off the lake bottom at 8 meters (Table 62, Figure 47). Conductivity increased towards the lake bottom, and the pH dropped from 9.1 to 6.0 in the cool, anaerobic lake bottom water. The hypolimnion was anaerobic for the sample periods of May through September, 1991.

Submergent Macrophytes

Extensive algal blooms in Winchester Lake block out most of the sunlight, accounting for the relative absence of submergent macrophytes, except for _Elodea_ and _Myriophyllum_ that were found in an extremely narrow and shallow littoral zone band with a water depth of less than 0.5 meters.

LWQA Water Quality Data

LWQA water chemistry data indicated that Winchester Lake is very eutrophic (Tables 62-63, Figure 47). High levels of ammonia, total kjehldahl nitrogen, total phosphorus and orthophosphate and chlorophyll "a" indicated the Lake is extremely eutrophic. More specific discussion of some of these and other parameters can be found under specific parameter subtitles in this report.

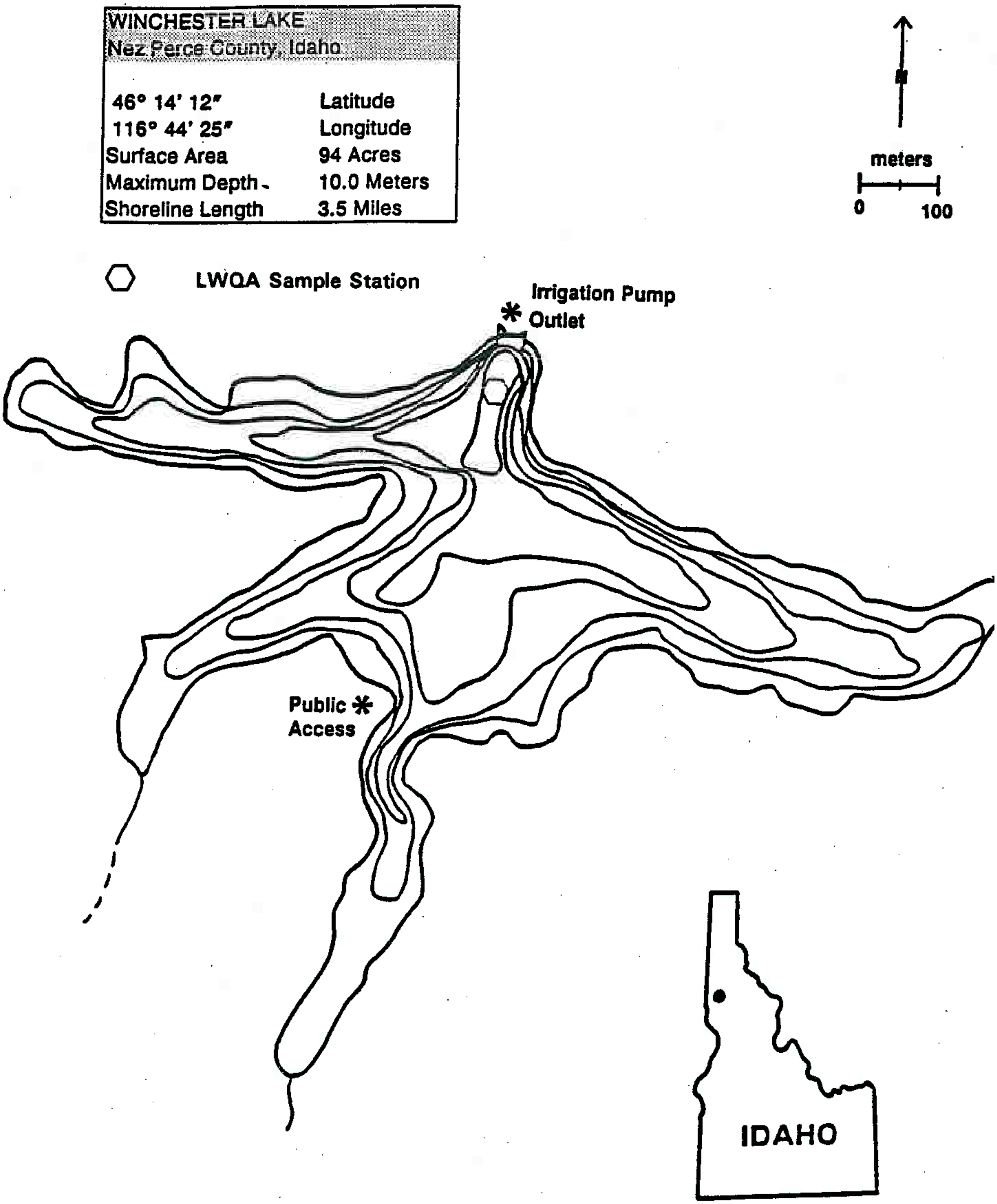


Figure 46. Map of Winchester Lake.

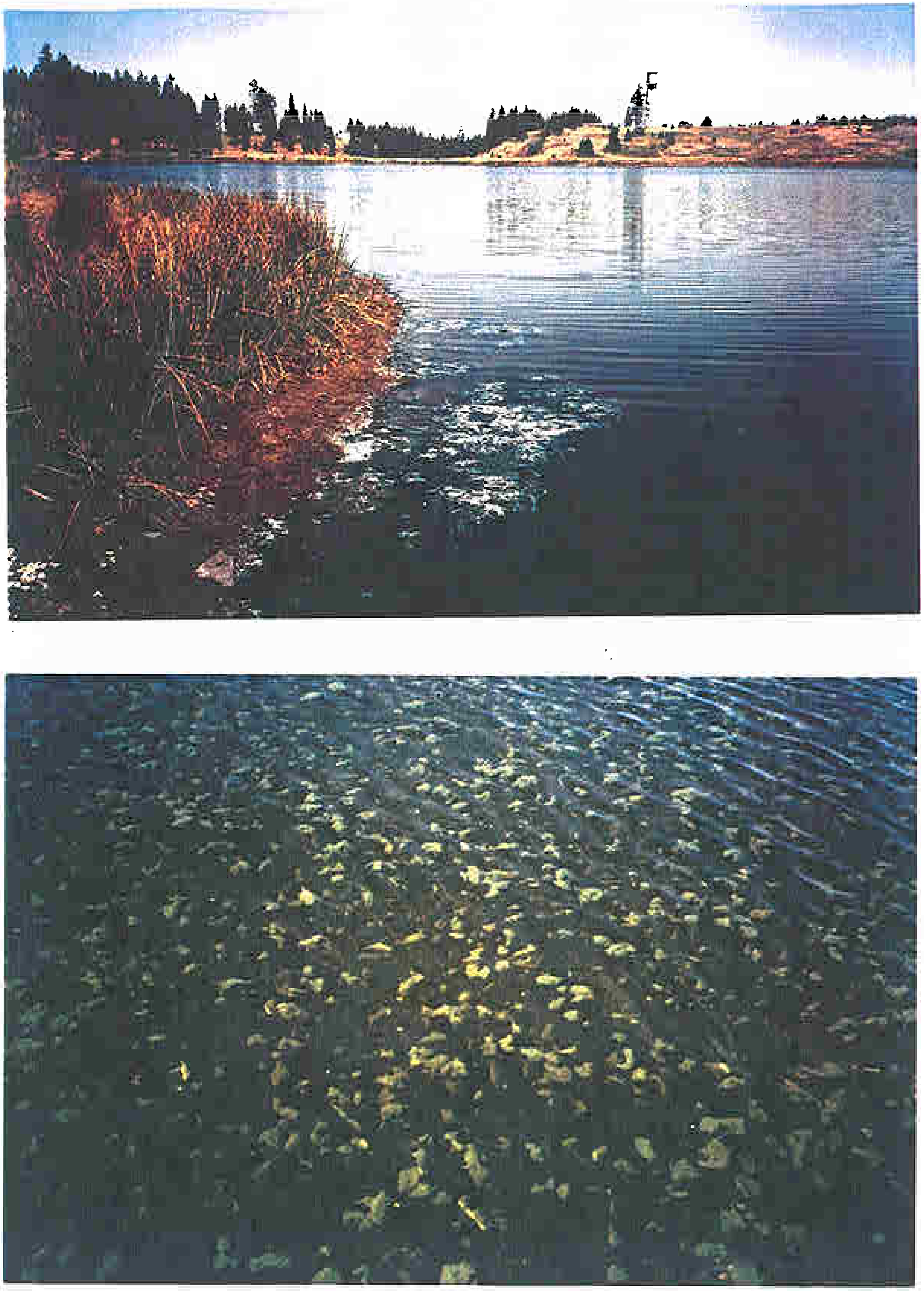


Plate 17. Winchester Lake photographs showing extensive "clumps" of blue-green algae blooms (Aphanizomenon flos-aquae) and representative shoreline and littoral zone makeup.

Figure 47. Dissolved oxygen and temperature profile for Winchester Lake, August 19, 1991.

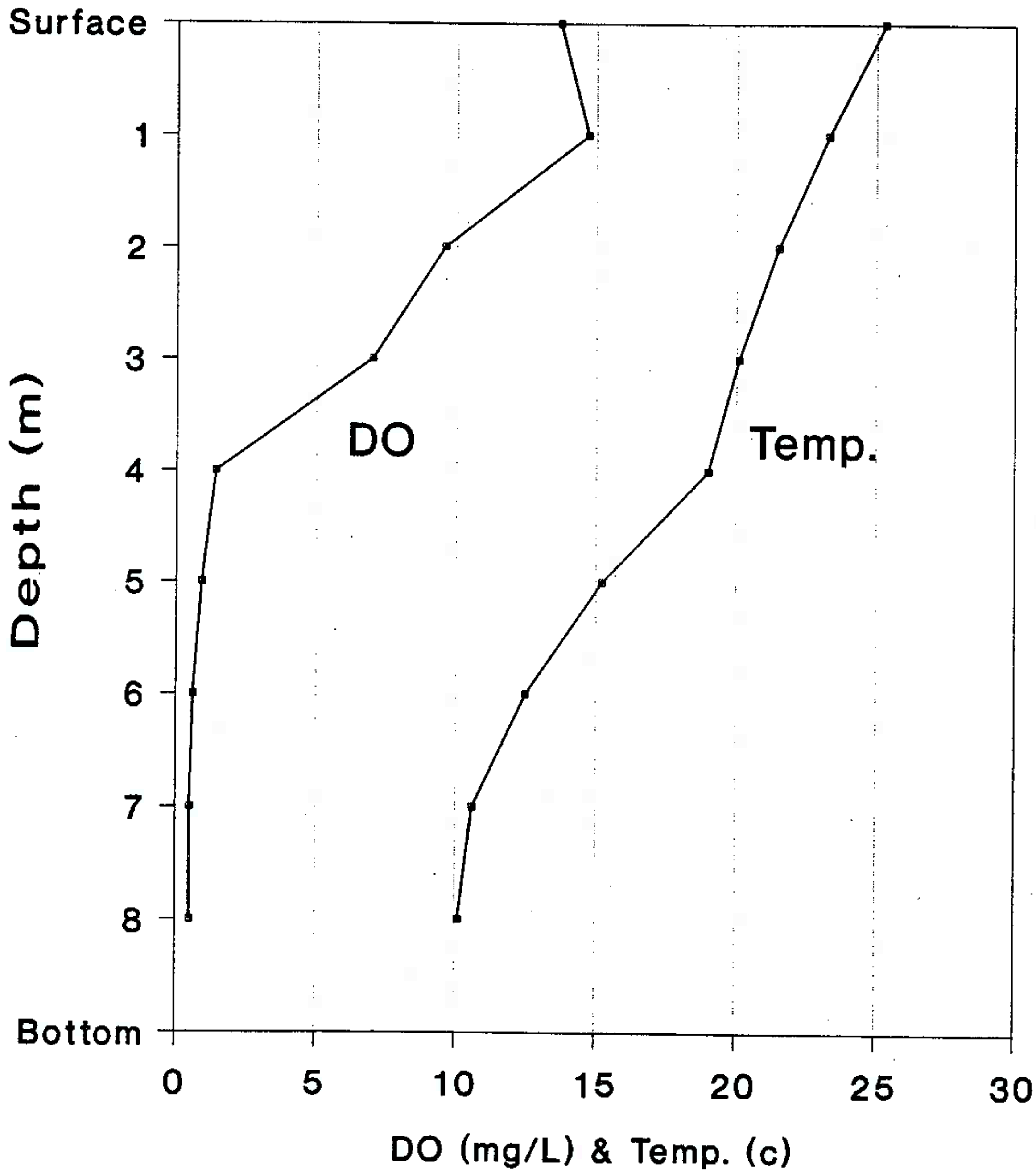


Table 62. LWQA dissolved oxygen/temperature profiles, specific conductivity and pH during summer thermal stratification for Winchester Lake on August 19, 1991.

Depth (meters)	Dissolved Oxygen (mg/L)	Temperature (°C)	Specific Conductance (umhos/cm)	pH
0.0	13.7	25.3	143.0	9.1
1.0	14.7	23.3	143.0	9.2
2.0	9.6	21.5	139.0	8.7
3.0	7.0	20.1	140.0	8.1
4.0	1.4	19.0	144.0	6.8
5.0	0.9	15.2	155.0	6.3
6.0	0.6	12.5	171.0	6.1
7.0	0.5	10.6	183.0	6.0
8.0	0.5	10.1	190.0	6.0

Table 63. 1990 Lake Water Quality Assessment (LWQA) water chemistry for Winchester Lake.

Date	5-14-90	5-14-90	6-21-90	8-1-90	8-1-90	9-13-90	9-13-90	10-24-90
Time	1530	1530	0815	1650	1650	0830	0830	1150
Sample Depth (meters)	7.5	1	8.5	7.5	1	7	1	2.5
Total Depth	9.1	9.1	9.4	8.5	8.5	8.4	8.4	8.9
Secchi Depth	1	1	2.5	1.1	1.1	0.8	0.8	2.3
T. NH3-N (mg/L)	0.607	0.072	1.04	1.88	0.068	1.77	0.05	0.408
T. NO2+NO3-N	0.048	<.005	<.005	<.005	<.005	<.005	<.005	0.111
T. Kjeldahl-N	1.22	1.07	1.68	2.27	1.3	2.38	1.48	1.08
T. Phosphorus-P	0.215	0.091	0.644	0.799	0.054	1.2	0.08	0.12
Dissl. Phosphate-P	0.055	0.01	0.63	0.687	0.056	0.92	0.011	0.1
Hardness-CaCO3	52	60	64	65	56	76	64	64
T.Alkalinity-CaCO3	64	59	70	80	67	101	76	73

	5-14				6-21				8-1			
Meters	Temp.(C)	pH	cond(umhos/cm)	D.O.(mg/L)	temp	pH	cond	D.O.	temp	pH	cond	D.O.
1	12.2	8.2	143	12.6	17.9	7.5	144	8.5	22.9	9	155	13.5
2	11.8	7.7	144	8.4	16.8	7.4	145	8.5	20.7	8.5	153	10.2
3	10.6	6.8	144	5.8	13.8	7	146	5.9	18.7	6.9	154	0.8
4	9.4	6.5	146	3.6	12.4	6.7	149	4.1	15.4	6.5	167	0.3
5	7.6	6.4	149	1.4	11	6.5	153	1.2	11.9	6.3	172	0.3
6	6.8	6.3	150	0.5	9.7	6.3	155	0.5	10.1	6.2	184	0.2
7	6.4	6.3	152	0.5	8.6	6.2	163	0.4	9.2	6.2	195	0.2
8	6.1	6.3	154	0.5	8	6.3	175	0.4	—	—	—	—
9	—	—	—	—	7.9	6.3	178	0.4	—	—	—	—

	9-13				10-24			
	temp	pH	cond	D.O.	temp	pH	cond	D.O.
1	18	8.7	153	10.7	7	6.5	162	6.6
2	18.1	8.5	153	10.4	7.1	6.6	162	6.4
3	17.8	8.6	155	6.1	7	6.6	162	6.4
4	16.6	7.3	167	0.7	7	6.6	162	6.3
5	14.4	6.6	183	0.4	6.9	6.6	161	6.2
6	11.5	6.3	205	0.3	6.9	6.6	163	6.1
7	10.2	6.3	215	0.3	7	6.6	161	6.1
8	9.6	6.2	232	0.3	6.9	6.6	161	6.1
9	—	—	—	—	—	—	—	6.1

Citizen's Volunteer Monitoring Program:

Water quality data for all nine lakes involved in the 1990 and 1991 Citizen Volunteer Monitoring Program (CVMP) have been presented for their respective lakes in the results and discussion section of this LWQA Report.

Quality Assurance of Citizen's Volunteer Monitoring Program:

The precision of water quality samples taken by the Citizen Volunteer Monitoring Program and the Idaho Division of Environmental Quality is shown in Table 64. The average relative range (ARR) for CVMP volunteers, and the ARR between DEQ/CVMP samples are calculated according to Bauer (1986). The ARR is an expression of sampling precision. The ARR rating schedule for precision in sampling is as follows: 0-5 percent = excellent, 5-10 percent = good, 10-20 percent = fair, greater than 20 percent = poor. The percent spike recovery and percent blank recovery was also determined as an expression of laboratory accuracy (Table 65).

The average relative range (ARR) was low for secchi depth (0-3.9 %) and required no extreme values to be removed to attain an ARR of less than 10 per cent (= good precision). Secchi depth had excellent precision in sampling among volunteers, and between volunteers and DEQ sampling (Table 64, 66-67).

The ARR for water temperature among volunteers was excellent (0%). However, the ARR between volunteers and DEQ sampling was higher (22%) and required 3 extreme values to be removed to obtain a 10 per cent ARR (Tables 64, 68-69). The three extreme values came from one team with a malfunctioning YSI temperature meter. Consequently, if one eliminates these data, the precision and consistency between DEQ and volunteer temperature data is very good.

The ARR for dissolved oxygen among volunteers was good (6.8%). However, the ARR between volunteers and DEQ sampling was higher (21.2%) and required 2 extreme values to be removed to obtain a 10 per cent ARR (Tables 64, 70-71). As with temperature, the extreme values came from one team with a malfunctioning YSI meter. Again, if one eliminates these extreme values the precision between DEQ and volunteer dissolved oxygen data is very good. The importance of using properly-maintained electronic equipment for reliable dissolved oxygen and temperature data cannot be overemphasized.
The ARR for chlorophyll "a" among volunteers (12.3%) required the removal of one extreme value of nine to attain an ARR of less than 10 percent. The removal of one extreme value of 14 samples taken between DEQ and volunteers, also attained an ARR of less than 10 percent (Table 64, 72-73). Consequently, the precision for chlorophyll a was considered to be good.

Duplicate DEQ samples for chlorophyll "a" taken for 17 lakes in 1991 for the LWQA, also demonstrated very good precision and consistency. These chlorophyll "a" analyses were very expensive, with projected costs doubling this year.

The ARR for total phosphorus among volunteers (14.5%) required the removal of two extreme values of 16 sampled to attain an ARR of less than 10 percent. The removal of eight extreme values of 20 sampled between DEQ and volunteers was required to attain an ARR of less than 10 percent. The precision for total phosphorus was more consistent among volunteers than between DEQ and volunteers (Tables 64, 74-75).

It can be speculated that the poor precision for phosphorus between DEQ and volunteers (ARR = 26.1%) may have been primarily due to the disturbance of lake bottom muds by the volunteers. When sampling one meter off the lake bottom, the drifting and movement of the boat can be considerable during windy days. This may have strongly introduced sampling errors in the field. The possibility of contamination of these deep hypolimnetic samples taken near the lake bottom will be studied in the 1992 and 1993 CVMP sampling seasons.

The ARR for orthophosphate among volunteers (11.1%) required the removal of one extreme value of 16 sampled to attain an ARR of less than 10 percent. The removal of four extreme values of 22 sampled between DEQ and volunteers was required to attain an ARR of less than 10 percent. The ARR for orthophosphate was 26.6 per cent between DEQ and volunteers (Tables 64, 76-77). Like total phosphorus, the precision for orthophosphate was more consistent among volunteers, than between DEQ and volunteers. The same sampling problems that were discussed for total phosphorus, most likely occurred with orthophosphate since the water samples for both of these analyses were obtained from the same samples and sampling methodology. The source(s) of these phosphorus data inconsistencies will be determined in 1992 and 1993.

The ARR for total nitrite and nitrate, total K. nitrogen and total ammonia among volunteers, required the removal of 3, 7 and 11 extreme values, respectively, to attain an ARR of less than 10 per cent (Table 64). The ARR for these parameters ranged from 24.2 per cent to 46.1 percent. The removal of 7, 12 and 17 extreme values from three sets of 22 samples taken between DEQ and volunteers was required to attain an ARR of less than 10 percent. The ARR for DEQ and volunteers for total nitrite and nitrates, total K. nitrogen and total ammonia was 27,7, 38.9 and 46.0 percent, respectively. The precision was poor for all nitrogen parameters collected and analyzed, both among the volunteers and between DEQ and the volunteers (Tables 64, 79-83). The high variability and lack of precision for nitrogen data is a definite concern. At this time, both the precision and the laboratory accuracy for nitrogen analysis are being reviewed (Tables 64-65).

Laboratory accuracy expressed as per cent spike recovery ranged from 69-105 percent recovery (Table 65). Another measure of laboratory accuracy, the percent blank recovery, ranged from 95-111 percent (Table 65).

Although DEQ has not defined acceptable levels of precision for volunteer monitoring parameters, most of the replicate sampling results indicate relatively low levels of sample variability, when one or two "extreme values" are removed from the data base.

Based in part on the results of the quality assurance analysis, it is recommended that secchi depth, chlorophyll "a" and total phosphorus can be used in the determination of lake trophic status. However, nitrogen analysis were variable and provided very little meaningful data for the CVMP program.

Table 64. Quality Assurance/Precision for water quality samples taken by Citizen Volunteer Monitoring Program (CVMP) and Idaho Division of Environmental Quality (DEQ) individuals during 1990 & 1991.

	CVMP			DEQ/CVMP		
Water Quality Parameter	N	ARR*	Number of Extreme Values Removed to Obtain 10% ARR	N	ARR	Number of Extreme Values Removed to Obtain 10% ARR
Secchi Depth	10	0	0	15	3.9	0
Temperature	9	0	0	15	22.0	3
Dissolved Oxygen	9	6.8	0	16	21.2	2
Chlorophyll a	9	12.3	1	14	12.8	1
T. Phosphorus	16	14.5	2	20	26.1	8
Ortho Phosphate	16	11.1	1	22	26.6	4
T. NO2+NO3	16	24.2	3	22	27.9	7
T.K. Nitrogen	16	29.2	7	22	38.9	12
T. Ammonia	16	46.1	11	23	46.0	17

* Indicates Average Relative Range.

Table 67. DEQ/CVMP/QA/Secchi Depth. Summary of duplicate secchi depth readings taken by DEQ and Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	X1	X2	Mean	Range	% Range
1	2	2	2	0	0.0%
2	2.5	2.5	2.5	0	0.0%
3	2.5	2.5	2.5	0	0.0%
4	3	3	3	0	0.0%
5	3	3.5	3.25	0.5	15.4%
6	4.4	4.5	4.45	0.1	2.2%
7	5	4.5	4.75	0.5	10.5%
8	5	5	5	0	0.0%
9	5	6	5.5	1	18.2%
10	8.5	7.5	8	1	12.5%
11	9.5	9.5	9.5	0	0.0%
12	10	10	10	0	0.0%
13	11	11	11	0	0.0%
14	11.1	11.1	11.1	0	0.0%
15	11.1	11.1	11.1	0	0.0%
Total =					58.8%
Average Relative Range (%) =					3.9%

Table 66. CVMP/QA/Secchi Depth. Summary of duplicate secchi depth readings taken by Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	X1	X2	Mean	Range	% Range
1	0.75	0.75	0.75	0	0.0%
2	2	2	2	0	0.0%
3	2	2	2	0	0.0%
4	2.5	2.5	2.5	0	0.0%
5	3.2	3.2	3.2	0	0.0%
6	4	4	4	0	0.0%
7	4	4	4	0	0.0%
8	5	5	5	0	0.0%
9	6.6	6.6	6.6	0	0.0%
10	9.5	9.5	9.5	0	0.0%
Total =					0.0%
Average Relative Range (%) =					0.0%

Table 67. DEQ/CVMP/QA/Secchi Depth. Summary of duplicate secchi depth readings taken by DEQ and Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	X1	X2	Mean	Range	% Range
1	2	2	2	0	0.0%
2	2.5	2.5	2.5	0	0.0%
3	2.5	2.5	2.5	0	0.0%
4	3	3	3	0	0.0%
5	3	3.5	3.25	0.5	15.4%
6	4.4	4.5	4.45	0.1	2.2%
7	5	4.5	4.75	0.5	10.5%
8	5	5	5	0	0.0%
9	5	6	5.5	1	18.2%
10	8.5	7.5	8	1	12.5%
11	9.5	9.5	9.5	0	0.0%
12	10	10	10	0	0.0%
13	11	11	11	0	0.0%
14	11.1	11.1	11.1	0	0.0%
15	11.1	11.1	11.1	0	0.0%
Total =					58.8%
Average Relative Range (%) =					3.9%

Table 68. CVMP/QA/Temperature. Summary of duplicate samples taken by Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	X1	X2	Mean	Range	% Range
1	5.5	5.5	5.5	0	0.0%
2	7	7	7	0	0.0%
3	10	10	10	0	0.0%
4	10.7	10.7	10.7	0	0.0%
5	11	11	11	0	0.0%
6	11	11	11	0	0.0%
7	14	14	14	0	0.0%
8	19	19	19	0	0.0%
9	20	20	20	0	0.0%
Total =					0.0%
Average Relative Range (%) =					0.0%

Table 69. DEQ/CVMP/QA/Temperature. Summary of duplicate samples taken by DEQ and Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	(CVMP)X1	(DEQ)X2	Mean	Range	% Range
1	3	3	3	0	0.0%
2	4.4	15	9.7	10.6	109.3%
3	4.8	6	5.4	1.2	22.2%
4	5.4	7.4	6.4	2	31.3%
5	6	7.6	6.8	1.6	23.5%
6	6.5	9.1	7.8	2.6	33.3%
7	8.5	15.7	12.1	7.2	59.5%
8	10	10.7	10.35	0.7	6.8%
9	11	11	11	0	0.0%
10	18	19.5	18.75	1.5	8.0%
11	18	19.9	18.95	1.9	10.0%
12	18	19.5	18.75	1.5	8.0%
13	19.7	19.7	19.7	0	0.0%
14	21	19	20	2	10.0%
15	21	22.9	21.95	1.9	8.7%
Total =					330.6%
Average Relative Range (%) =					**22.0%**

Table 68. CVMP/QA/Temperature. Summary of duplicate samples taken by Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	X1	X2	Mean	Range	% Range
1	5.5	5.5	5.5	0	0.0%
2	7	7	7	0	0.0%
3	10	10	10	0	0.0%
4	10.7	10.7	10.7	0	0.0%
5	11	11	11	0	0.0%
6	11	11	11	0	0.0%
7	14	14	14	0	0.0%
8	19	19	19	0	0.0%
9	20	20	20	0	0.0%
Total =					0.0%
Average Relative Range (%) =					0.0%

Table 69. DEQ/CVMP/QA/Temperature. Summary of duplicate samples taken by DEQ and Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	(CVMP)X1	(DEQ)X2	Mean	Range	% Range
1	3	3	3	0	0.0%
2	4.4	15	9.7	10.6	109.3%
3	4.8	6	5.4	1.2	22.2%
4	5.4	7.4	6.4	2	31.3%
5	6	7.6	6.8	1.6	23.5%
6	6.5	9.1	7.8	2.6	33.3%
7	8.5	15.7	12.1	7.2	59.5%
8	10	10.7	10.35	0.7	6.8%
9	11	11	11	0	0.0%
10	18	19.5	18.75	1.5	8.0%
11	18	19.9	18.95	1.9	10.0%
12	18	19.5	18.75	1.5	8.0%
13	19.7	19.7	19.7	0	0.0%
14	21	19	20	2	10.0%
15	21	22.9	21.95	1.9	8.7%
Total =					330.6%
Average Relative Range (%) =					**22.0%**

Table 70. CVMP/QA/Dissolved Oxygen. Summary of duplicate samples taken by Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	X1	X2	Mean	Range	% Range
1	1	1	1	0	0.0%
2	6.7	6.7	6.7	0	0.0%
3	8	8	8	0	0.0%
4	9	9	9	0	0.0%
5	9	9	9	0	0.0%
6	9	10	9.5	1	10.5%
7	9	5	7	4	57.1%
8	10.3	10.3	10.3	0	0.0%
9	10.5	10.5	10.5	0	0.0%
Total =					67.7%
Average Relative Range (%) =					6.8%

Table 71. DEQ/CVMP/QA/Dissolved Oxygen. Summary of duplicate samples taken by DEQ and Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	(CVMP)X1	(DEQ)X2	Mean	Range	% Range
1	0.1	0.2	0.15	0.1	66.7%
2	0.2	0.9	0.55	0.7	127.3%
3	0.3	0.3	0.3	0	0.0%
4	4.8	6	5.4	1.2	22.2%
5	6	10.7	8.35	4.7	56.3%
6	6	4.7	5.35	1.3	24.3%
7	6.8	7.1	6.95	0.3	4.3%
8	6.8	7	6.9	0.2	2.9%
9	7	7	7	0	0.0%
10	7.5	7.5	7.5	0	0.0%
11	7.6	8.7	8.15	1.1	13.5%
12	7.6	11	9.3	3.4	36.6%
13	7.8	8	7.9	0.2	2.5%
14	8.6	8.2	8.4	0.4	4.8%
15	10.2	12.8	11.5	2.6	22.6%
16	11.2	11.2	11.2	0	0.0%
Total =					317.3%
Average Relative Range (%) =					21.2%

Table 72. CVMP/QA/Chlorophyll a. Summary of duplicate samples taken by Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	X1	X2	Mean	Range	% Range
1	0.6	0.8	0.7	0.2	28.6%
2	1.4	1.6	1.5	0.2	13.3%
3	2	2.9	2.45	0.9	36.7%
4	2	2	2	0	0.0%
5	3.3	3	3.15	0.3	9.5%
6	3.5	3.8	3.65	0.3	8.2%
7	5.3	4.2	4.75	1.1	23.2%
8	6.6	6.6	6.6	0	0.0%
9	15.2	15.7	15.45	0.5	3.2%
Total =					122.8%
Average Relative Range (%) =					12.3%

Table 73. DEQ/CVMP/QA/Chlorophyll a. Summary of duplicate samples taken by DEQ and Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	(CVMP)X1	(DEQ)X2	Mean	Range	% Range
1	1	1.6	1.3	0.6	46.2%
2	1	1	1	0	0.0%
3	1	1	1	0	0.0%
4	1	1	1	0	0.0%
5	1	1	1	0	0.0%
6	1	1	1	0	0.0%
7	2.2	2.7	2.45	0.5	20.4%
8	2.2	3	2.6	0.8	30.8%
9	2.2	3.2	2.7	1	37.0%
10	2.3	2	2.15	0.3	14.0%
11	4.2	4.2	4.2	0	0.0%
12	4.3	3.4	3.85	0.9	23.4%
13	7.6	6.4	7	1.2	17.1%
14	9.5	9.8	9.65	0.3	3.1%
Total =					192.0%
Average Relative Range (%) =					**12.8%**

Table 74. CVMP/QA/T. Phosphorus. Summary of duplicate samples taken by Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	X1	X2	Mean	Range	% Range
1	0.002	0.004	0.003	0.002	66.7%
2	0.006	0.009	0.0075	0.003	40.0%
3	0.009	0.009	0.009	0	0.0%
4	0.01	0.02	0.015	0.01	66.7%
5	0.011	0.011	0.011	0	0.0%
6	0.011	0.011	0.011	0	0.0%
7	0.012	0.017	0.0145	0.005	34.5%
8	0.014	0.017	0.0155	0.003	19.4%
9	0.015	0.016	0.0155	0.001	6.5%
10	0.018	0.019	0.0185	0.001	5.4%
11	0.019	0.02	0.0195	0.001	5.1%
12	0.027	0.025	0.026	0.002	7.7%
13	0.045	0.042	0.0435	0.003	6.9%
14	0.2	0.19	0.195	0.01	5.1%
15	0.4	0.42	0.41	0.02	4.9%
16	0.7	0.6	0.65	0.1	15.4%
Total =					217.5%
Average Relative Range (%) =					14.5%

Table 75. DEQ/CVMP/QA/T. Phosphorus. Summary of duplicate samples taken by DEQ and Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	(CVMP)X1	(DEQ)X2	Mean	Range	% Range
1	0.002	0.004	0.003	0.002	66.7%
2	0.003	0.005	0.004	0.002	50.0%
3	0.004	0.005	0.0045	0.001	22.2%
4	0.005	0.009	0.007	0.004	57.1%
5	0.006	0.006	0.006	0	0.0%
6	0.01	0.012	0.011	0.002	18.2%
7	0.012	0.016	0.014	0.004	28.6%
8	0.014	0.012	0.013	0.002	15.4%
9	0.015	0.015	0.015	0	0.0%
10	0.015	0.016	0.0155	0.001	6.5%
11	0.018	0.024	0.021	0.006	28.6%
12	0.018	0.016	0.017	0.002	11.8%
13	0.02	0.02	0.02	0	0.0%
14	0.03	0.033	0.0315	0.003	9.5%
15	0.03	0.4	0.215	0.37	172.1%
16	0.077	0.068	0.0725	0.009	12.4%
17	0.103	0.144	0.1235	0.041	33.2%
18	0.133	0.1	0.1165	0.033	28.3%
19	0.19	0.22	0.205	0.03	14.6%
20	0.32	0.283	0.3015	0.037	12.3%
Total =					391.4%
Average Relative Range (%) =					**26.1%**

Table 76. CVMP/QA/Ortho Phosphate. Summary of duplicate samples taken by Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	X1	X2	Mean	Range	% Range
1	0.001	0.001	0.001	0	0.0%
2	0.001	0.001	0.001	0	0.0%
3	0.001	0.001	0.001	0	0.0%
4	0.001	0.001	0.001	0	0.0%
5	0.001	0.001	0.001	0	0.0%
6	0.001	0.001	0.001	0	0.0%
7	0.002	0.002	0.002	0	0.0%
8	0.002	0.002	0.002	0	0.0%
9	0.002	0.002	0.002	0	0.0%
10	0.003	0.003	0.003	0	0.0%
11	0.003	0.002	0.0025	0.001	40.0%
12	0.007	0.008	0.0075	0.001	13.3%
13	0.01	0.006	0.008	0.004	50.0%
14	0.012	0.017	0.0145	0.005	34.5%
15	0.19	0.17	0.18	0.02	11.1%
16	0.38	0.32	0.35	0.06	17.1%
Total =					166.1%
Average Relative Range (%) =					11.1%

Table 77. DEQ/CVMP/QA/Ortho Phosphate. Summary of duplicate samples taken by DEQ and Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	(CVMP)X1	(DEQ)X2	Mean	Range	% Range
1	0.001	0.001	0.001	0	0.0%
2	0.001	0.001	0.001	0	0.0%
3	0.001	0.001	0.001	0	0.0%
4	0.001	0.002	0.0015	0.001	66.7%
5	0.002	0.002	0.002	0	0.0%
6	0.002	0.002	0.002	0	0.0%
7	0.002	0.002	0.002	0	0.0%
8	0.002	0.002	0.002	0	0.0%
9	0.002	0.002	0.002	0	0.0%
10	0.002	0.002	0.002	0	0.0%
11	0.002	0.002	0.002	0	0.0%
12	0.002	0.002	0.002	0	0.0%
13	0.003	0.005	0.004	0.002	50.0%
14	0.005	0.005	0.005	0	0.0%
15	0.011	0.01	0.0105	0.001	9.5%
16	0.012	0.005	0.0085	0.007	82.4%
17	0.016	0.016	0.016	0	0.0%
18	0.016	0.016	0.016	0	0.0%
19	0.081	0.108	0.0945	0.027	28.6%
20	0.095	0.007	0.051	0.088	172.5%
21	0.17	0.19	0.18	0.02	11.1%
22	0.27	0.171	0.2205	0.099	44.9%
Total =					399.0%
Average Relative Range (%) =					**26.6%**

Table 78. CVMP/QA/T.NO2 & No3. Summary of duplicate samples taken by Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	X1	X2	Mean	Range	% Range
1	0.001	0.001	0.001	0	0.0%
2	0.001	0.001	0.001	0	0.0%
3	0.005	0.005	0.005	0	0.0%
4	0.005	0.005	0.005	0	0.0%
5	0.005	0.005	0.005	0	0.0%
6	0.005	0.007	0.006	0.002	33.3%
7	0.005	0.005	0.005	0	0.0%
8	0.005	0.005	0.005	0	0.0%
9	0.005	0.019	0.012	0.014	116.7%
10	0.009	0.005	0.007	0.004	57.1%
11	0.01	0.011	0.0105	0.001	9.5%
12	0.015	0.022	0.0185	0.007	37.8%
13	0.028	0.031	0.0295	0.003	10.2%
14	0.036	0.026	0.031	0.01	32.3%
15	0.069	0.037	0.053	0.032	60.4%
16	0.1	0.094	0.097	0.006	6.2%
Total =					363.5%
Average Relative Range (%) =					24.2%

Table 79. DEQ/CVMP/QA/T. NO2 & NO3. Summary of duplicate samples taken by DEQ and Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	(CVMP)X1	(DEQ)X2	Mean	Range	% Range
1	0.001	0.001	0.001	0	0.0%
2	0.005	0.005	0.005	0	0.0%
3	0.005	0.005	0.005	0	0.0%
4	0.005	0.005	0.005	0	0.0%
5	0.005	0.005	0.005	0	0.0%
6	0.006	0.017	0.0115	0.011	95.7%
7	0.007	0.015	0.011	0.008	72.7%
8	0.008	0.012	0.01	0.004	40.0%
9	0.009	0.011	0.01	0.002	20.0%
10	0.01	0.01	0.01	0	0.0%
11	0.01	0.009	0.0095	0.001	10.5%
12	0.012	0.01	0.011	0.002	18.2%
13	0.012	0.01	0.011	0.002	18.2%
14	0.014	0.014	0.014	0	0.0%
15	0.019	0.031	0.025	0.012	48.0%
16	0.02	0.012	0.016	0.008	50.0%
17	0.021	0.023	0.022	0.002	9.1%
18	0.026	0.022	0.024	0.004	16.7%
19	0.037	0.005	0.021	0.032	152.4%
20	0.087	0.114	0.1005	0.027	26.9%
21	0.108	0.101	0.1045	0.007	6.7%
22	0.125	0.128	0.1265	0.003	2.4%
Total =					419.0%
Average Relative Range (%) =					27.9%

Table 80. CVMP/QA/T.K. Nitrogen. Summary of duplicate samples taken by Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	X1	X2	Mean	Range	% Range
1	0.025	0.44	0.2325	0.415	178.5%
2	0.12	0.06	0.09	0.06	66.7%
3	0.13	0.09	0.11	0.04	36.4%
4	0.13	0.2	0.165	0.07	42.4%
5	0.14	0.16	0.15	0.02	13.3%
6	0.15	0.16	0.155	0.01	6.5%
7	0.16	0.43	0.295	0.27	91.5%
8	0.2	0.08	0.14	0.12	85.7%
9	0.3	0.25	0.275	0.05	18.2%
10	0.35	0.36	0.355	0.01	2.8%
11	0.36	0.37	0.365	0.01	2.7%
12	0.48	0.34	0.41	0.14	34.1%
13	0.72	0.76	0.74	0.04	5.4%
14	0.98	0.92	0.95	0.06	6.3%
15	1.64	1.55	1.595	0.09	5.6%
16	2.12	1.73	1.925	0.39	20.3%
Total =					438.0%
Average Relative Range (%) =					29.2%

Table 81. DEQ/CVMP/QA/T.K. Nitrogen. Summary of duplicate samples taken by DEQ and Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	(CVMP)X1	(DEQ)X2	Mean	Range	% Range
1	0.05	0.25	0.15	0.2	133.3%
2	0.1	0.08	0.09	0.02	22.2%
3	0.11	0.16	0.135	0.05	37.0%
4	0.11	0.28	0.195	0.17	87.2%
5	0.12	0.14	0.13	0.02	15.4%
6	0.14	0.22	0.18	0.08	44.4%
7	0.16	0.2	0.18	0.04	22.2%
8	0.17	0.2	0.185	0.03	16.2%
9	0.2	0.05	0.125	0.15	120.0%
10	0.22	0.3	0.26	0.08	30.8%
11	0.23	0.42	0.325	0.19	58.5%
12	0.25	0.17	0.21	0.08	38.1%
13	0.26	0.75	0.505	0.49	97.0%
14	0.26	0.26	0.26	0	0.0%
15	0.33	0.18	0.255	0.15	58.8%
16	0.35	0.2	0.275	0.15	54.5%
17	0.36	0.31	0.335	0.05	14.9%
18	0.37	0.38	0.375	0.01	2.7%
19	0.48	0.58	0.53	0.1	18.9%
20	0.62	0.35	0.485	0.27	55.7%
21	0.76	0.79	0.775	0.03	3.9%
22	0.9	0.78	0.84	0.12	14.3%
Total =					584.2%
Average Relative Range (%) =					**38.9%**

Table 82. CVMP/QA/T. Ammonia. Summary of duplicate samples taken by Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	X1	X2	Mean	Range	% Range
1	0.005	0.02	0.013	0.015	120.0%
2	0.013	0.026	0.020	0.013	66.7%
3	0.015	0.018	0.017	0.003	18.2%
4	0.017	0.013	0.015	0.004	26.7%
5	0.017	0.001	0.009	0.016	177.8%
6	0.025	0.024	0.025	0.001	4.1%
7	0.025	0.026	0.026	0.001	3.9%
8	0.03	0.048	0.039	0.018	46.2%
9	0.037	0.023	0.030	0.014	46.7%
10	0.045	0.065	0.055	0.02	36.4%
11	0.051	0.033	0.042	0.018	42.9%
12	0.092	0.029	0.061	0.063	104.1%
13	0.132	0.291	0.212	0.159	75.2%
14	0.41	0.514	0.462	0.104	22.5%
15	0.54	0.515	0.528	0.025	4.7%
16	1.14	0.982	1.061	0.158	14.9%
Total =					690.8%
Average Relative Range (%) =					46.1%

Table 83. DEQ/CVMP/QA/T. Ammonia. Summary of duplicate samples taken by DEQ and Citizen Volunteer Monitoring Program (CVMP) individuals during 1990 & 1991.

Number	(CVMP)X1	(DEQ)X2	Mean	Range	% Range
1	0.021	0.01	0.016	0.011	71.0%
2	0.024	0.032	0.028	0.008	28.6%
3	0.029	0.016	0.023	0.013	57.8%
4	0.039	0.044	0.042	0.005	12.0%
5	0.051	0.037	0.044	0.014	31.8%
6	0.058	0.135	0.097	0.077	79.8%
7	0.058	0.044	0.051	0.014	27.5%
8	0.059	0.327	0.193	0.268	138.9%
9	0.064	0.062	0.063	0.002	3.2%
10	0.072	0.078	0.075	0.006	8.0%
11	0.085	0.018	0.052	0.067	130.1%
12	0.086	0.068	0.077	0.018	23.4%
13	0.104	0.046	0.075	0.058	77.3%
14	0.107	0.204	0.156	0.097	62.4%
15	0.122	0.058	0.090	0.064	71.1%
16	0.133	0.077	0.105	0.056	53.3%
17	0.15	0.128	0.139	0.022	15.8%
18	0.161	0.168	0.165	0.007	4.3%
19	0.283	0.119	0.201	0.164	81.6%
20	0.291	0.139	0.215	0.152	70.7%
21	0.477	0.303	0.390	0.174	44.6%
22	0.514	0.688	0.601	0.174	29.0%
23	0.744	0.636	0.690	0.108	15.7%
Total =					690.4%
Average Relative Range (%) =					46.0%

CONCLUSION

The primary goal of the LWQA was to assess the water quality and trophic status of 17 Idaho lakes and make management recommendations to prevent further lake eutrophication and water quality degradation of these lakes. Beneficial uses in the Idaho State Water Quality Standards, including, domestic water supply, agricultural water supply, cold water biota, warm water biota, salmonid spawning, primary contact recreation, secondary contact recreation and special resource water, were evaluated on the basis of water quality criteria, biological data and professional judgement; a determination was made as to whether the lakes were threatened and/or impaired.

The seventeen Idaho Lakes studied in a 1990 and 1991 Lake Water Quality Assessment Study (LWQA) illustrated the extreme differences found in freshwater lakes ranging in trophic classification from oligotrophic to eutrophic. Specific discussion of the trophic status and water quality trends of lakes were discussed for each of the seventeen lakes in the LWQA Report. The Idaho Lakes studied, in order of oligotrophy to eutrophy, were: Priest, Hayden, Spirit, Upper Priest, Lower Twin, Fernan, Kelso, Upper Twin, Cocolalla, Hauser, Round, Granite, Soldier's Meadow, Waha, Rose, Mann and Winchester Lakes.

The determination of the trophic status of a lake is both a science and an art. The selection of important water quality and biological parameters used in determining a lake's trophic status can be highly conjectoral at times. The Idaho Division of Environmental Quality LWQA Study utilized secchi depth, chlorophyll "a", total phosphorus, the number of prevalent species of submergent macrophytes, the maximum depth of submergent macrophytes, dissolved oxygen/temperature profiles, the maximum hypolimnetic phosphorus, the maximum hypolimnetic ammonia and the minimum hypolimnetic dissolved oxygen. These parameters provided an excellent balance of water quality and biological measurements to assess lake trophic status. These parameters were reliable and cost-effective in ascertaining the trophic status and water quality of lakes.

Based on the results of the Idaho LWQA Study, it is recommended that some of the more time-consuming and expensive lake study procedures be modified for future citizen volunteer monitoring programs. The use of more reliable, cost-effective lake assessment techniques used in this LWQA Study provided an improved forum for citizen volunteer lake monitors to assess the water quality of lakes.

Other water quality parameters sampled in the LWQA Study included: orthophosphate, nitrogen (TKN, total nitrites and nitrates, total ammonia), pH, specific conductivity and phytoplankton. While data from the analysis of these parameters traditionally have value and usefulness, budgetary constraints on lake water quality agencies and volunteer monitors strongly suggest there was a need to look at other options to ascertain the water quality of lakes. In order to maintain citizen and governmental lake water quality monitoring programs and provide meaningful and quality baseline information of lakes, it has becoming increasingly necessary to prioritize what parameters can be sampled. Herein, lies the reason for the need to further refine lake trophic classification methods. Measurements such as secchi depth are inexpensive to obtain and provide accurate and valuable information concerning the trophic status and water quality of lakes. Dissolved oxygen and temperature profiles taken during the month of peak cumulative biological productivity (August) provided excellent and easily-understood information concerning the oxygen and thermal characteristics from the surface to the bottom of the lake.

The number of prevalent species of submergent macrophytes was an extremely useful and cost-effective measurement in determining lake trophic status. Submergent macrophytes were sampled in August, along with secchi depth, chlorophyll "a", total phosphorus and dissolved oxygen and temperature profiles. Consequently, data for these parameters were obtained on the same field trip, thereby reducing travel expenses. Conceivably, if there was an absolute need to reduce costs and field work to one month a year in order to monitor a lake and determine the trophic status, the recommended month would be August.

The use of secchi depth, dissolved oxygen and temperature profiles and the number of prevalent species of submergent macrophytes provides an opportunity for citizen volunteer lake monitors to easily visualize changes in lake water quality, in contrast to water chemistry data, which oftentimes, can be more difficult for volunteers to comprehend. The meaning of water clarity (transparency) is easily visualized by volunteer monitors. Furthermore, graphical illustrations of the dissolved oxygen and temperature profile in lakes can be readily understood, providing the data is presented in a simplified and logical format.

Other lake trophic classification systems used in recent years were compared with lake trophic classifications determined by the Idaho Lake Water Quality Assessment Study. The classification of lake trophic status was compared among the Division of Environmental Quality (DEQ), the University of Idaho, EPA-National Eutrophication Study and Wetzel's trophic classification system. There was some agreement and some disagreement for trophic status among the seventeen LWQA lakes studied. Some of the differences may have been due to a combination of actual changes in trophic conditions of these lakes and/or the lake rating system.

The selection of what types and numbers of water quality and biological parameters to use in ascertaining lake trophic status is one of the most critical steps a limnologist will take in designing a lake study plan. It is strongly suggested from data obtained in this LWQA Study and from comparative literature, that the design of any lake study plan, should ideally include: secchi depth, chlorophyll "a", total phosphorus, the number of prevalent species of submergent macrophytes, the maximum depth of submergent macrophyte growth and dissolved oxygen and temperature profiles during August.

RECOMMENDATIONS

The LWQA also was designed to evaluate the CVMP and determine the most effective and efficient means and parameters to monitor and evaluate lake water quality.

The LWQA Study demonstrated that secchi depth, chlorophyll "a" and total phosphorus can be used in conjunction with dissolved oxygen and temperature (August) profiles and the number of prevalent species of submergent macrophytes to determine water quality trends and trophic status of lakes. The maximum water depth that submergent macrophytes grow as related to secchi depth and lake trophic status was also found to be an important parameter.

The cost and reliability of water quality and biological parameters used in citizen volunteer lake monitoring programs was a major concern that was evaluated in this LWQA Study. Based on the results of this Study and other information, the following recommendations can be made for implementing a citizen's volunteer lake monitoring program:

* Measure those parameters in citizen volunteer monitoring programs which provide meaningful, cost-effective information for use in determining lake water quality and trophic status:

1) dissolved oxygen/temperature profiles in August,
2) secchi depth,
3) number of prevalent submergent macrophyte species,
4) chlorophyll "a", and
5) total phosphorus.

* Nitrogen water chemistry provided limited utility, reliability and poor precision, relative to the cost and time expended.
* Diatoms, flagellates and green algal groups were not a reliable measure of water quality and lake trophic status. Only the blue-green algal group was found to be a reliable lake trophic status indicator. Phytoplankton analysis should be a low priority parameter in volunteer lake monitoring programs, based on the cost, time and limited utility of this information.

LITERATURE CITED

Beckwith, M. and J. Skille. 1987. Volunteer Lake Monitoring: A Brief Data Analysis, Comparison with Previous Studies, and General Observations. Unpublished report. Idaho Department of Health and Welfare, Division of Environmental Quality, Coeur d'Alene, Idaho. 13 pp.

Bellatty, J.M. 1989. 1988 North Idaho Annual Summary: Citizens Volunteer Monitoring Program. Idaho Department of Health and Welfare, Division of Environmental Quality, Boise, Idaho. 75 pp.

Bellatty, J.M. 1990. Hayden Lake. Water Quality Status Report No. 92. Idaho Department of Health and Welfare, Division of Environmental Quality. 26 pp.

Bellatty, J. and Meitl, J. 1991. Idaho Volunteer Monitoring Program Lake Protocols. Idaho Department of Health and Welfare, Division of Environmental Quality. 78 pp.

Bauer, S.B. 1986. Pilot study of quality assurance sample procedures. Water Quality Bureau Report, Idaho Department of Health and Welfare, Division of Environment, Boise, Idaho. 41 pp.

Carlson, R.E. 1977. A trophic state index for lakes. Limnol. & Ocean. 22(2):361-369.

Curtis, J.T. 1959. The Vegetation of Wisconsin. The University of Wisconsin. 657 pp.

Dion, N.P. and S.S. Sumioka. 1985. Trophic Classification of Washington Lakes Using Reconnaissance Data. Department of Ecology. Water-Supply Bulletin No. 57. 320 pp.

Entranco Engineers. 1990. Final Report: Phase I Diagnostic and Feasibility Analysis for Hauser Lake, Kootenai County, Idaho. Idaho Department of Health and Welfare, Division of Environmental Quality. 58 pp.

EPA. 1977. National Eutrophication Survey, Reports on Idaho Lakes, Working Paper Nos. 776-786 and 836, Environmental Research Center, Corvallis, Oregon.

EPA. 1988. Clean Lakes Program Handbook for Regional Coordinators. Clean Lakes Program, Nonpoint Sources Branch, Office of Water, EPA.

EPA. 1988. The Lake and Reservoir Restoration Guidance Manual First Ed. EPA 440/5-88-002.

Falter, C.M. and J.C. Good. 1987. Cocolalla Lake Phosphorus Loading and Trophic Status Assessment. University of Idaho, College of Forestry, Wildlife, and Range Sciences, Department of Fish and Wildlife Resources, Moscow, Idaho. 124 pp.

Falter, C.M. and D. Hallock. 1987. Limnological Study and Management Plan for Upper and Lower Twin Lakes, Kootenai County, Idaho. Idaho Water Resources Research Institute, University of Idaho, Moscow, Idaho. 186 pp.

Fassett, N.C. 1966. A Manual of Aquatic Plants. The University of Wisconsin Press. 405 pp.

Idaho Department of Fish and Game. 1988. Personal Commumication.

Idaho Department of Health and Welfare (IDHW). 1985. Idaho Water Quality Standards and Wastewater Treatment Requirements. IDHW, Division of Environment, Boise, Id.

Johnson, D.M., Petersen, R.R., Lycan, D.R., Sweet, J.W., Neuhaus, M.E. and Schaedel, A.L. 1985. Atlas of Oregon Lakes. Oregon State University Press, Corvallis, Oregon. 317 pp.

McKee, J.E. and H.W. Wolf. 1963. Water Quality Criteria. Second Ed. The Resources Agency of California, State Water Resources Control Board. Publication No. 3-A.

Milligan, J.H., R.A. Lyman, C.M. Falter, E.E. Krumpe, and J.E. Carlson. 1983. Classification of Idaho's Freshwater Lakes.Id. Water & Energy Res. Res. Inst. U. of Idaho.

Mossier, J. 1992. A Lake Water Quality Assessment and Citizen's Lake Water Quality Handout. Idaho Division of Environmental Quality. 100 pp.

National Academy of Sciences. 1969. Eutrophication: Causes, Consequences, Correctives. Proceedings of a Symposium. Washington, D.C. 661 pp.

Nichols, D.G. and F.W. Rabe. 1988. Water Quality Study of the Spirit Lake, Idaho Watershed. Completion Report Submitted to the Spirit Lake Property Owners Association.

Palmer, C.M. 1962. Algae In Water Supplies. U.S. Department of Health, Education and Welfare. Washington, D.C. Public Health Service Publication No. 657. 88 pp.

Prescott, G.W. 1970. The Freshwater Algae. Wm.C. Brown Company. Dubuque, Iowa. 348 pp.

Rector,J. and D. Hallock. 1989. Lake Water Quality Assessment Project. Washington State Department of Ecology. Olympia, Washington. 209 pp.

Sculthorpe, C.D. 1967. The Biology of Aquatic Vascular Plants. Edward Arnold (Publishers) Ltd. London. 610 pp.

Simpson, J.T. 1991. Volunteer Lake Monitoring: A Methods Manual. EPA 440/4-91-002.

Soltero, R.A. and J.A. Hall. 1985. Completion Report: Water Quality Assessment of Spirit Lake, Idaho. Eastern Washington University, Department of Biology, Cheney, Washington. 85 pp.

Soltero, R.A., K.R. Merrill, M.R. Cather, and L.M. Appel. 1986. Completion Report: Water Quality Assessment of Hayden Lake, Idaho. Eastern Washinbgton University, Department of Biology, Cheney, Washington. 92 pp.

Taras, M.J. et. al. 1992. Standard Methods for the Examination of Water and Wastewater. 18th edition. 874 pp.

Wetzel, R. G. 1975. Limnology. W.B. Saunders Company. 743 pp.