Appendix F

Water Quality Monitoring Program

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BIG LAKE, LAKE MANAGEMENT PLAN
WATER QUALITY MONITORING

WORK PLAN FOR
PHASE 1 - BASELINE / DIAGNOSTIC STUDY

"You can't manage what you can't measure" *Lake Leaders Handbook*

1.0 INTRODUCTION

Background

A primary task of the Big Lake, Lake Management Plan was to review and analyze available hydrologic and water quality data at Big Lake and it's major tributary streams. It was quickly determined that no regular data collection programs had been implemented in the area. In general, the data record was limited to occasional grab samples and a small number of chemical and biological constituents. The exception was the study conducted by Woods (1992), where data were obtained on physical water quality and planktonic algae productivity in the center of the main basins during 1983 and 1984. Although this information has proven to be useful, many data gaps remain and present water quality conditions of the lake and it's watershed are largely unknown.

Based on review of this limited data record and observations offered by the Big Lake Citizen's Advisory Committee and local resource agency staff, several water quality problem areas were identified:

- The lake appears to experiencing an acceleration of the natural process of nutrient eutrophication (increasing productivity of algae and other aquatic plants).
- Temporary and localized cases of high turbidity have been observed during periods of high boating activity.
- It is expected that fecal coliform bacteria levels are elevated in lake areas where residential septic systems are malfunctioning or improperly designed.
- Homeowners have noted a change in taste of drinking water from local wells, suspecting contamination from septic systems

Potential management actions for control of each of these problems were identified in the Management Plan. However, it was recognized that implementation of these strategies should be accompanied by development of a focused water quality monitoring program. This program could serve several primary functions:

- Establish baseline conditions for comparison to observed or anticipated future conditions.
- Attempt through diagnostic monitoring to further identify causal factors which influence water quality.
- Ongoing compliance and trend monitoring to determine if standards or objectives are violated and alert the Borough when a problem may be developing.

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At present, there are no comprehensive lake water quality monitoring programs being conducted within the Matanuska-Susitna Burough. Thus, the Big Lake program would provide some secondary benefits to the region:

- Develop and standardize procedures for data collection and analysis at south-central Alaska lakes.
- Contribute significantly to the regional water quality database, which can be used for assessment and planning purposes in the Big Lake watershed area as well as other drainages.

Taking a Phased Approach

The Federal Clean Lakes Program, authorized under Section 314 of the *Clean Water Act*, encourages a phased approach for investigation and management of publicly owned lakes (USEPA 1981). Phase I projects are designed to determine a lake's current condition and assist in identification of methods for lake restoration and protection. Phase II projects implement and monitor the most feasible restoration/protection alternatives for the lake and/or associated watershed. Phase III studies determine the longevity and effectiveness of restoration techniques and provide for further understanding of dynamic relationships occurring in the lake system.

This document provides a Work Plan for implementation of a Phase I investigation at Big Lake. The investigation will involve a minimum of one year of data collection. Additional years will be required if goals and objectives change significantly or if conditions (temperatures, precipitation, etc.) in the first study year are clearly outside the normal range. Many of the components of the Phase I study will likely be continued after the first year as part of a long-term trend monitoring program. Recommendations for long-term monitoring and/or Phase II investigations will be made at completion of the Phase I program.

The Phase I Work Plan defines goals and objectives of the monitoring program, identifies appropriate sampling locations and field and laboratory procedures, and outlines primary data assessment methods. Prior to implementing this Plan, several tasks will need be completed. These include:

- **Establish a Water Quality Steering Committee (WQSC)**. This group will oversee implementation of the program including refining goals and objectives, data collection and analysis, interaction with regulatory agencies, and reporting to the Mat-Su Borough and Big lake Citizen's Advisory Committee. Core members should include Borough planning staff and their technical consultants.

- **Establish a Big Lake Volunteer Monitoring Program**. Proper application of a volunteer labor force could result in significant financial savings for the monitoring program without sacrificing data credibility. Volunteers will be particularly useful as field assistants in initial stages of the program and capable of implementing the majority of long-term trend monitoring. Recruiting, training, and field supervision would be the responsibility of a volunteer coordinator (or coordinating committee) who reports to the WQSC. Guidance for development of volunteer monitoring programs is provided in *Volunteer Monitoring: A Methods Manual* (USEPA 1991) and *Volunteer Monitoring: A Guide for State Managers* (USEPA 1990a).

- **Develop a Quality Assurance Project Plan (QAPP).** An important follow-up to the Work Plan, the QAPP will outline data quality objectives, sampling and analytical quality control procedures, equipment maintenance and calibration, and methods for data validation, storage, and analysis. The purpose is to ensure that monitoring data are accurate and precise and that data analysis and reporting are focused on the objectives of the study. Preparation of the QAPP will also facilitate the project budgeting process and logistics planning for field and laboratory work. EPA specifies minimum requirements for quality assurance plans for projects which are federally funded or which generate data for regulatory assessments. These requirements are found in *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations* (USEPA 1994).

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2.0 PROGRAM OBJECTIVES

Management Objectives

As stated in the Lake Management Plan, the current management objective of monitoring at Big Lake is to "protect water quality by developing a better understanding of water quality conditions at Big Lake and the processes that influence them". This objective is general in nature, consistent with the problem diagnosis and baseline assessment functions of a Phase I study.

Monitoring Objectives and Expected Application

Clear definition of the purpose of each component of the monitoring program is critical for ensuring success. It is necessary to describe information you are going to collect as well as how you will use this information for management of the lake. Moreover, these objectives will need to be periodically reviewed as the program progresses. Results collected along the way may lead to changes in the data collection program as priorities change and time and financial resources are reallocated.

<u>Hydrologic Budget and Nutrient/Sediment Loading</u>

Objective: Document water and nutrient/sediment inflow and outflow characteristics for Big Lake for one complete year.

Approach: Collect water discharge, phosphorus, nitrogen, and suspended sediment data in tributary streams and inlet/outlet channels on a monthly basis during open water conditions and once during at major storm event.

Application: The data will be used to develop a hydrologic budget for the lake as well as estimates of input and output loadings of nutrients and sediments. The information will be applied as follows:

- Establish baseline conditions for the lake - for ongoing trend analysis. In subsequent years, it may be possible to characterize input/output trends with a more limited program (i.e., reduced number of sites and/or water quality constituents).

- Identify primary sources of nutrients and sediments - for problem identification and development of best management practices (BMPs). Upstream contributions to primary sources such as Meadow Creek will be examined in subsequent phases of the investigation.

- Evaluate potential for predictive modeling of lake inputs, internal sinks, and outputs - for simulation of impacts of future shoreline development scenarios.

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Limnology of Open Waters

Objective: Document trophic status indicators within the water column of the lake for one complete year.

Approach:

- Collect physical data (clarity, temperature, dissolved oxygen) as well as nutrient concentrations and planktonic algae biomass on a monthly basis during open water conditions and at least once during ice cover.

- Optional tasks: Conduct algal growth potential bioassays and sedimentation rate measurements during months of high plant growth and biomass (summer and early fall). These tests provide additional information on primary production dynamics and are particularly useful at lakes (such as Big Lake) where nutrient response is relatively complex. If necessary (due to budget limitations), this work could be deferred to a later study phase.

Application:

- Establish baseline conditions for the lake - for ongoing trend analysis.

- Calculate trophic status relative to other lakes in the region and Alaska - for problem diagnosis.

- Identify limiting nutrient(s) for seasonal algal productivity - for problem identification and development of BMPs.

- Assess relationship between seasonal algae growth and hydrologic/nutrient inputs and outputs - for problem diagnosis.

- Evaluate potential for predictive modeling of nutrient mass balance, algal productivity, and hypolimnetic (deep water) oxygen deficit - for simulation of impacts of future shoreline development scenarios.

Plant Growth in Nearshore Waters

Objective: Document extent of attached algae and rooted aquatic plant growth in nearshore (littoral) zones of the lake.

Approach: Collect composition, distribution, and abundance data in representative areas during the peak growth period (late summer).

Application:

- Establish baseline conditions for the lake - for trend analysis.
- Examine spatial distribution relative to potential nutrient sources (streams, septic system flows, etc.) - for problem diagnosis.

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Septic Leachate and Bacteriological Evaluations

Objective: Document extent of septic discharges to the lake and distribution of fecal bacteria in nearshore waters.

Approach: During wet weather and dry weather conditions in the summer, conduct nearshore sampling surveys involving collection of fecal bacteria samples and direct field measurement of septic leachate constituents.

Applications:

- Establish baseline conditions for the lake - for trend analysis.
- Examine spatial distribution relative to potential human and animal sources (streams, septic system flows, boats, wildlife, etc.) - for problem diagnosis
- If sources of bacteriological contamination are unclear from the spatial data, more sophisticated testing can be attempted in later phases to discriminate between human, waterfowl, and bovine coliform types.
- If significant septic discharge is detected, subsequent investigation may be required. This could include measurement of local aquifer characteristics (construct monitoring wells or drive point installations) and/or septic system performance testing (dye injection and receiving water monitoring).

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3.0 FIELD AND LABORATORY PROCEDURES

Hydrologic Budget and Nutrient/Sediment Loading

Sampling Stations and Schedule

Field sampling locations will be identified following boat reconnaissance of the Big Lake shoreline. The intent of the survey is to collect samples at all locations of measurable flow in inlet and outlet streams. Stations will include but not be limited to Meadow Creek, Mud Lake outlet channel, Fish Creek, and identified "blue line" streams (Figure 1). Sample sites will be located as close to the outlet or inlet point as can be accessed by the sampling crew.

Each sampling station will be visited once a month starting in May (or as soon as flowing water is evident) and ending when freeze-up occurs (probably in late October). In addition, it will be attempted to sample each station once during a spring or early summer storm rainfall event. For the purpose of the study, a storm can be defined as an event exceeding 0.5 inch of rainfall in a 6-hour period, or 1.0 inch in a 24-hour period, following 60 to 72 hours of dry conditions (less than 0.25 inch of rain per day). Time and/or logistics may limit this storm event survey; highest priority will be given to sampling major streams at the peak of the storm discharge hydrograph.

Sampling and Flow Measurement Procedures

Manual grab sampling methods will be used to collect both base flow and storm flow inlet and outlet water samples. This assumes there are no significant vertical or horizontal gradients within the stream; this will be checked during each survey with field instruments (i.e., temperature/conductivity probe). Where possible, grab samples will be collected at midstream and half of full depth. In high flow conditions this may be modified, with field personnel wading in only as far as is safe.

A modified sampling method may be necessary at the Mud Lake outlet channel. If vertical temperature stratification is evident, samples will be collected at one meter intervals and composited.

At each location, instantaneous flow measurements will be made using the standard "velocity-area" method (USEPA 1990b). Prior to start of the sampling program, cross sectional measurements will be taken and a fixed staff gage installed at each site. At each sampling event, velocity will be measured directly with a current meter or timed-float and the gage height recorded.

Outflow to Fish Creek passes through a man made weir which also maintains the constant elevation of the lake. This structure is an ideal location for direct measurement of stream discharge and water surface elevation. It is also an established USGS monitoring site (although inactive in terms of water quality data collection) so is likely to have a detailed cross section on file.

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Chemical Analyses

A preliminary list of water quality constituents to be analyzed in the monitoring program is provided in Table 1. A more complete list, with specified detection limits, analytical methods, and sample handling procedures, will be provided in the QAPP.

Table 1. Water Quality Constituents - Big Lake Inlet/Outlet Survey

Temperature
Conductivity
Dissolved oxygen
pH
alkalinity
Total suspended solids
Total nitrogen
Ammonia-nitrogen
Nitrate/nitrite-nitrogen
Total phosphorus
Orthophosphate-phosphorus

Limnology of Open Waters

Sampling Stations and Schedule

Sampling stations for limnological investigation will include the two deep water stations used by USGS in their 1983/84 survey as well as a representative shallow water littoral station (Figure 1). The center of the lake arm leading to the Fish Creek outlet will probably be used as the latter site. Additional or alternative stations can be added at a later date if it is apparent that water quality problems (i.e., algae blooms or extended periods of high turbidity) are prevalent in other arms or bays.

Samples will be collected on a monthly basis during the open water period from late May through October. In addition, samples will be collected at least once during the winter period of ice cover. An attempt will be made to visit each site at the same time of the day. Ideally, this should be at midday or in early afternoon when incident light is at a high level.

If time and sample budget allows, each site will be visited on a biweekly basis during the first open water month. During this period the lake normally experiences "turnover", the transition from winter to summer vertical stratification patterns. Physical profiling (with field instruments only) of the water column during a 24-hour cycle will also be attempted at some time during the summer months when algal biomass is at a high level.

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Sampling and Field Measurement Procedures

At each site, secchi depth (estimate of light penetration) will be recorded and standard field measurements (temperature, pH, conductance, dissolved oxygen) will be taken at one meter intervals. Water samples will be collected at representative depths in the water column; a surface water and deep water (below the thermocline) sample will likely be sufficient.

Chemical Analyses

A preliminary list of water quality constituents to be analyzed in the monitoring program is provided in Table 2. A more complete list, with specified detection limits, analytical methods, and sample handling procedures, will be outlined in the QAPP.

Table 2. Water Quality Constituents - Big Lake Limnological Survey

Secchi depth
Chlorophyll *a*,
Phaeophyton
Temperature
Conductivity
Dissolved oxygen
pH
alkalinity
Total suspended solids
Total nitrogen
Ammonia-nitrogen
Nitrate/nitrite-nitrogen
Total phosphorus
Orthophosphate-phosphorus

Algae Growth Testing (optional)

Additional information on nutrient dynamics and algae productivity in the lake could be obtained by conducting algal growth potential (AGP) bioassays. These should be conducted at least twice, in summer and early fall, at one of the lake sites. Detailed methodology for this type of test can be found in Peterson (1995). Water samples would be collected from the euphotic zone (surface layer of photosynthetic activity) and placed within large (20 liter) plastic carboys. The carboys would receive treatments of nitrogen and phosphorus at various concentrations and be incubated in the lake for one week. Samples would be extracted twice during the experiment and analyzed for chlorophyll *a* (algae biomass) and carbon-14 uptake (nutrient biostimulation).

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Sedimentation Rate Testing (Optional)

The rate of sedimentation in the lake water column has a strong influence on phytoplankton growth and removal of available nutrients. To quantify this rate of settling of suspended material, sediment traps (a passive interceptor trap suspended in the water column) would be placed at the deep water stations and sampled monthly for total settleable solids and total suspended solids (TSS). Traps would be anchored, marked with buoys, and maintained at a level of 2.5 - 3.0 meters below the surface.

Plant Growth in Nearshore Areas

Sampling Stations and Schedule

The entire nearshore area of Big Lake will be initially inspected from a boat for presence of emergent and submergent macrophytes (attached algae and rooted vascular plants). Then several areas will be selected for more detailed mapping of spatial extent, composition, and relative abundance. These locations are expected to include the Meadow Creek inlet, Fish Creek outlet, and sites representative of a small stream inlet, isolated bay, well developed shoreline, and undeveloped shoreline. Both initial reconnaissance and the detailed survey will be conducted in late summer when plant biomass is at the highest level.

Sampling and Field Measurement Procedures

Selected macrophyte beds will be assessed visually from a boat, shoreline, or wading A rake sampler will be used to determine presence of submergent macrophytes below a depth of three feet. The location of these beds and major plant community types will be plotted on a map of the shoreline along with measurements of spatial area covered and maximum depth of growth. Dominant plant forms will be identified to species level using an appropriate identification manual such as Fassett (1969) or Hotchkiss (1972). Abundance of each species will be plotted using a standard rating scheme (A = abundant, C = common, S = sparse). Representative voucher specimens will be collected, dried, and pressed for future reference or verification.

Bottom substrate type will be visually characterized at each of the selected macrophyte stations. Features such as dominant grain size, organic content, woody debris, and distinctive color or odor will be recorded. A weighted bucket or standard sediment sampler (e.g., Eckman dredge) will be used to collect representative samples.

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Septic Leachate and Bacteriological Evaluations

Sampling Stations and Schedule

Sampling will be conducted at each of the lake's inlet streams and major recreational beaches as well as several shoreline locations where septic leachate and/or bacteriological contamination are suspected. Criteria for identification of the latter sites will include:

- Obvious groundwater seepage in the shoreline area.
- Known history of septic system failure or complaints of soggy or odorous drainfields.
- Conspicuously lush vegetation or dead vegetation in drainfield area
- Excessive aquatic plant growth at the shoreline.
- High use by waterfowl (primary shoreline nesting or foraging areas)

Two field surveys will be conducted during the summer when recreational use is high and most shoreline residences are occupied. Sampling will be conducted once during dry weather conditions and once during wet weather conditions.

Sampling and Field Measurement Procedures

Sampling will be conducted by boat to provide access to the shoreline while respecting private property. The leachate survey will be conducted using a Septic Leachate Detector, a hand held flourometer indexed to intermediate degradation products of urine and sensitive to laundry whiteners. The instrument will be deployed continuously as the boat passes through shallow water parallel to the shoreline. When the unit shows a response, the location will be noted, visual observations made, and shoreline grab samples collected. At sites where samples are collected even when no leachate is detected (e.g., a recreational beach), a composite sample will be prepared from several grab samples taken along the shoreline.

Analytical Procedures

Shoreline grab samples will be analyzed in the field for temperature, pH, and conductivity. If time permits, additional measurements will be taken in the vicinity to attempt to characterize the spatial extent of the effluent plume. Laboratory analyses of grab samples will be limited to fecal coliform bacteria.

4.0 DATA ANALYSIS

A complete description of the data analysis approach including validation/verification, database development, data reduction, modeling, statistical analysis, and trends evaluation will be provided in the QAPP. Some of the primary features of the anticipated data assessment are discussed below.

Hydrologic Budget and Nutrient/Sediment Loading

Discharge measurements from the inlet/outlet survey will provide the basis for development of annual and average monthly water budgets for the lake. Data will be reduced to monthly or daily water flow tables for each of the inlet/outlet streams. Additional terms of the water budget will be estimated by standard techniques:

- Inflow volume from any unmeasured perennial stream will be calculated by applying a water yield coefficient and regional precipitation rate to the size of the specific subwatershed area.

- Non-perennial stream flow inputs (i.e., sheetflow or small, first-order intermittent streams) will be estimated using a standard Soils Conservation Service (SCS) stormwater model. This type of model calculates runoff from daily rain or snow equivalent inputs.

- Annual and monthly precipitation will be estimated from the closest available data source, possibly the Matanuska Agricultural Experimental Station.
- Evaporation will be estimated using a regional free-water-surface evaporation rate (obtained from NOAA or USGS).
- Groundwater interactions will be treated as a residual input term (i.e., estimated from the mass balance itself). This approach will be modified if existing groundwater flow data are found to be available.

Loading estimates for nitrogen, phosphorus, and total suspended sediment will be developed by applying inflow and outflow water volume to measured chemical concentrations. Net loss of these constituents to in-lake sediments will also be estimated, at least on an annual basis. Comparative analyses will be conducted to examine relationships between stream loadings and such variables as watershed area, extent of watershed development, frequency and intensity of storms, and in-lake sedimentation rates (if measured).

Limnology of Open Waters

Monthly depth profile plots will be developed for each measured constituent in the lake in order to illustrate physical and chemical structure of the water column as well as seasonal changes. This will be compared to similar plots developed from the 1983/84 USGS survey (Woods 1992). Side-by-side comparisons will also be made between lake water quality data, input stream data, and sedimentation rates (if measrued) to identify common patterns or potential relationships.

For trophic status analysis, results for water clarity, chlorophyll *a*, phosphorus, and nitrogen will likely be compiled into weighted lake-wide averages. Ratios of nitrogen to phosphorus will be calculated for both total forms (total N / total P) and biologically available forms (total inorganic N / dissolved ortho-P) to provide interpretation of nutrient limitation patterns. Results of algal growth bioassays (if conducted) will also be used to assess limiting nutrient features. Trophic state classification will be calculated using an accepted method such as Ryding and Rast (1989) and compared to values from the literature and other lakes in Alaska.

Plant Growth in Nearshore Waters

Following preparation of an overall lake macropyhte map, percent cover will be estimated for each of the discrete basins and arms and any distinct spatial patterns will be identified. Data from the macrophyte sampling sites will then be reviewed. Comparisons will be made between plant distribution and abundance (at the species and community level) and presence of potential causal factors such as elevated nutrients, lake depth, water clarity, and substrate type. In addition, each of the primary macrophyte species will be ranked in terms of desirability for shoreline stabilization, water quality control, and aquatic habitat values.

Septic Leachate and Bacteriological Evaluations

Results of the survey (leachate hits and coliform counts) will be plotted on a lake map to identify spatial patterns and apparent causes such as poorly performing individual septic systems or high density development at the shoreline or upstream of a tributary discharge. Fecal coliform counts will be interpreted relative to State of Alaska health standards and potential incidence of associated human pathogens.

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5.0 REFERENCES

Fassett, N.C. 1969. *A Manual of Aquatic Plants.* University of Wisconsin Press, Madison.

Hotchkiss, N. 1972. *Common Marsh, Underwater & Floating-Leaved Plants of the United States and Canada.* Dover Publ., New York.

Peterson, R. 1995. *Algal Growth Potential in Priest lake, Idaho.* Prepared for: Idaho Dept. of Health and Welfare, Div. of Environmental Quality, Coeur d'Alene, ID.

Ryding, S. and W. Rast. 1989. *The Control of Eutrophication of Lakes and Reservoirs.* Vol. 1 of Jeffers, J.N.R., Man and the Biosphere Series. The Parthenon Publishing Group, Inc., New Jersey.

USEPA, 1981. *Clean Lakes Program Guidance Manual.*

USEPA, 1990a. *Volunteer Water Monitoring: A Guide for State Managers.* EPA 440/4-90-010.

USEPA, 1990b. *Monitoring Lake and Reservoir Restoration: Technical Supplement to The Lake and Reservoir Restoration Manual.* EPA 440/4-90-007

USEPA, 1991. *Volunteer Monitoring: A Methods Manual.* EPA 440/4-91-002

USEPA, 1994. *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations.* EPA/QA/R-5.

Woods, Paul F., 1992, *Limnology of Big Lake, South-Central Alaska,* 1983-84; U.S. Geological Survey Water-Supply Paper 2382.

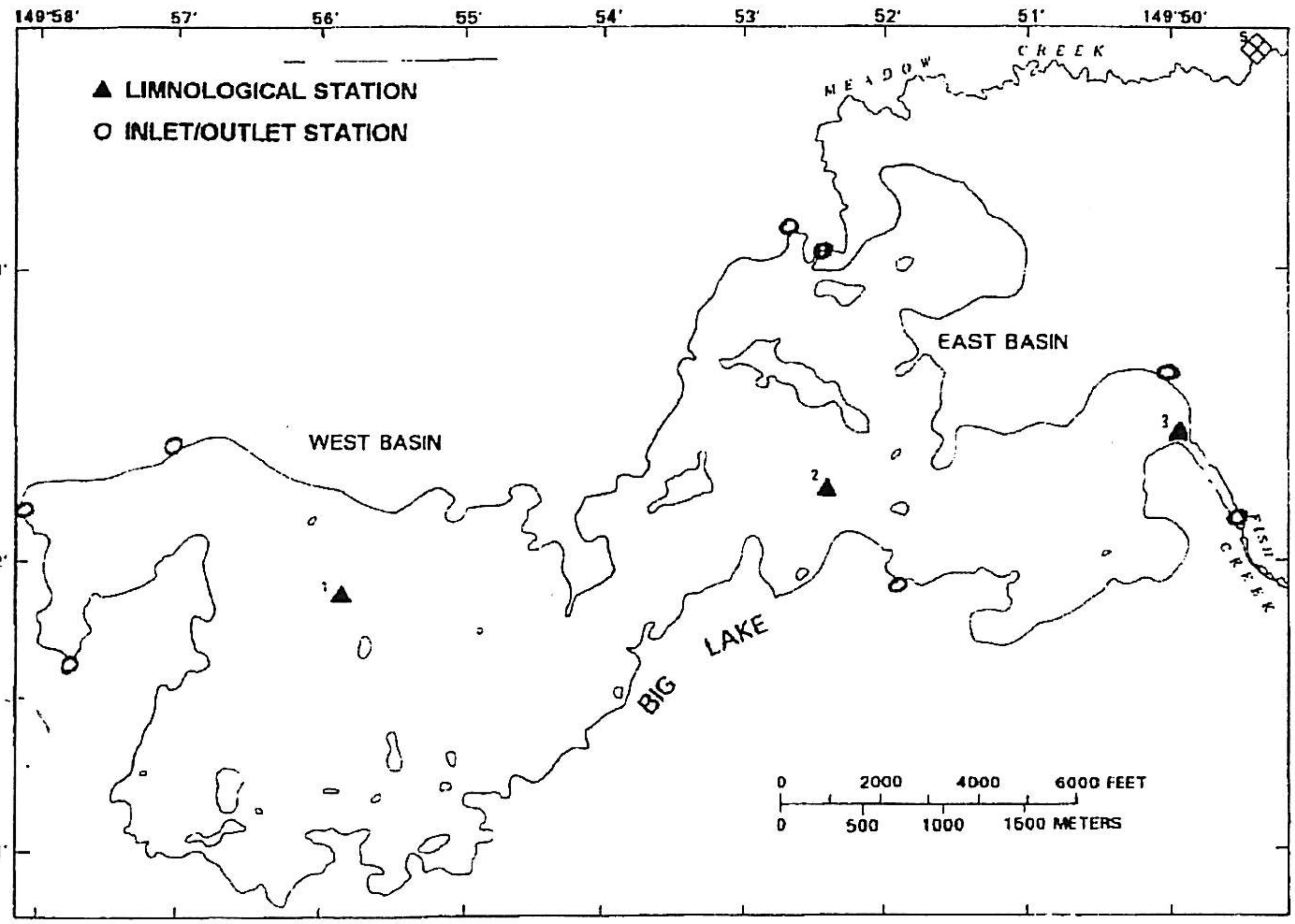

Figure 1. Big Lake Monitoring Program - Location of Sampling Sites