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COUNCIL MEMORANDUM NO. 93-02

From: Deputy Administrator

Date: January 6, 1993

Subject: Lake Lucille Paleoliminology Study

On September 14, 1992 Council authorized $3,600 for a paleoliminology study in conjunction with the Lake Lucille Water Study. The ordinance to appropriate the funds was postponed on December 14, 1992 because Council wanted to review a project status report. The report is attached for Council review.

Administration recommends reconsideration of Ordinance No. 92-37 to appropriate the funds for the earlier approved project.

Robert E. Harris
Deputy Administrator

Diagnostic and Feasibility Study of Lake Lucille, Alaska

Progress Report

Prepared by

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December 31, 1992

Period Covered: June 1991 through December, 1992

I. INTRODUCTION

Lake Lucille, a 362-acre lake, is located in the city of Wasilla, approximately 40 miles north of Anchorage, Alaska. Because of the current water quality problems, a diagnostic and feasibility study of Lake Lucille was funded through the Clean Lakes Program of EPA in concert with local funding from the City of Wasilla. The objective of the study is to document the nature of the water quality problems and evaluate various alternatives for improving the current status of the lake. This progress report describes progress for the project through December 1992.

II. LAKE AND WATERSHED MONITORING

Monthly monitoring on Lake Lucille began in June, 1991. The completed monitoring activities are presented in Table 1. The lag between when the samples are collected and when the results have been entered into the data base has been reduced to about two weeks. Consequently, laboratory data presentations are current through December, 1992.

A. Field Monitoring

Lake Lucille was sampled on the following dates:

1991	1992
June 27	January 6
July 24	February 10
August 19	March 9
September 18	April 7
October 9	May 11
November 27	June 9
	July 8
	July 23
	August 18
	September 22
	December 3

Additional sampling is planned for January, March, April, and May.

The field results for Lake Lucille show some typical patterns exhibited by eutrophic lakes and some less common patterns. Dissolved oxygen concentrations in the lake showed a very rapid

Table 1. Completed tasks and activities for the Lake Lucille project.

Task	1991 Jun	Jul	Aug	Sep	Oct	Nov	Dec	1992 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	1993 Jan	Feb	Mar	Apr	May
Field Sampling																								
Lake	●	●	●	●	●	●		●	●	●	●	●	●	● ●	●	●			●					
Outlet	●	●	●	●	●	●		●	●	●	●	●	●	● ●	●	●			●					
Groundwater	●	●	●	●	●				● (water level only) -----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----->					
Storm Drain	<-----	-----	-----	not flowing - no samples	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----->					
Plankton	●	●	●	●									●	●	●									
Macrophytes	●	●	●																					
Macrobenthos	○													●										
Sediment Survey										●														
Waterfowl Survey																●	●							
Data Compilation																								
Land Use Inventory		●	●																					
Data Base Management	●	●	●	●	●	●		●				●				●			●					
Climatic Compilation	●	●																	●					
Quality Assessment	●	●	●	●	●	●												●	●					
Modeling																								
Empirical							○											○	○					
Mechanistic																		○						
Feasibility																								
Literature Review						○												○	○					
Analysis/Report																								
Reporting					●				●			●				●			●					

● completed
○ initiated

depletion in winter 91/92 in which nearly all of the oxygen was consumed in about six weeks. Interestingly, oxygen concentrations partially recovered in spring 1992 before ice-out as a result of primary productivity under the ice (Figure 1). The pH values in Lake Lucille reflect a pattern consistent with high productivity in the summer and reducing conditions in the winter. The pH values observed in summer 1991 approached values that can be toxic to some fish species (Figure 2). The pH values were lower in summer 1992, possibly in response to reduced sunlight. Conductivity, which reflects total solute concentration in the water, increased steadily in 1991, but apparently became unstable in 1992 (Figure 3). We are checking some of these and other measurements to verify their accuracy.

B. Analytical Results

Analytical laboratory results are presented for selected parameters for the lake (top and bottom) and the outlet. Some of the field measurements have been repeated in the laboratory to verify the field results. One of those shown here, pH, also shows the same minima in the winter and maxima in the summer as addressed in the field (Figure 4). The major anions (negatively charged species) are dominated by alkalinity which shows two important patterns: (1) a slight increase from summer through fall and (2) a major increase in the winter and a return to minimum conditions in the early summer (Figure 5). This pattern which is repeated for the major cations (positively charged species) shows the importance of groundwater contributions to the lake. Secondary contributions to this pattern include increase in solutes caused by ice formation in the winter and the alkalinity generation under the ice as the dissolved oxygen is depleted. Sulfate is a minor ion from a percentage viewpoint, but is important in Lake Lucille because of its use as a source of sulfur for generating hydrogen sulfide (contributes to the "rotten egg" odor) in the winter. The sulfate concentrations also show a minimum in summer and a maximum in winter (Figure 6). Chloride concentrations have been more unpredictable than other ions, but reached a maximum in winter 91/92, presumably in response to use of salt for de-icing operations in the

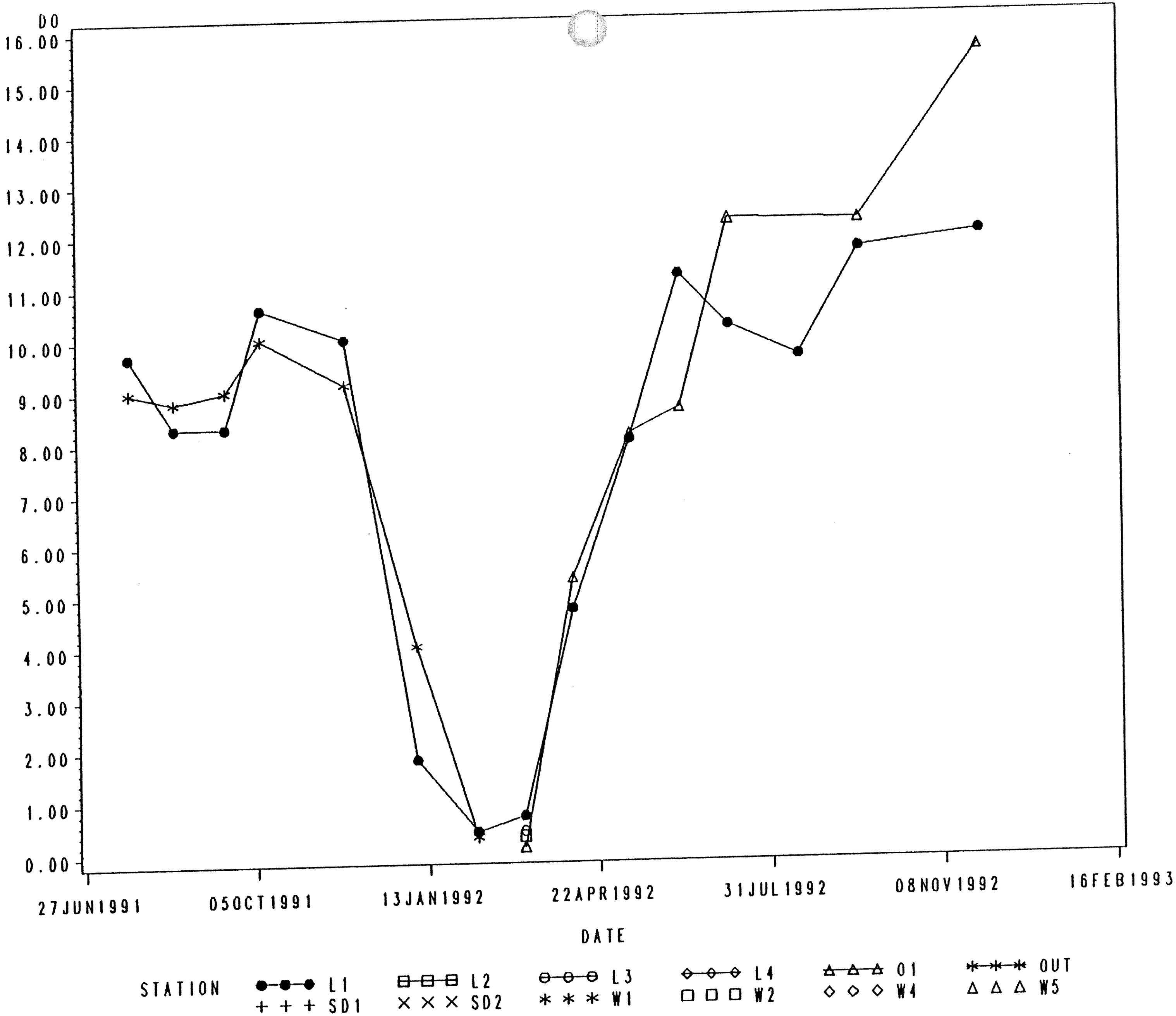

Figure 1. Dissolved oxygen (DO) concentrations (mg/L) for Lake Lucille from June 1991 to December 1992. The surface (1m) values are represented by a ● (site L1) and outlet (site O1) values are shown as a Δ. Other miscellansous sites measured include several well locations (indicated as "W" sites).

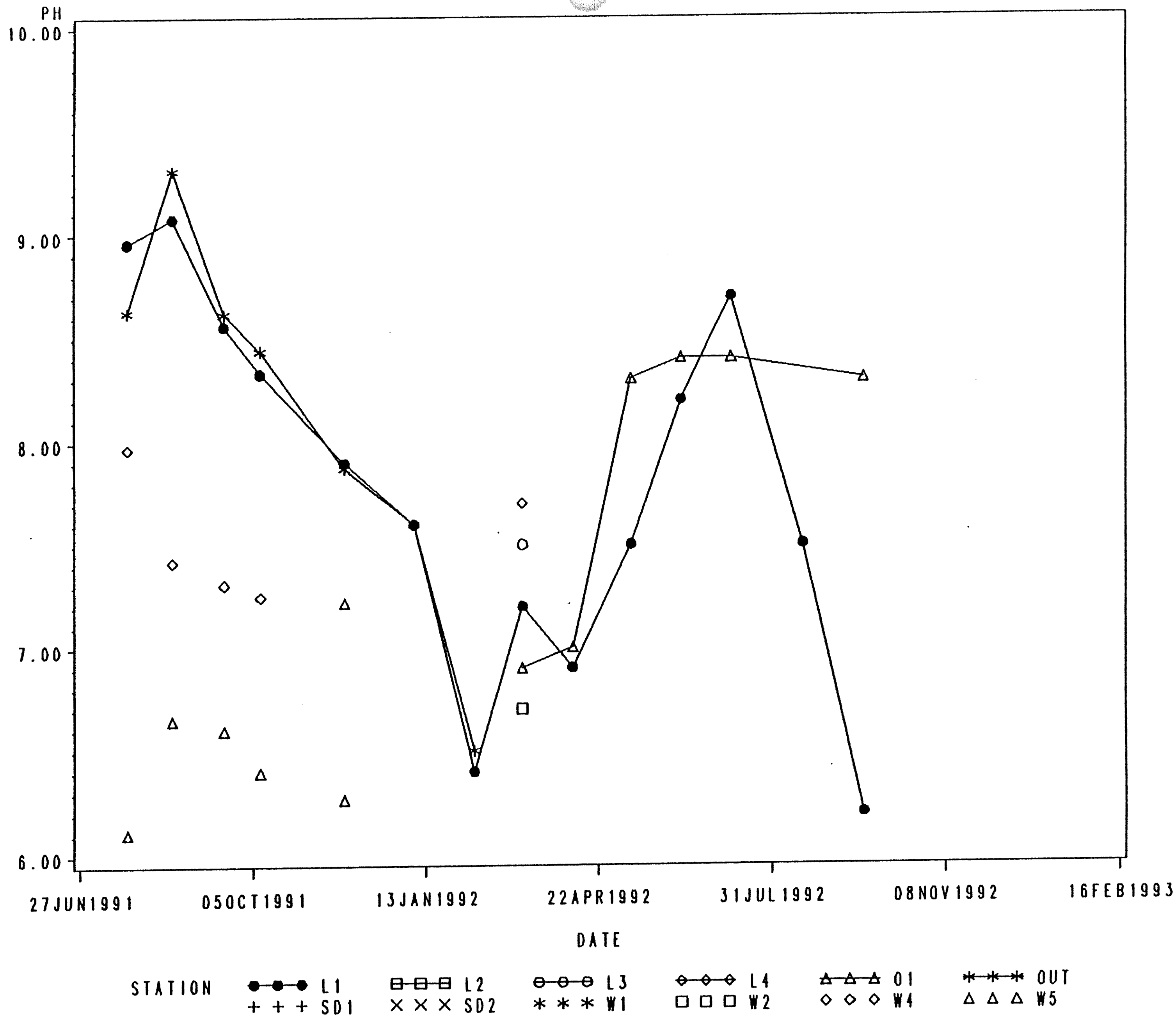

Figure 2. Field pH values for Lake Lucille from June 1991 to December 1992. The surface (1m) values are represented by a ● (site L1) and outlet (site O1) values are shown as a Δ. Other miscellansous sites measured include several well locations (indicated as "W" sites).

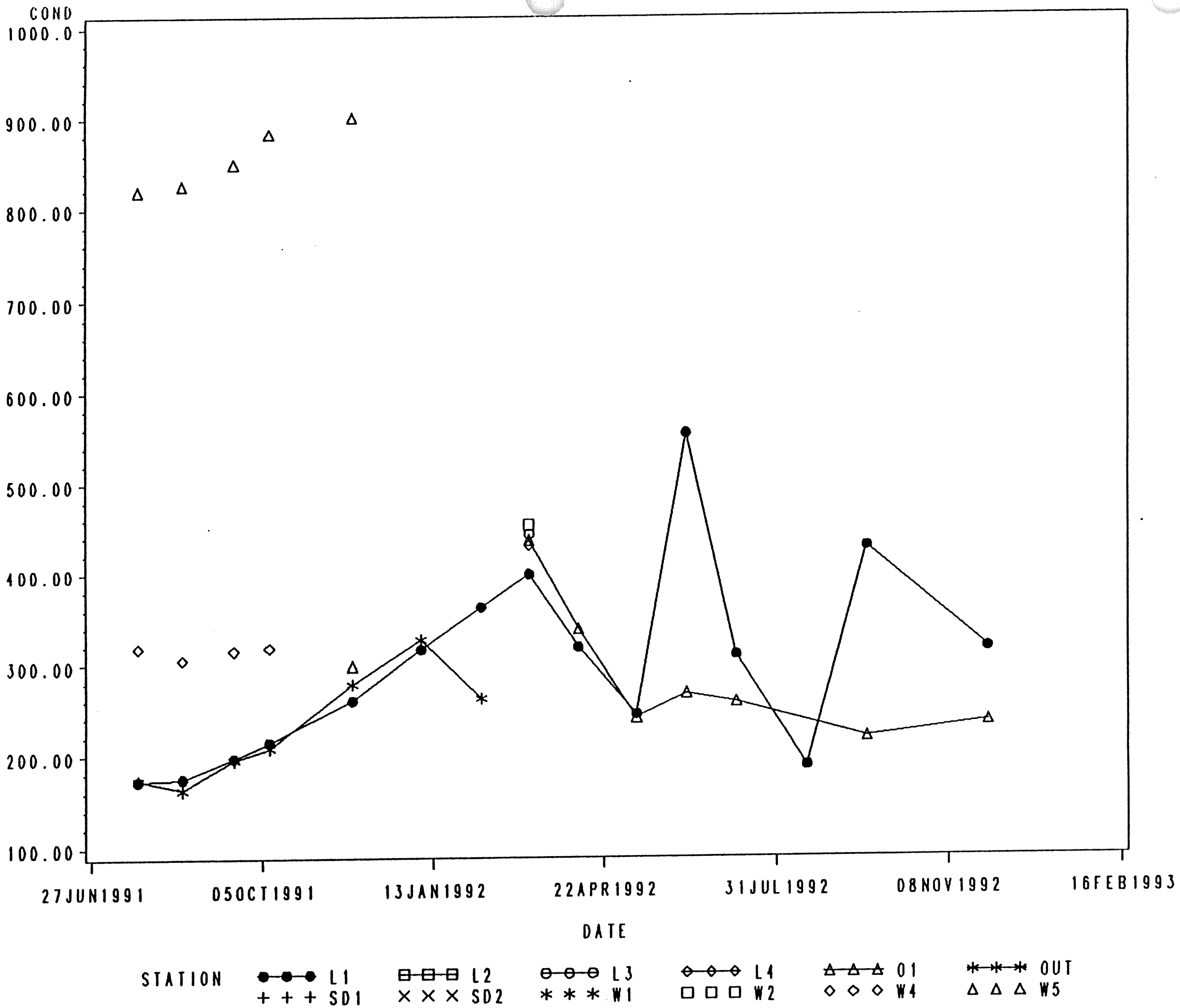

Figure 3. Field conductivity values for Lake Lucille from June 1991 to December 1992. The surface (1m) values are represented by a ● (site L1) and outlet (site O1) values are shown as a Δ. Other miscellansous sites measured include several well locations (indicated as "W" sites).

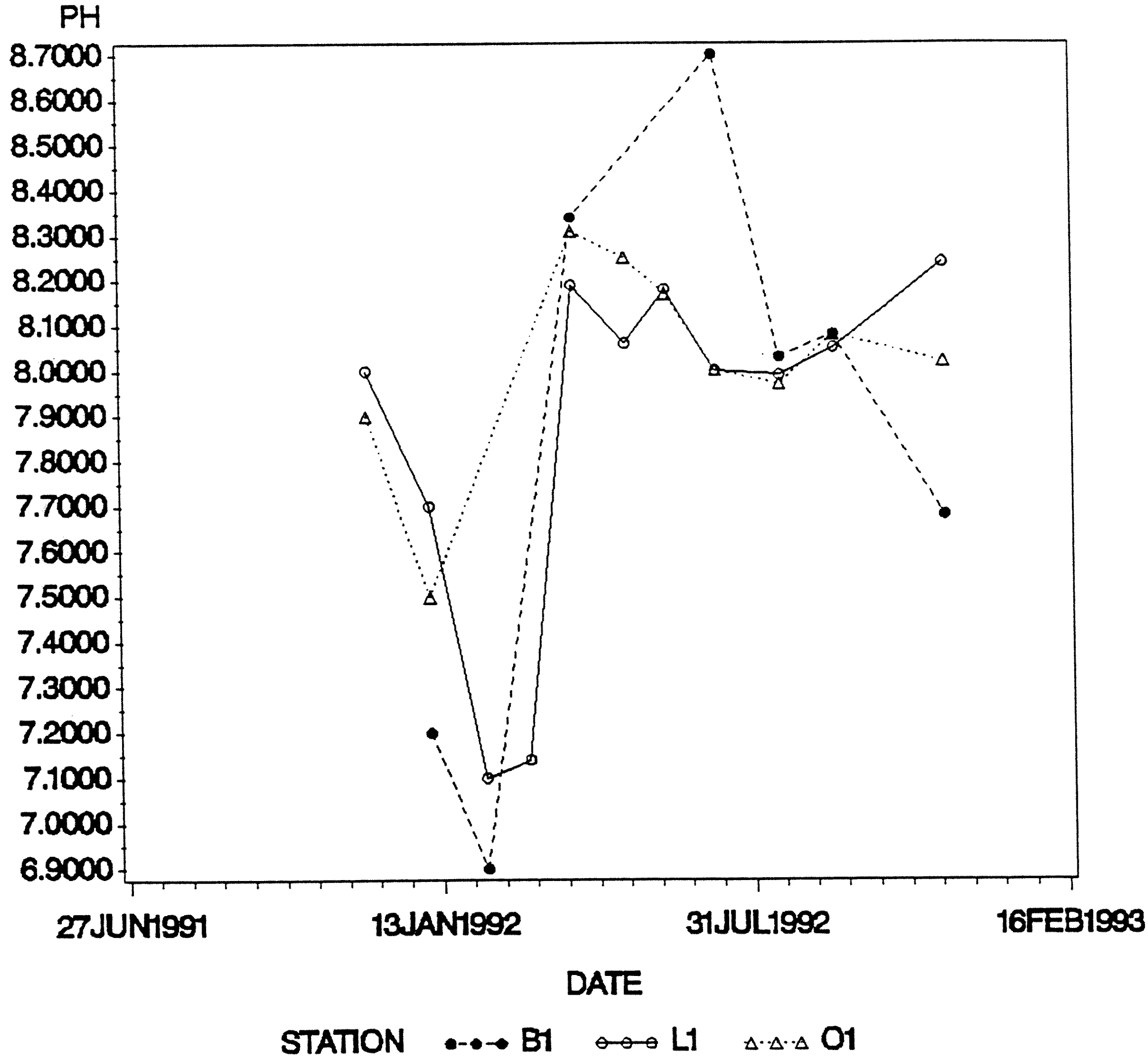

Figure 4. Laboratory pH values for Lake Lucille surface (L1 - o), bottom (B1 - •), and lake outlet (O1 - Δ).

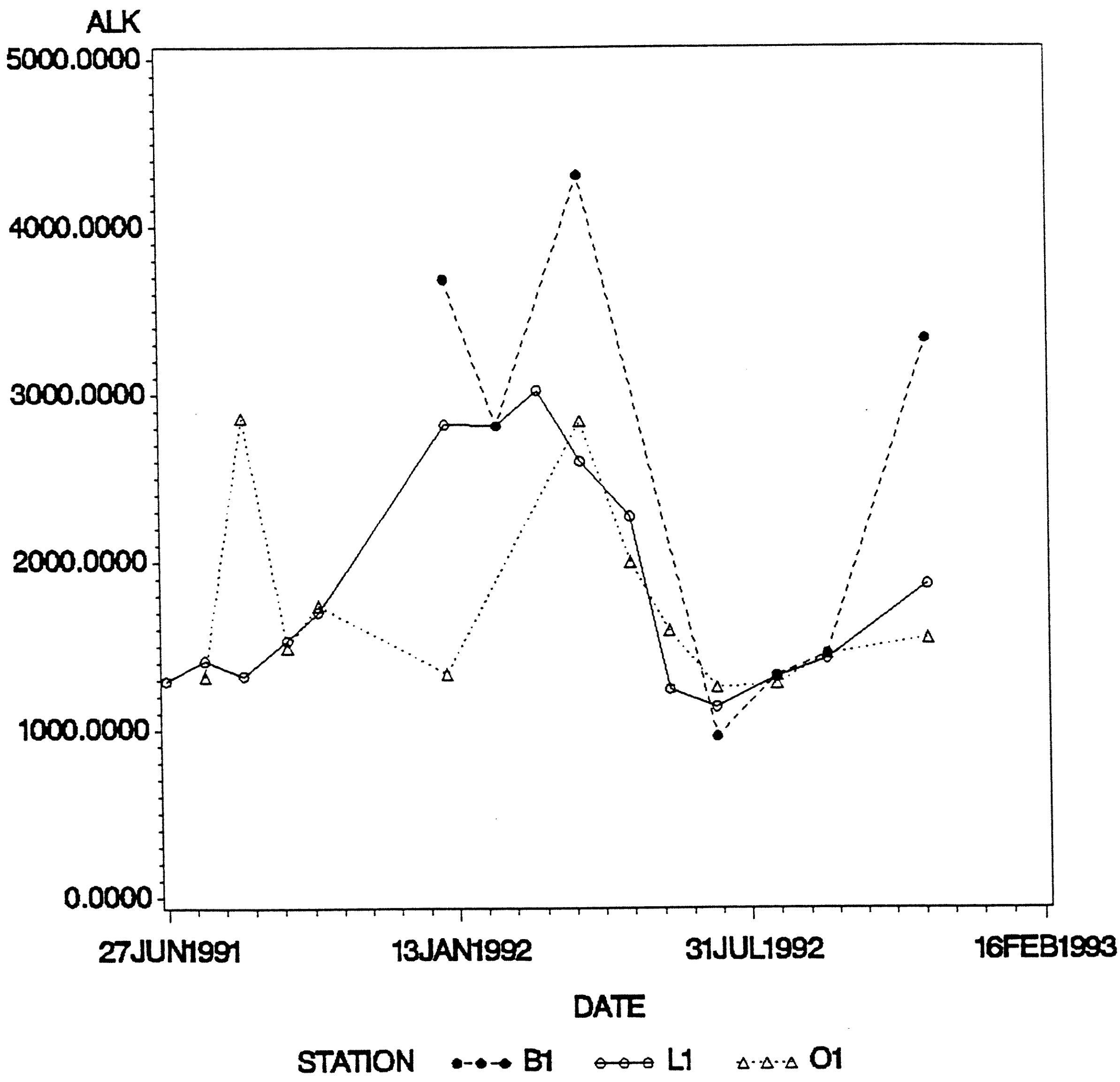

Figure 5. Alkalinity concentrations (μeq/L) for Lake Lucille surface (L1 - ○), bottom (B1 - ●), and lake outlet (O1 - Δ).

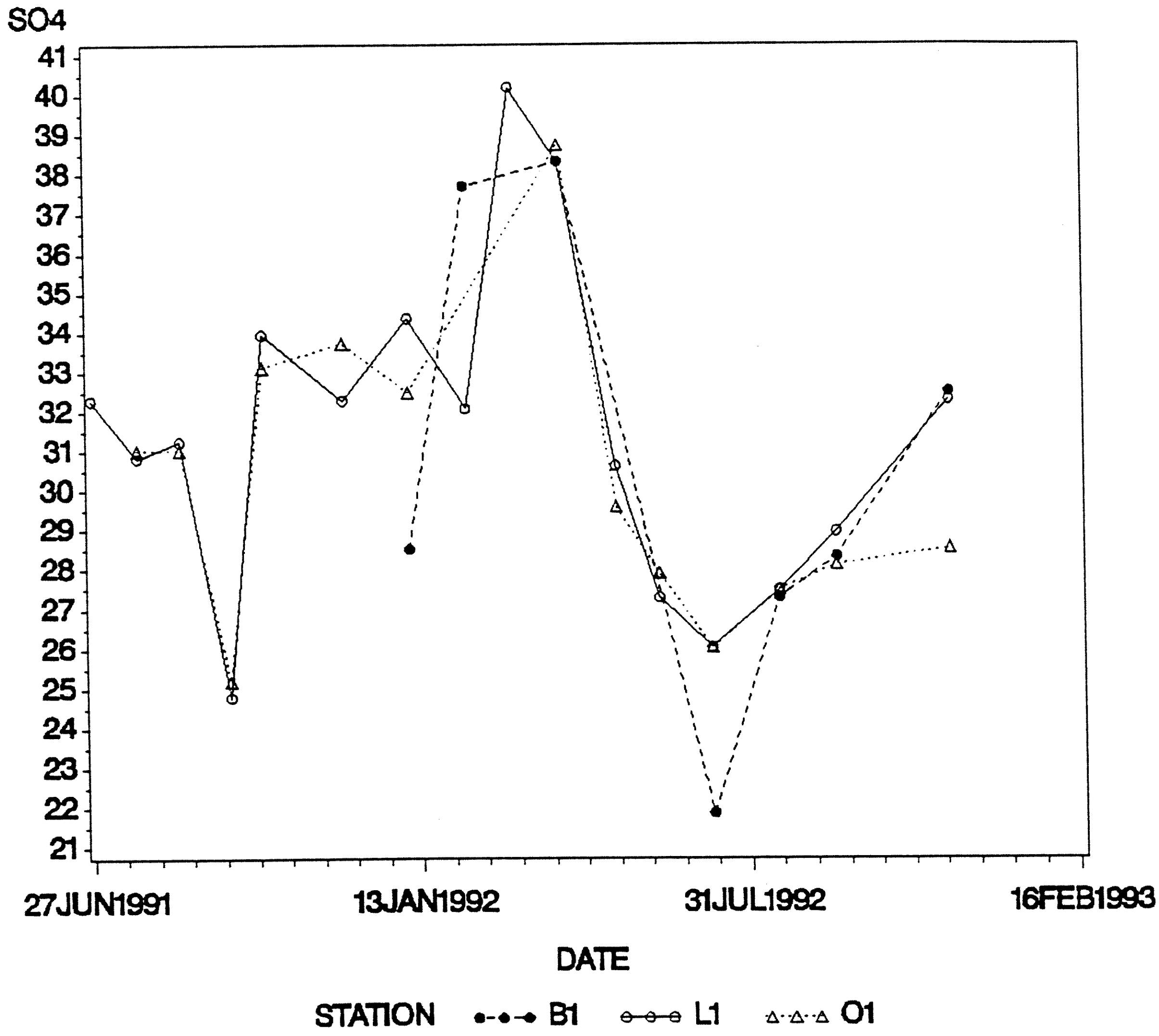

Figure 6. Sulfate (SO4) concentrations (μeq/L) for Lake Lucille surface (L1 - ○), bottom (B1 - ●), and lake outlet (O1 - Δ).

area (Figure 7). The base cations (calcium, magnesium, sodium, and potassium) show similar patterns to one another where the increase from the minima in late summer to the maxima in mid-winter represents a ratio of about 3:1. The order of abundance of the cations (calcium > magnesium > sodium > potassium) is consistent with the lithology of the till in the area (Figures 8-11). The absolute concentrations of the cations is very high resulting in classifying Lake Lucille as a "hard water" lake. These high concentrations of calcium and magnesium result in formation of marl which precipitates on the lake bottom. This is important because as the marl precipitates, it also co-precipitates with phosphorus. In part because of this process, phosphorus concentrations remain moderately low. Total phosphorus values have generally remained below 30 μg/L and soluble phosphorus (this form is easily taken up by plants) is below detection limit (10 μg/L) most of the time (Figures 12 and 13). One very interesting development is the apparent radical increase in phosphorus concentrations this December. Repeated sampling this winter will allow us to determine if this is an anomaly or represents a real departure from recent trends.

III. OTHER DATA COLLECTION EFFORTS

A. Aerial Photographs

We now have high quality aerial photography for Lake Lucille and its watershed from August 1950, October 1981, and May 1989. Land use information from these aerial photographs is being digitized to document land use changes in the watershed. The land use information will be used in the nutrient modeling effort for Lake Lucille.

B. Public Participation

We have obtained several personal histories of long-term residents of the area which have generated highly useful anecdotal information regarding lake changes. Several lakeshore residents provided waterfowl census data for fall 1992. We are developing background material for use by the City of Wasilla in presenting lake restoration options to the public. This is scheduled for spring 1993.

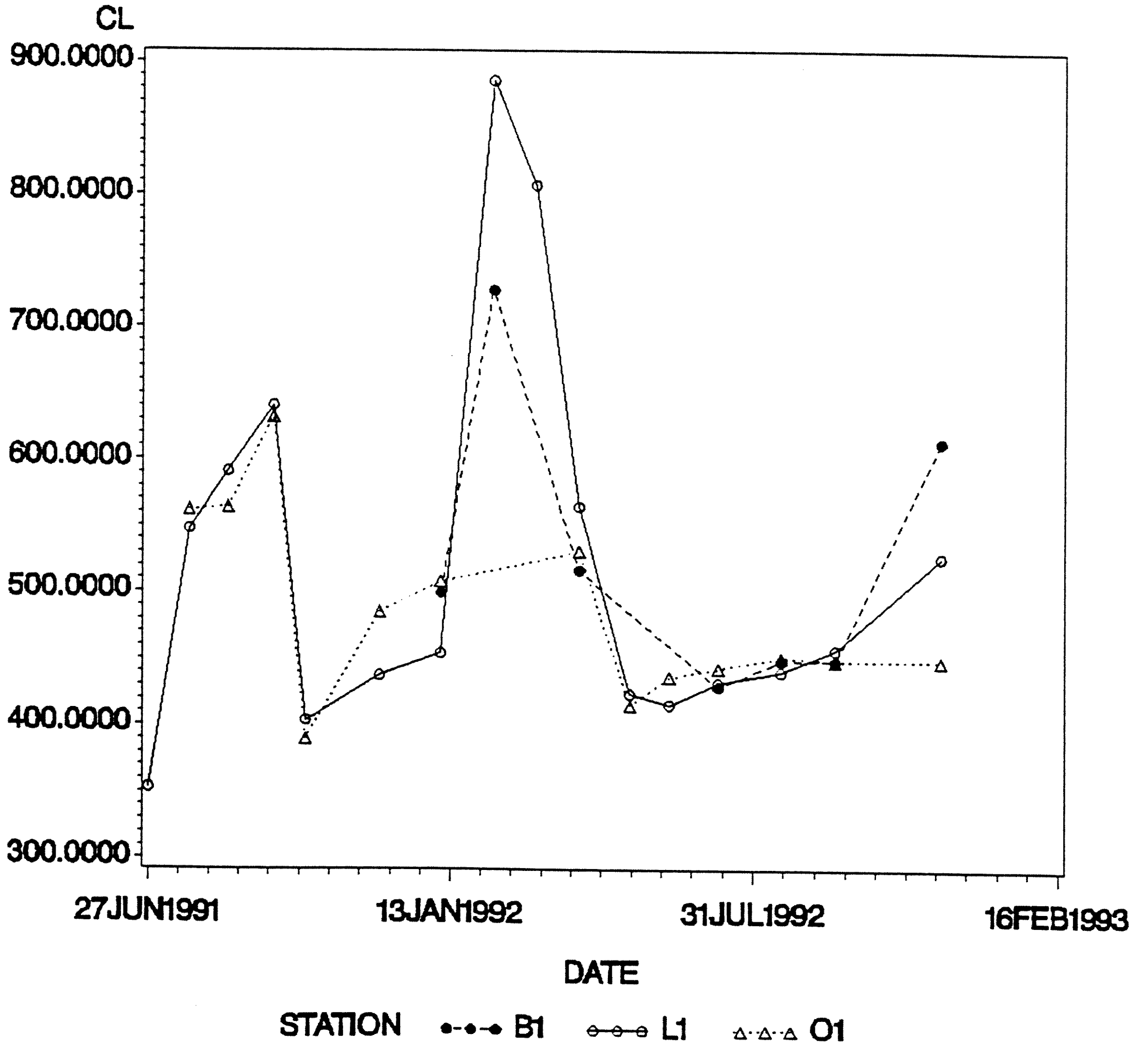

Figure 7. Chloride (CL) concentrations (μeq/L) for Lake Lucille surface (L1 - o), bottom (B1 - •), and lake outlet (O1 - Δ).

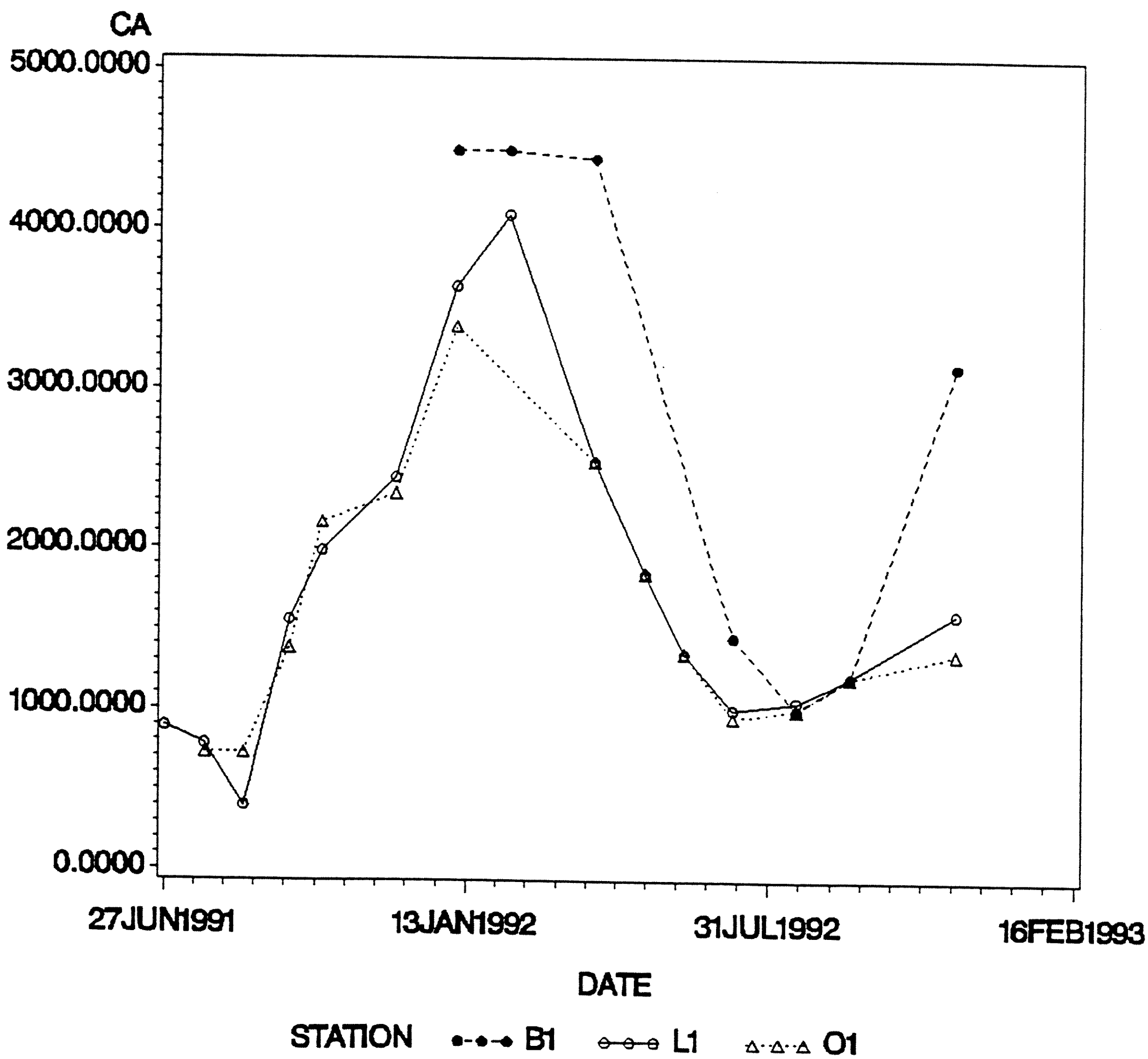

Figure 8. Calcium (CA) concentrations (μeq/L) for Lake Lucille surface (L1 - o), bottom (B1 - •), and lake outlet (O1 - Δ).

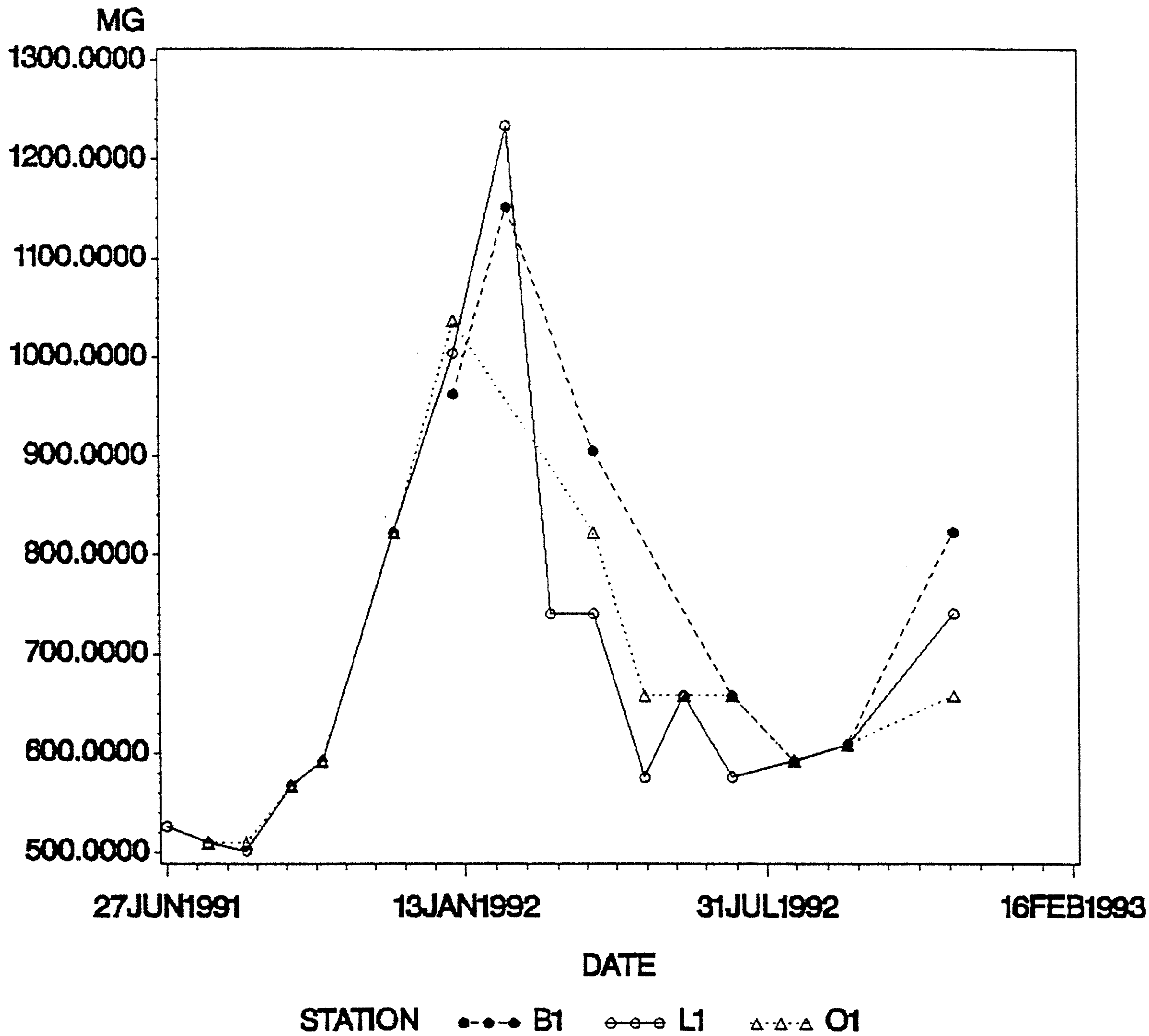

Figure 9. Magnesium (MG) concentrations (μeq/L) for Lake Lucille surface (L1 - o), bottom (B1 - ●), and lake outlet (O1 - Δ).

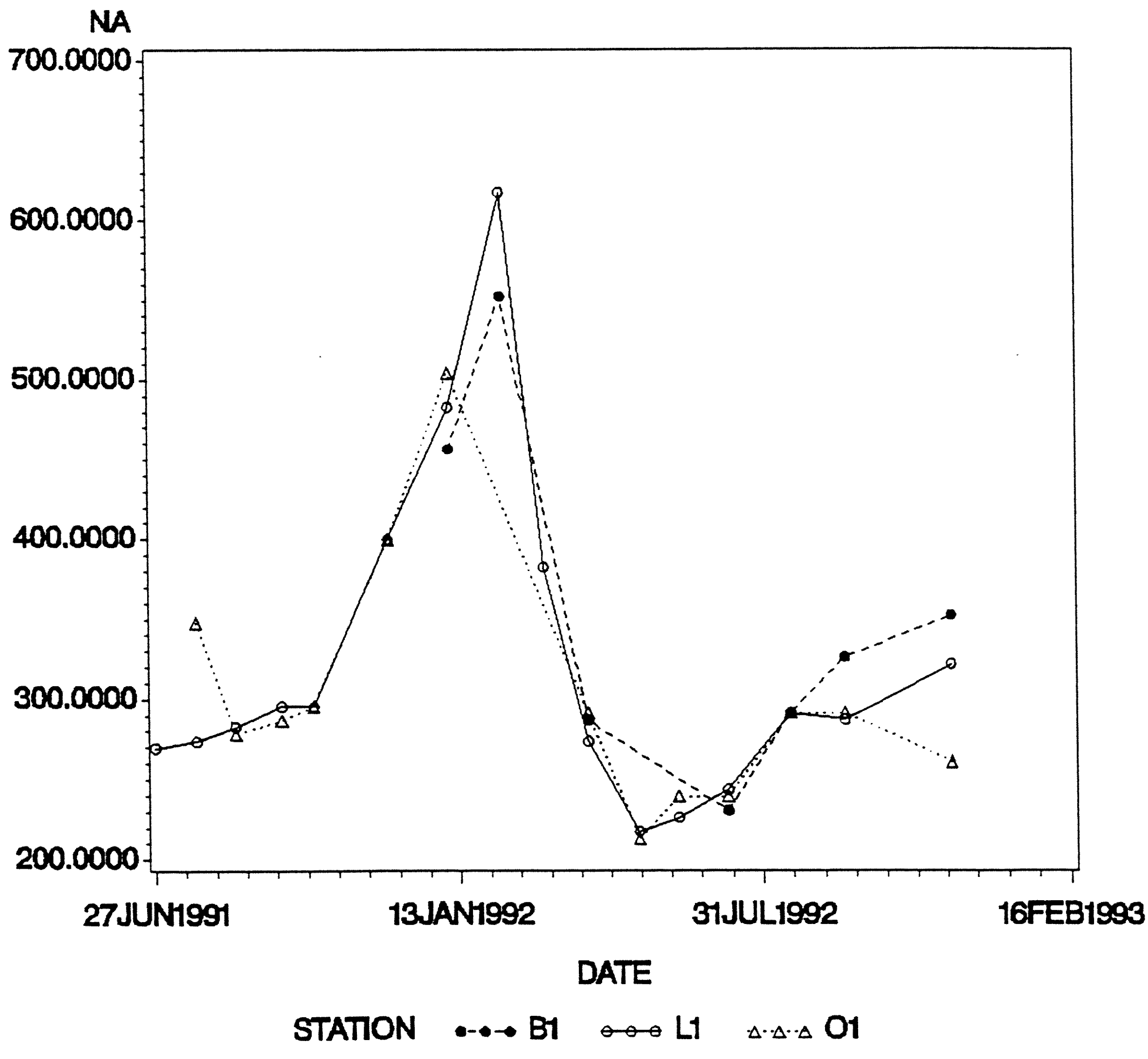

Figure 10. Sodium (NA) concentrations (μeq/L) for Lake Lucille surface (L1 - ○), bottom (B1 - ●), and lake outlet (O1 - Δ).

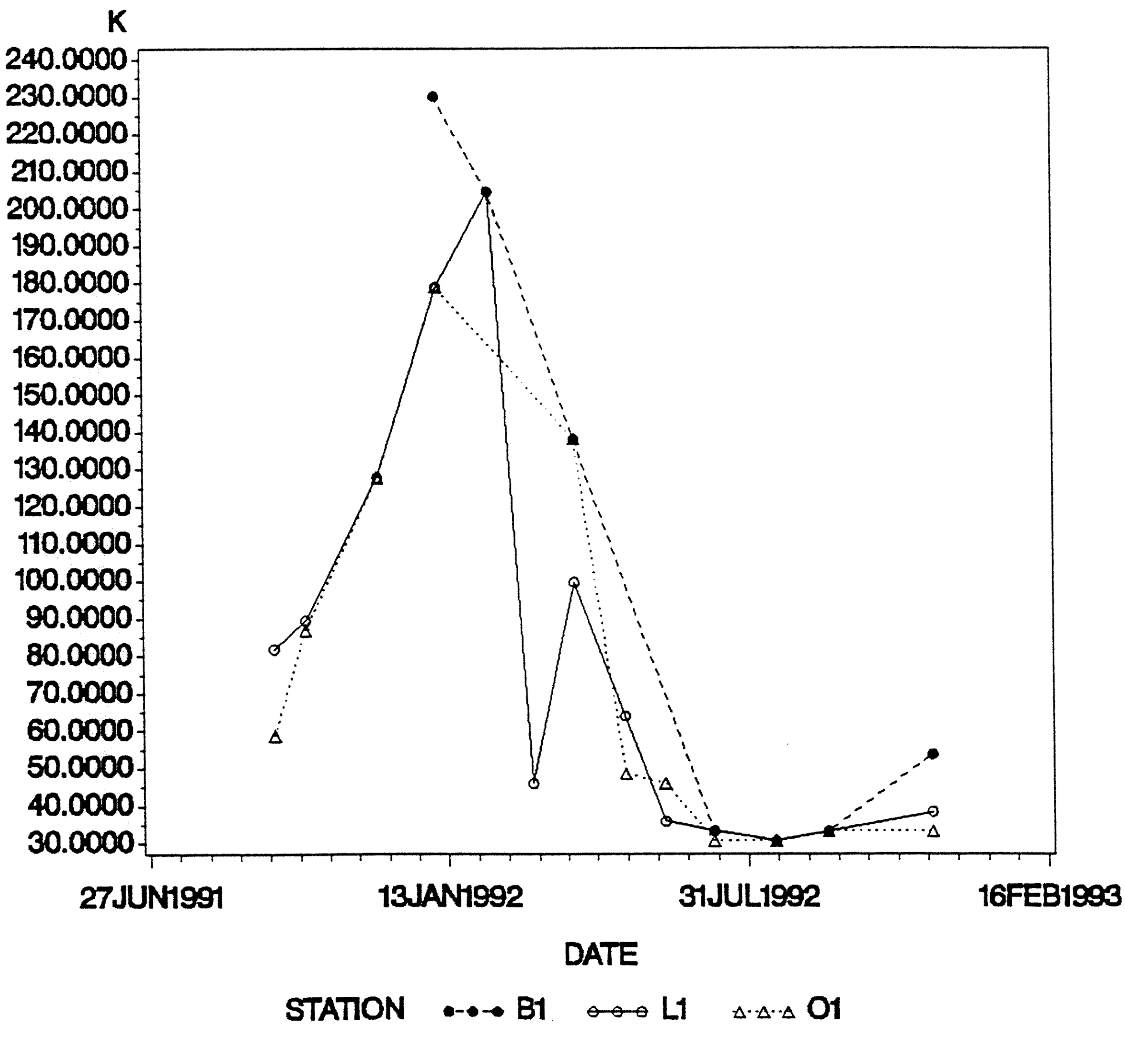

Figure 11. Potassium (K) concentrations (μeq/L) for Lake Lucille surface (L1 - o), bottom (B1 - ●), and lake outlet (O1 - Δ).

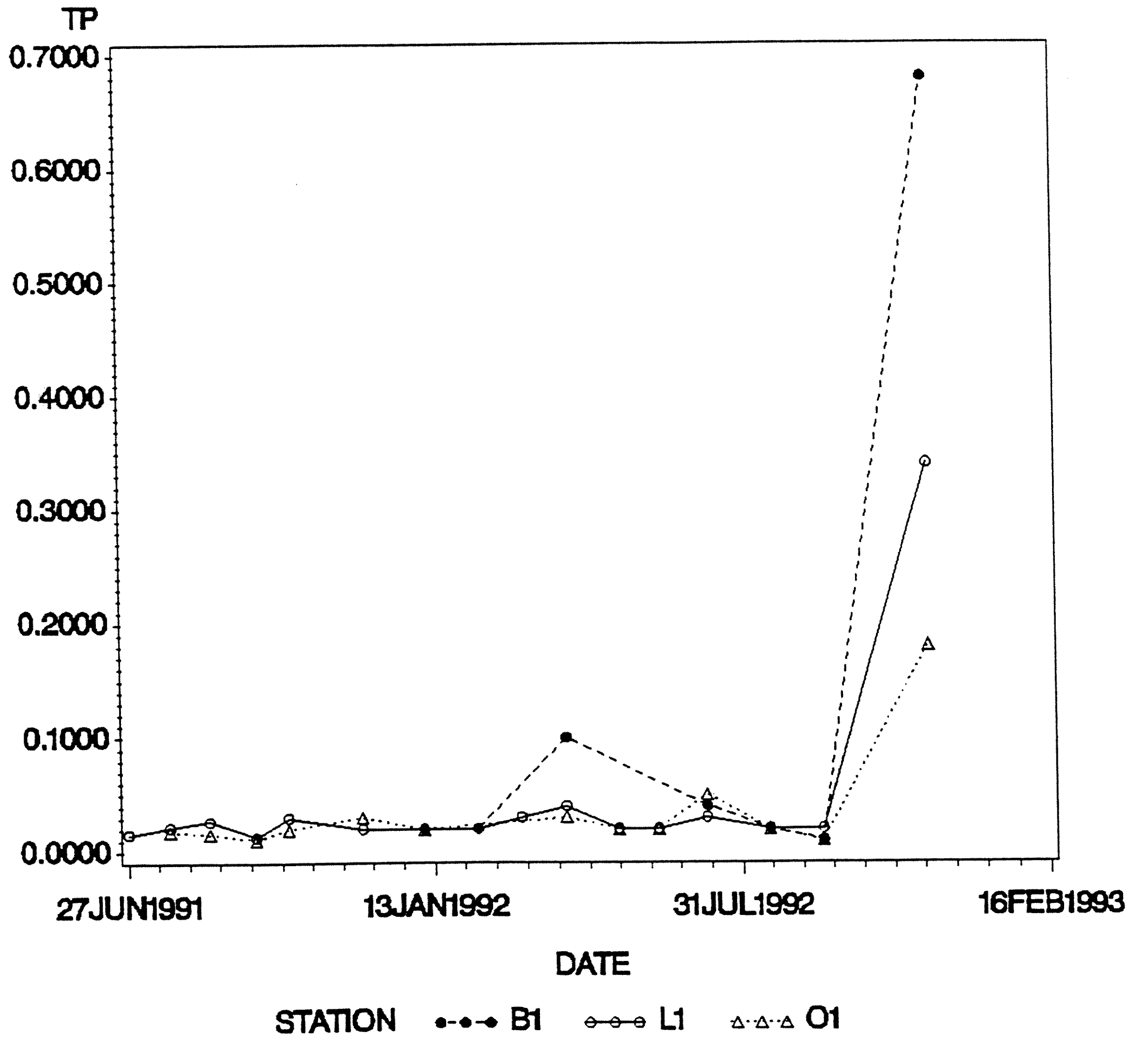

Figure 12. Total Phosphorus (TP) concentrations (mg/L) for Lake Lucille surface (L1 - o), bottom (B1 - ●), and lake outlet (O1 - Δ).

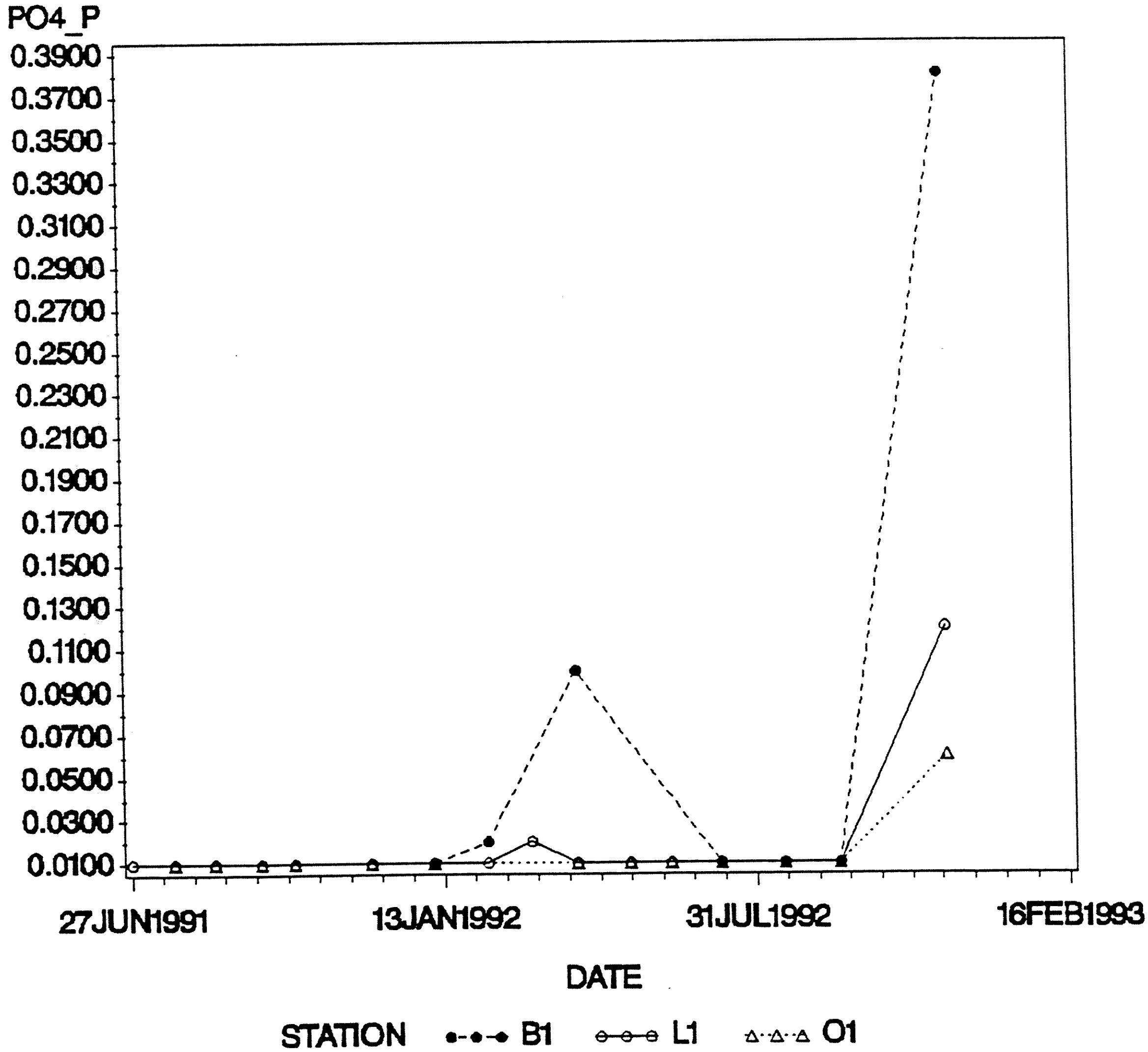

Figure 13. Soluble phosphorus (PO_4P) (mg/L) for Lake Lucille surface (L1 - o), bottom (B1 - ●), and lake outlet (O1 - Δ).

C. Supplemental Data

Fisheries records up through 1991 for Lake Lucille were obtained from the Fish and Game office in Palmer. Climatological data for the 30 years prior to the study have been obtained in digital format from NOAA. These data will be used to evaluate the degree of "normality" for the climatic data collected during the study period. Samples of the bivalves (freshwater mussels) in Lake Lucille were collected in July for identification. Phytoplankton data through summer 1992 have been analyzed and have been entered in the data base. Selected lakes and streams in the greater Wasilla area were sampled in July 1992 to help assess local groundwater flow paths and typical solute concentrations in the area.

Flow data from the outlet of Lake Lucille continues to be monitored routinely. Discharge from the lake remains only about 10% of the flow measured in July 1991.

D. Paleolimnology

To help resolve the timing and magnitude of water quality decline in Lake Lucille, we prepared a proposal to collect and analyze the sediments from the lake. The proposal was submitted through the City of Wasilla to the Alaska Department of Environmental Conservation (ADEC) in January, 1992. ADEC forwarded the proposal to the U.S. Environmental Protection Agency, Region 10 (Seattle) for consideration as a supplemental Phase I grant. EPA declined to fund the proposal in 1992, but is reconsidering this proposal for 1993 based on a revised proposal submitted in October 1992.

IV. DISCUSSION

The data collection activities are contributing to a much more thorough understanding of the mechanisms that influence the chemistry and water quality of Lake Lucille. We know that it is a hardwater lake with fairly predictable patterns. Groundwater flow into Lake Lucille is one of the most critical factors influencing the lake. Consequently, activities that diminish this in-flow would have a negative effect on the lake. We will use the data collected during the study to develop one or more mathematical models to represent the dynamics in the lake. Assuming that this is successful, we can use the model(s) to help determine approaches that might improve the conditions in the lake. Some of the restoration alternatives we plan to evaluate include dredging, aeration, chemical treatment, harvesting aquatic plants, winter drawdown (manipulating the lake level), and flow augmentation (dilution).