East Alaska Lake

Kewaunee County, Wisconsin

Alum Treatment Feasibility Study

April 2005

Sponsored by:

Tri-Lakes Association

&

Wisconsin Department of Natural Resources Lake Management Grant Program

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Lake Management Planning

ACKNOWLEDGEMENTS

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SUMMARY

The East Alaska Lake Management Plan (NES 1999) recommends studying the feasibility of completing an alum treatment to minimize the affects of internal phosphorus loadings on the lake. During 2004, a study was completed with two primary components; 1) to measure the amount of phosphorus entering East Alaska Lake from its two primary point-sources, and 2) determine if internal nutrient loadings were a significant source of phosphorus to the lake. These two components were then combined to determine if the completion of an alum treatment is appropriate for East Alaska Lake. The study included field-collected data from the lake, and its two primary tributaries (referred to as the Drain Tile Site and the Inlet Site in this document) along with estimated values generated through modeling and predictive equations.

The major results of this study are outlined below:

- The data collected during the 2004 field season indicate that East Alaska Lake is currently in a eutrophic state.
- FLUX Modeling (Walker 1999) estimated that 40,000 m^3 of water exited the Drain Tile, loading approximately 18.8 kg of phosphorus to the lake and that approximately 640,000 m^3 of water had passed the Inlet site carrying approximately 17.6 kg of phosphorus.
- Modeling using data collected during the 2004 field season indicated that approximately 131 kg of phosphorus are internally loaded to East Alaska Lake on an annual basis. This value is believed to be an overestimate, but indicative of a high load value.
- Scenario development indicated that internal nutrient loading is a significant source of phosphorus to East Alaska Lake. Furthermore, the scenarios indicate that due to the unnaturally high amount of phosphorus that enters the lake through the Drain Tile and uncertainties associated with lakeshore septic systems, an alum treatment would not be feasible at this time.

Major recommendations presented to the Tri-Lakes Association as a result of the findings described above, include the following:

- The creation of a detention basin to minimize loadings from the Drain Tile site was recommended.
- Septic system inspections and necessary updates/replacements were recommended to further reduce phosphorus loads to the lake.
- Possible funding sources were also included to assist in the implementation of the recommendations.

East Alaska Lake, Kewaunee County (Map 1), is a 53-acre seepage lake with a maximum depth of 50-feet and a mean depth of 17-feet. A Comprehensive Management Plan was developed for the lake in 1999 (NES 1999). The plan's study included a delineation of the lake's drainage basin, digital elevation modeling of watershed drainage patterns, identification of existing land uses in the East Alaska Lake watershed, examination of the impacts of existing land uses on water quality, water quality monitoring, and an aquatic vegetation inventory.

The primary sponsor for the management plan's development was the Town of Pierce because the lake did not have a qualified association that could undertake the project at the time. Recently, concerned lake stakeholders organized and incorporated the Tri-Lakes Association (TLA). The TLA currently oversees the management activities on the Town of Pierce's three lakes, East and West Alaska Lakes, and Krohns Lake.

The East Alaska Lake Comprehensive Management Plan determined that the lake's current eutrophic nature and nuisance algae blooms are largely the result of internal phosphorus loads. The plan also surmises that this phenomenon is the result of a combination of two factors; 1) excessive loads of phosphorus that historically entered the lake from a local cheese factory, agricultural runoff (e.g., barnyards), and failed septic systems, and 2) the lake's long retention time of approximately 4.13 years. In essence, the lake acted as a nutrient sink for these external loads leading to bottom sediments rich in phosphorus. Frequent anaerobic conditions in the lake's hypolimnion promote the release of phosphorus from the bottom sediments, which in turn, fuel the internal loading during turnover periods.

The planning study also indicates that these historic loads have now been minimized through agricultural best-management-practices, updating and replacement of failing septic systems, and a modified discharge plan currently used by the cheese factory that allows it to safely land-spread its pre-treated waste outside of the East Alaska Lake watershed.

A primary recommendation of the plan pertains to the use of an alum treatment to curb the affects of the internal nutrient loads. This is likely the correct course of action considering the extent of work that has been completed in the watershed to minimize external nutrient loads. However, an alum treatment for East Alaska Lake would be very expensive (approximately $35,000-$55,000); therefore the plan also recommends that this process should begin with a study to determine the feasibility of conducting the in-lake treatment. Specifically, the study would need to include the monitoring of the lake's inlet flowing from West Alaska Lake and a drain tile that outfalls on the lake's northwest shoreline.

Internal nutrient loading is the recycling of nutrients, most commonly phosphorus, from bottom sediments. If a lake's nutrient-rich bottom sediments are exposed to anoxic (devoid of oxygen) conditions during stratification, the iron that normally holds the phosphorus in the sediments releases it into the hypolimnion (bottom water layer) of the lake. During turnover events, this nutrient-rich water is mixed with the other layers often spurring or maintaining algal blooms. Internal nutrient loading can be a significant source of phosphorus in lakes long after external sources have been minimized.

The goal of this project was to discover if internal nutrient loading is a significant source of phosphorus within East Alaska Lake and to clarify the significance phosphorus loads entering the lake from the drain tile outfall described above and through the lake's inlet that originates from West Alaska Lake. Then, based upon those findings, determine if an alum treatment is feasible to minimize the internal phosphorus load with the lake in its current condition, or if further work in the watershed would be required to minimize external phosphorus loads.

RESULTS AND DISCUSSION

An Introduction to Water Quality & Lake Ecology

Judging the quality of lake water can be difficult because lakes display problems and benefits in many ways. However, focusing on specific aspects or parameters that are important to lake ecology, comparing those values to similar lakes within the region, and with historical data from the study lake provides an excellent method to evaluate the quality of a lake's water. To complete this task, three water quality parameters are focused upon throughout this report:

1. **Phosphorus** is a nutrient that controls the growth of plants in the vast majority of Wisconsin lakes. It is important to remember that in lakes, the term "plants" includes both *algae* and *macrophytes*. Monitoring and evaluating concentrations of phosphorus within the lake helps to create a better understanding of the growth rates of the plants, especially algae, within the lake.
2. **Chlorophyll-*a*** is the pigment in plants that is used during *photosynthesis*. Chlorophyll-*a* concentrations indicate algal abundance within a lake.
3. **Secchi disk transparency** is a measurement of water clarity. Of all limnological parameters, it is the most used and the easiest for non-professionals to understand. Furthermore, measuring Secchi disk transparency over long periods of time is one of the best methods of monitoring lake health. The measurement is conducted by lowering a weighted, 20-cm diameter disk with alternating black and white quadrates (a Secchi disk) into the water and recording the depth just before it disappears from sight.

The parameters described above are inter-related. Phosphorus controls algal abundance, which is measured by chlorophyll-*a* levels. Water clarity, as measured by Secchi disk transparency, is directly affected by the particulates that are suspended in the water. In the majority of natural, Wisconsin lakes, the primary particulate matter is algae; therefore, algal abundance directly affects water clarity. In addition, studies have shown that water clarity is used by most lake users to judge water quality – in the layperson's mind, clear water equals clean water.

Each of these parameters is also directly related to the *trophic state* of the lake. As nutrients, primarily phosphorus, accumulate within a lake, its productivity increases and the lake progresses through three trophic states: *oligotrophic*, *mesotrophic*, and finally *eutrophic*. Every lake will naturally progress through these states; however, under natural conditions (i.e. not influenced by the activities of humans) this process can take tens of thousands of years. Unfortunately, human influence has accelerated this natural aging process in most Wisconsin lakes. Monitoring the trophic state of a lake gives stakeholders a method by which to gauge the health of their lake over time. Yet, classifying a lake into one of three trophic states does not

> **An alum treatment** is an in-lake treatment used in reducing internal nutrient loading. The treatment includes the application of aluminum sulfate or other aluminum salt (alum) directly to the lake. Once added to the lake, the alum changes form and begins to form a floc. As the floc settles to the bottom, it pulls phosphorus and particulate matter down with it. Finally, the floc settles to the bottom creating a "blanket" or barrier that prevents phosphorus from entering the water column from the bottom sediments and as a result, reduces internal phosphorus loading significantly.

give clear indication of where a lake really exists in its trophic progression. To solve this problem, the parameters measured above can be used in an index that will indicate a lake's trophic state more clearly and provide a means for which to track it over time.

The main focus of this study is phosphorus, particularly, the loading of phosphorus from external and internal sources; therefore, throughout the text, the relationships described above are used to estimate what the chlorophyll-*a* and Secchi disk transparencies would be for the given phosphorus levels. Furthermore, the estimated levels are used to calculate the trophic state index values for those parameters. Specifically, the Wisconsin Trophic State Index (WTSI) (Lillie, et al. 1993) was used to index these values. The WTSI is based upon the widely used Carlson Trophic State Index (TSI) (Carlson 1977), but is specific to Wisconsin lakes. The WTSI is used extensively by the WDNR and is reported along with lake data collected by Self-Help Volunteers.

Comparisons with regional and statewide data are also presented within the text and in the WTSI. These data are derived from Lillie and Mason (1983), an excellent source for comparing lakes within specific regions of Wisconsin. They divided the state's lakes into five regions each having lakes of similar nature or apparent characteristics. Kewaunee County lakes are included within the study's Southeast Region and are among 61 lakes randomly selected from the region that were analyzed for water clarity (Secchi disk), chlorophyll-*a*, and total phosphorus.

The complete set of water quality data used to support the modeling effort can be found in Appendix A. Charts displaying current and historic data from East Alaska Lake along with comparative data from the state and region can also be found there.

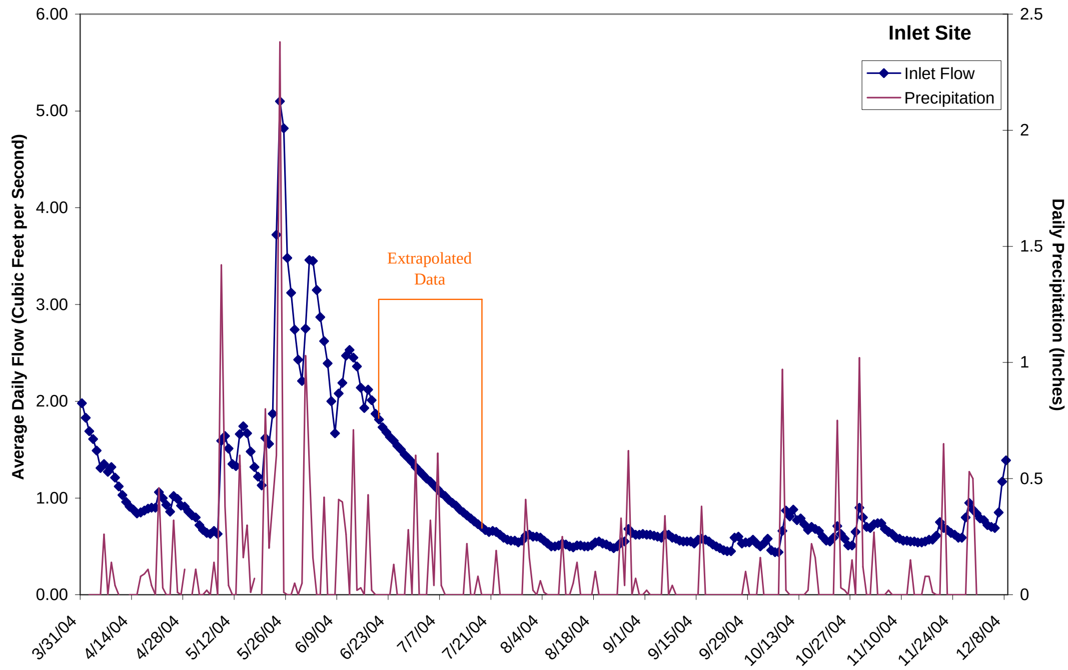
Finally, when classifying lakes into trophic levels, it must be remembered that values that fall into the mesotrophic or eutrophic categories are not indicative of poor lake health. There are benefits associated with the higher rates of productivity found in these lakes. For instance, lakes that are not as productive are unable to support a large fishery.

Tributary Flows and Phosphorus Loading

Flows from the Drain Tile and Inlet sites (Map 1) were monitored during the spring, summer, and fall of 2004. The Inlet site flowed during the entire study period, while the Drain Tile site was reduced to nothing more than a trickle after mid July (Figure 1). As displayed in Figure 1, the affect of precipitation on the flow rates of both sites diminished as the monitoring period progressed and the ground dried as a result of below average precipitation during July, August and September (Figure 2).

Unfortunately, the monitoring unit located at the Inlet site malfunctioned and was in for repair from June 19 to July 18. As a result, the data used in FLUX and displayed in Figure 1 were extrapolated. It is believed that these data are relatively accurate as no more than a half-inch of rain fell during any one day while the unit was being repaired and the flow pattern follows that of the Drain Tile site.

FLUX modeling (Table 1) indicated that approximately 18.8 kg and 17.6 kg of phosphorus entered the lake during the study period from the Drain Tile and Inlet sites, respectively. Flux also indicated that based upon the 2004 data, the Drain Tile site likely adds approximately 27.4 kg/yr of phosphorus to the lake, while the Inlet site loads approximately 25.4 kg annually.



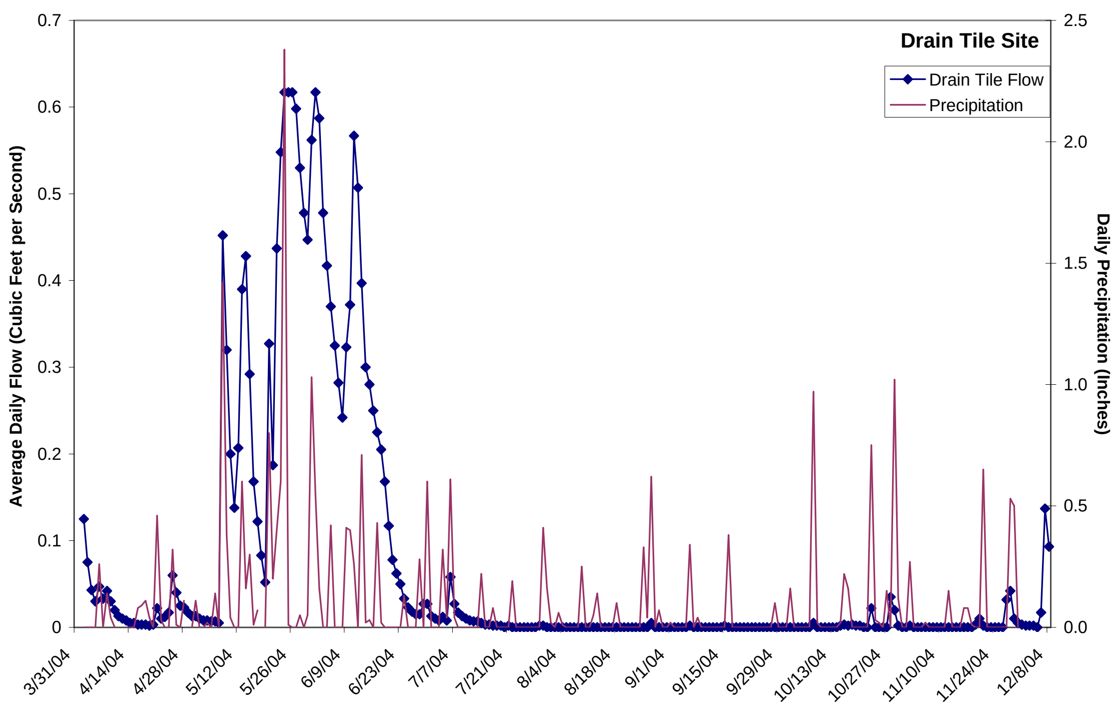


Figure 1. Inlet and Drain Tile average daily flows and daily precipitation. Note that the primary Y-axes on each graph pertaining to flow rate are different while the secondary axes indicating precipitation are identical.

Based upon these data, it appears as though both sites impact the lake similarly; however, when flow volumes are used to weight these values, this is found not to be the case. Over the course of the study period the Inlet site delivered 16 times more water than that of the Drain Tile site. This of course means that the average phosphorus concentration that is actually being delivered to the lake is much less for the Inlet site then that of the Drain Tile site (final entry in Table 1).

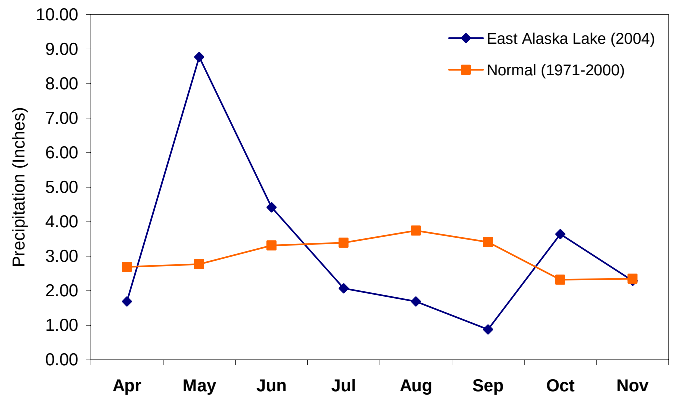


Figure 2. Normal and observed precipitation values. Normal values are from Kewaunee, Wisconsin while the observed values were recorded at the lake by Mr. Alan Stangel.

For demonstrative purposes, the average flow-weighted concentrations for each site were treated as the lake's sole source of water and phosphorus through the use of the Wisconsin Lake Modeling Suite (WiLMS). In other words, the only source of water and phosphorus for East Alaska Lake would be either the Drain Tile or the Inlet site. Modeling results for the Inlet site only indicate that the average surface phosphorus concentration would be approximately .025 mg/l, which would be considered "good" by the Apparent Water Quality Index (AWQI) developed by Lillie and Mason (1983). Using predictive values for regional lakes presented in Lillie et al. (1993), a chlorophyll-*a* value of 7.8 µg/l would likely occur and the Secchi disk clarity would be approximately 6.1 feet. Using the AWQI, the chlorophyll-*a* reading would be considered "good" the Secchi disk depth "Fair".

Modeling results for the same scenario using the Drain Tile site as the source indicated a much higher phosphorus concentration of approximately .045 mg/l, resulting in predictive chlorophyll-*a* values and clarities of 11.3 µg/l and 4.8 feet, respectively. AWQI values for these readings would be "Fair" and "Poor", respectively.

Utilizing the WTSI (Figure 3) for the Inlet (Scenario 1), the lake would be considered moderately eutrophic (much as it is now). The WTSI for the Drain Tile (Scenario 2) calculations indicates that the lake would be much more eutrophic, especially considering the phosphorus value.

WiLMS analysis using the land use data from NES (1999) and the Drain Tile and Inlet data described above resulted in a total phosphorus load of approximately 190 lbs/yr and an average growing season phosphorus concentration of .063 mg/l (slightly higher than the measured value of 0.050 mg/l). Removing the Drain Tile inputs (water and phosphorus) lowered the annual load to approximately 130 lbs and the predicted phosphorus concentration to 0.045 mg/l. Removing the Inlet source from the original model lowered the annual load to approximately 134 lbs, but drastically increased the predicted phosphorus concentration to 0.183 mg/l. This increase in average concentration is due to the differences in the volume of water that is added with the estimated loads of phosphorus from the two sites. The original model and the analysis including only the Inlet site have very similar estimated water residence times of approximately one year, meaning that the water is changed within the lake once a year. Removing the Inlet site, but leaving in the Drain Tile site significantly reduces the flow through the lake and increases the estimated water residence time to 8.2 years. As with the scenarios described above, this demonstration indicates the impact of the Drain Tile site on the lake's phosphorus cycle.

Overall, the modeling analysis indicates that although the Drain Tile contributes much less water to the lake, its loading impact is much greater than that of the Inlet. In fact, the considerable amount of water entering the lake from the Inlet is likely the diluting force that keeps East Alaska Lake from becoming highly eutrophic.

Table 1. FLUX modeling results. Full results of FLUX modeling, including input values and statistics, can be found in Appendix B.

FLUX Result	Drain Tile Site	Inlet Site
Phosphorus Mass Delivered During Study (kg)	18.8	17.6
Estimated Annual Phosphorus Load (kg/yr)	27.4	25.4
Flow Duration (days)	251	253
Flow Volume During Study Period (m^3)	40,000	640,000
Estimated Annual Flow Volume (m^3/yr)	63,000	922,000
Average Flow-weighted Phosphorus Concentration (mg/l)	0.435	0.276

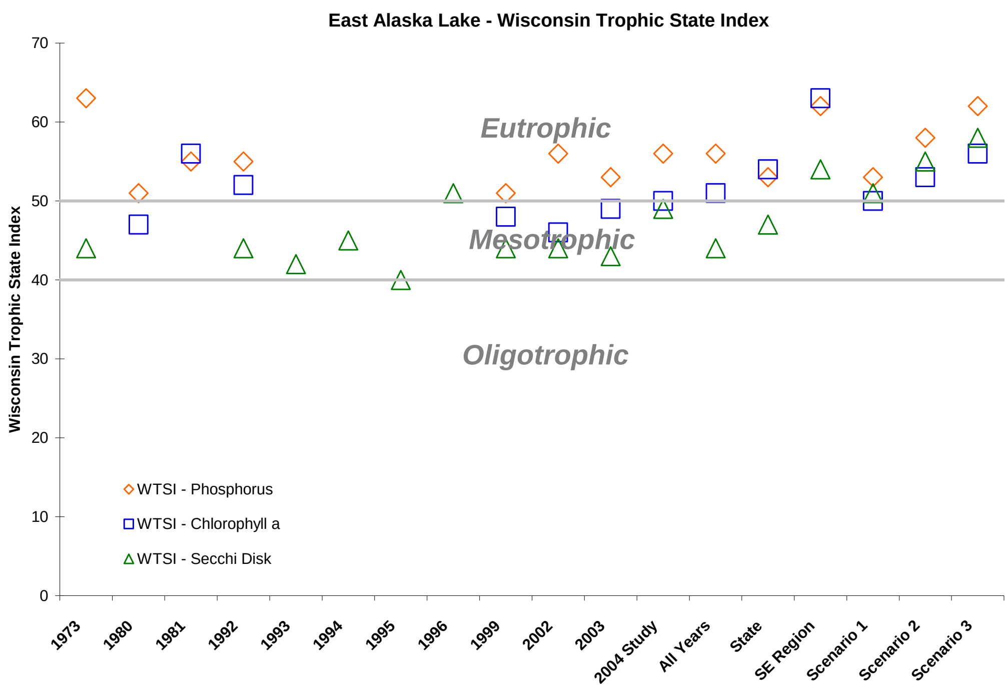


Figure 3. Wisconsin Trophic State Index results for East Alaska Lake, state, and region. Scenario 1 – Inlet as sole source. Scenario 2- Drain Tile as sole source. Scenario 3 – Internal loads as single phosphorus source.

Internal Nutrient Loading

A main component of this study was to discover if internal loading is a significant source of phosphorus in East Alaska Lake. To determine this, the Wisconsin Internal Load Estimator (WINTLOAD) module of WiLMS was used to estimate the amount of phosphorus that is added to the lake on an annual basis through internal loading. The WINTLOAD results indicate that approximately 131 kg of phosphorus are potentially loaded to the lake through internal loading. As with the estimates from the Inlet and Drain Tile sites, WiLMS was used to determine the potential affect that a load of this magnitude could have on the water quality of the lake and its trophic state.

Because the load is internally generated, there would be no associated water inputs with the 131 kg addition. WiLMS requires some sort of water input to generate its estimates; therefore, a false watershed was created to mimic the water entering the lake through the runoff. The false watershed was set to 61.9-acres, corresponding to the area of the actual East Alaska Lake watershed (not including West Alaska Lake's watershed). Unlike a normal watershed, there is no phosphorus load associated with its runoff. The model estimated the average surface water phosphorus value to be approximately .081 mg/l, a "Poor" level according to the AWQI. Predictive chlorophyll-*a* and Secchi disk values were also considered "Poor" at 16.5 µg/l and 3.8 feet, respectively. These results correspond to a highly eutrophic state based upon the WTSI (Scenario 3, Figure 3).

Obviously the WINTLOAD results are gross over estimates because if 131 kg of phosphorus were recycled within the lake along with the external loads, the lake would likely be in a hyper-eutrophic condition. Still, these results indicate that internal loads are a significant source of phosphorus in East Alaska Lake. However, these results are not the only evidence pointing toward the significance of the internal loads.

Internal nutrient loading is apparent in most lakes that are found to have phosphorus levels around .500 mg/l in the hypolimnion during anoxic periods. During the summer of 2004, the average hypolimnetic phosphorus concentration was 0.484 mg/l with the highest concentration of 0.680 mg/l occurring during the September sampling. The surface layer (epiliminion) phosphorus concentration during that same sampling was 0.026 mg/l. That value was increased to 0.091 following the fall turnover. Furthermore, this increase in phosphorus spurred a moderate algae bloom as indicated by the increased chlorophyll-*a* concentration found after the turnover (Sept. = 8.84 µg/l, Oct. = 20.80 µg/l). Based upon these data, it is undeniable that internal nutrient loading is a significant source of phosphorus in East Alaska Lake.

Lake Outflow Monitoring

Mr. Alan Stangel graciously measured lake stage on nearly a daily basis throughout most of the study. Mr. Stangel's measurements were coupled with the measured flows exiting the lake to produce a rating curve allowing outflows to be determined using lake stage (Figure 4). These data indicate that the outflow discharges throughout the majority of the year. Calculations using time-weighted flow determined that approximately 356,000 m^3 of water exited the lake during the study. Comparing this volume to the volume that entered the lake through the Inlet and Drain Tile sites (approximately 680,000 m^3) demonstrates that much of the lake's inflow discharges through groundwater.

RECOMMENDATIONS

As the project title implies, a chief goal of the project was to determine the feasibility of completing an alum treatment at East Alaska Lake if internal loading was found to be significant. Results of this study indicate that a great deal of phosphorus is loaded to East Alaska Lake internally; however, considering the amount of external loading, completing the alum treatment now would be much like shoveling the driveway before it stops snowing.

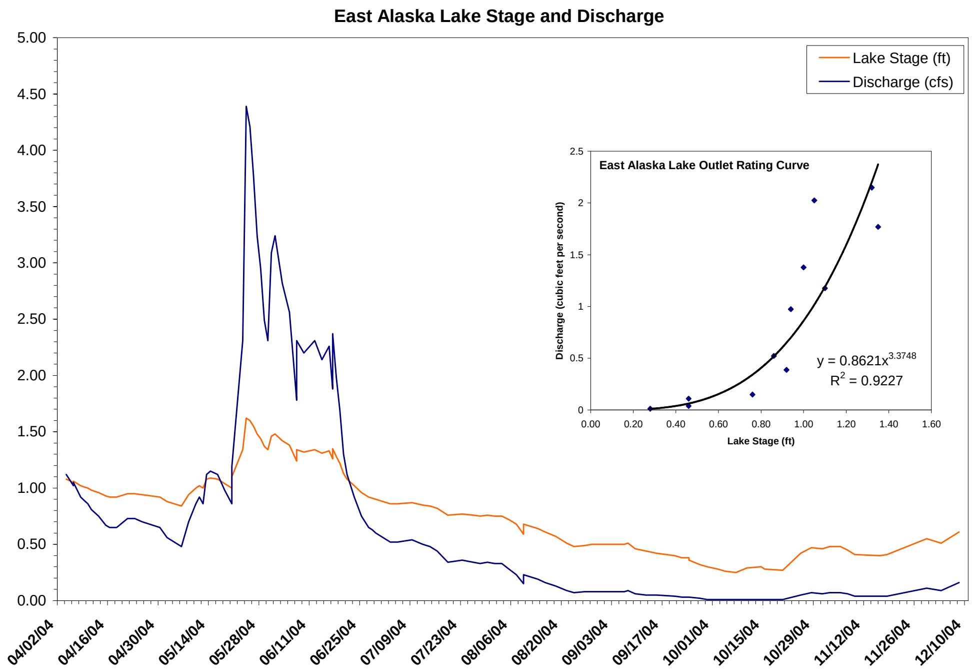


Figure 4. Lake stage and outlet flows for study period. The discharge values were calculated using the rating curve relationship displayed in the inset chart.

An alum treatment not only pulls phosphorus out of the water column, but it also locks the sediment phosphorus in place by creating a barrier between it and the anoxic hypolimnion. The beneficial longevity of an alum treatment will be reduced considerably if external sources of phosphorus are not minimized. If this is the case these loads will continue to build on top of the alum layer just to be recycled as the original bottom phosphorus was.

FLUX modeling indicated that the Drain Tile site contributes a significant amount of phosphorus annually; therefore, completing the alum treatment at this time would not be considered prudent. In addition to that source, concern remains about the impact of shoreland private septic systems. The 1999 study states that a few of the lake's shoreland septic systems were inspected in the 1990's and many were found to be failing. The study also states that the majority of these systems were updated. However, recent investigations indicate that many of the properties around the lake still maintain private sewerage systems that are in an unknown state considering their functionality.

Minimizing the impact of the Drain Tile could be accomplished through the creation of a sedimentation basin to intercept and treat the discharges before they enter the lake. A study completed at English Lake, Manitowoc County, Wisconsin determined that over 60% of inflowing phosphorus was removed before it entered the lake by a newly constructed wetland detention basin (NES 2001). If a basin could be constructed at East Alaska Lake that would remove 50% of the phosphorus from the Drain Tile, it would be a significant reduction in loading. A secondary benefit to the construction of the basin would be enhanced wildlife habitat.

A suitable location for such a detention basin is located just inland from the Drain Tile outfall (Figure 1 and Photo 1). If the Tri-Lakes Association intends to pursue the construction of the basin, it is recommended that they enlist the assistance of a professional engineering firm experienced with stormwater management. In recent years, implementation of stormwater regulations by the EPA has forced many engineering firms to become well-acquainted with the design of detention basins with maximum removal efficiencies. Furthermore, the Tri-Lakes Association could apply for a WDNR Lake Protection Grant to pay 75% of the construction costs. To pay for the design of the basin, which needs to be included in the Protection Grant application, the Association could apply for a Lake Planning Grant to provide 75% of the engineering fees. However, it must be noted that the Planning Grant program is highly

Photo 1. Potential detention basin site to treat Drain Tile discharge. Photo taken facing northwest at the Drain Tile site. It is likely that the tileline follows this valley as it slopes towards East Alaska Lake.

competitive, so there is a chance that the application may not rank well and not be funded. Being that East Alaska Lake is in a coastal county, the Association may be able to receive funds through the Wisconsin Coastal Management Grant Program.

Determining the nutrient loads from lakeshore septic systems is a difficult and expensive task involving groundwater monitoring and sampling. Many of the systems around the lake have been inspected and failing systems replaced; however, conditions of many of the systems remain unknown. At the very least, the remaining systems should be inspected and failing systems replaced before the alum treatment is performed. The fees for these inspections may be offset by the Association via the grant programs described above. The Wisconsin Department of Commerce partially funds private sewage system replacements through their Wisconsin Fund, Private Sewage System Replacement and Rehabilitation Grant Program, but the requirements are stringent and include that the system must be serving the owner's principal residence and the owners not make in excess of a specified annual income.

METHODS

Tributary Phosphorus Load Determination

Phosphorus loadings for the Drain Tile and Inlet sites (Figure 1) were estimated using FLUX, a model developed by William Walker of the US Army Corps of Engineers Waterways

Experiment Station (Walker 1999). FLUX is an interactive program designed for use in estimating the loadings of nutrients or other water quality components passing a tributary sampling station over a given period of time. Using six calculation techniques, the model maps the flow/concentration relationship developed from the sample record onto the entire flow record to calculate total mass discharge and associated error statistics.

FLUX requires three sets of data for loading estimations; 1) continuous, daily flows spanning the time period of interest, 2) periodic grab samples analyzed for the parameter of concern and collected over a range of flows, and 3) instantaneous flows corresponding to the time the grab samples were collected (Appendix B) Daily and instantaneous flows were determined using Isco Model 4300, bubble-type flowmeters that were installed at the sites and programmed to record stage (feet) every quarter hour. Weirs (inset photos, Figure 1) were used at each of the sites to allow standard flow-stage relationships to be used; however, stage readings were collected during each sampling trip and the units were recalibrated as needed.
Grab samples were collected by volunteers from the Kewaunee County Land and Water Conservation Department and during regular field visits by staff ecologists and technitians. Samples were fixed with sulfuric acid and refrigerated prior to shipping on ice to the Wisconsin State Laboratory of Hygiene for analysis,. To maintain data consistency, time and stage information were recorded from the ISCO equipment during the collection of grab samples.

Lake Water Quality

Lake water quality samples were collected six times throughout the duration of the project and included analysis of samples collected with a 3-liter Van Dorn bottle from 3-feet below the water surface and 3-feet above the lake bottom. Furthermore, Secchi disk transparencies and dissolved oxygen/temperature profiles were determined on nearly a biweekly basis. All nutrient samples collected were preserved as described above for the tributary phosphorus samples and shipped on ice with the chlorophyll *a* samples to the Wisconsin State Laboratory of Hygiene for analysis.

Data Analysis and Modeling

Watershed modeling was completed using the Wisconsin Lake Modeling Suite v. 3.3(WiLMS) (Panuska and Kreider 2003). Internal phosphorus loading estimates were calculated using the Internal Load Estimator Module (WINTLOAD) of WiLMS. The Prediction and Uncertainty Analysis Module of WiLMS was used to support watershed modeling and the internal nutrient loading estimated in WINTLOAD. Predictive equations presented in Lillie et. al (1993) were used to estimate chlorophyll-*a* and Secchi disk clarities from total phosphorus levels.

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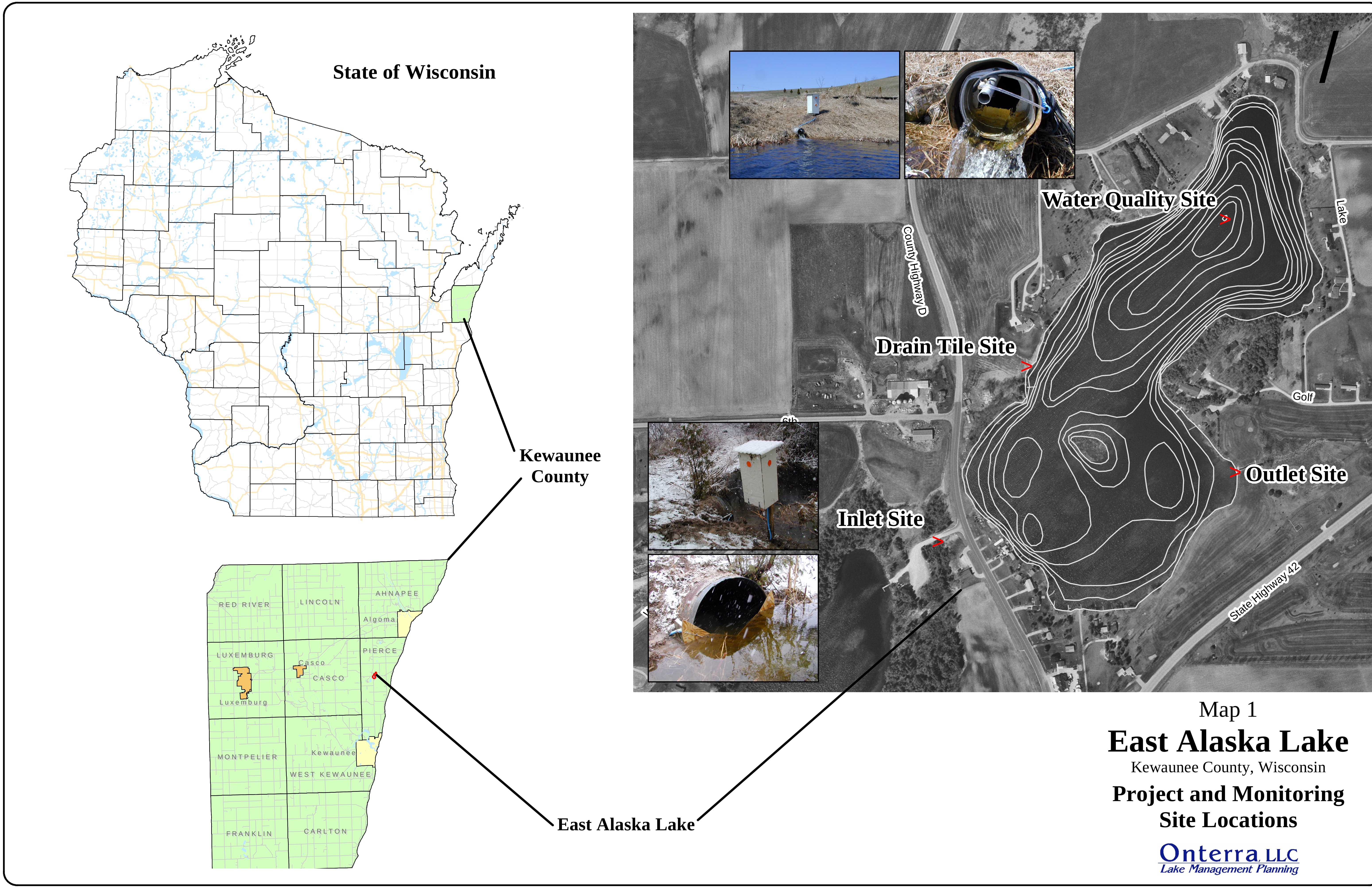

State of Wisconsin
Kewaunee County
RED RIVER
LINCOLN
AHNAPEE
Algoma
LUXEMBURG
Casco
CASCO
PIERCE
Luxemburg
MONTPELIER
Kewaunee
WEST KEWAUNEE
FRANKLIN
CARLTON
East Alaska Lake
Water Quality Site
Drain Tile Site
Inlet Site
Outlet Site
County Highway D
State Highway 42
Lake
Golf
6th
Map 1
East Alaska Lake
Kewaunee County, Wisconsin
Project and Monitoring Site Locations
Onterra, LLC
Lake Management Planning

A

APPENDIX A

Water quality dataset collected during 2004-2005.

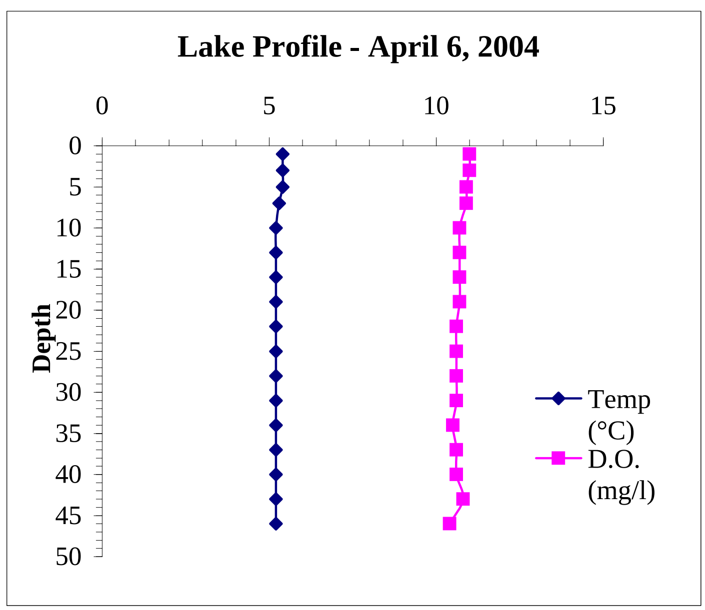
East Alaska Lake

Date: 04-06-04
Time: 10:03
Weather: 44F, Clear, Breezy
Ent: TSN **Verf:**

Max Depth (ft): 49.0
EALAS 3.0
EALAB 46.0
Secchi Depth (ft): 3.2 .

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (μS/cm)
1.0	5.4	11.0	na	510
3.0	5.4	11.0	na	510
5.0	5.4	10.9	na	511
7.0	5.3	10.9	na	511
10.0	5.2	10.7	na	512
13.0	5.2	10.7	na	511
16.0	5.2	10.7	na	511
19.0	5.2	10.7	na	512
22.0	5.2	10.6	na	512
25.0	5.2	10.6	na	511
28.0	5.2	10.6	na	511
31.0	5.2	10.6	na	511
34.0	5.2	10.5	na	511
37.0	5.2	10.6	na	512
40.0	5.2	10.6	na	512
43.0	5.2	10.8	na	512
46.0	5.2	10.4	na	512
49.0				

Parameter	EALS	EALB
Total P (mg/l)	0.049	0.044
Dissolved P (mg/l)		
Chl a (μg/l)	35.20	
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (μS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
'otal Susp Sol (mg/l)		
Calcium (mg/l)		

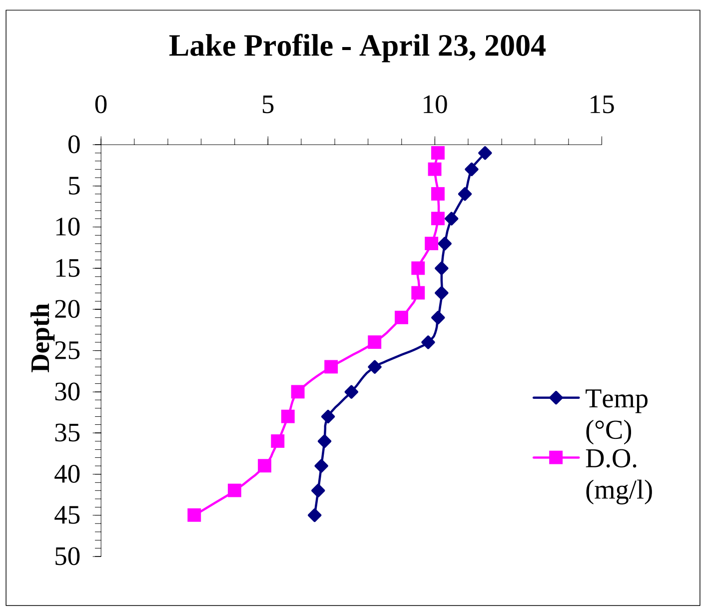


East Alaska Lake

Date: **04-23-04** **Max Depth (ft):** 46.2
Time: 13:48 **EALAS**
Weather: 50F, Mostly Cloudy (80%) **EALAB**
Ent: TSN **Verf:** **Secchi Depth (ft):** 5.2 .

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	11.5	10.1	na	513
3.0	11.1	10.0	na	513
6.0	10.9	10.1	na	513
9.0	10.5	10.1	na	513
12.0	10.3	9.9	na	513
15.0	10.2	9.5	na	513
18.0	10.2	9.5	na	514
21.0	10.1	9.0	na	515
24.0	9.8	8.2	na	515
27.0	8.2	6.9	na	517
30.0	7.5	5.9	na	519
33.0	6.8	5.6	na	518
36.0	6.7	5.3	na	518
39.0	6.6	4.9	na	519
42.0	6.5	4.0	na	520
45.0	6.4	2.8	na	522

Parameter	EALS	EALB
Total P (mg/l)		
Dissolved P (mg/l)		
Chl a (µg/l)		
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)		
Calcium (mg/l)		

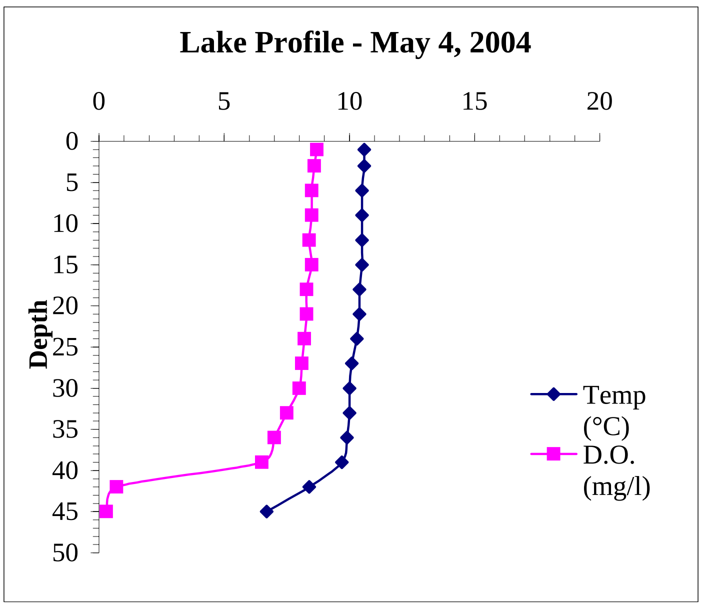


East Alaska Lake

Date:	**05-04-04**	**Max Depth (ft):**	46.2
Time:	9:56	**EALAS**	
Weather:	45F, Rainy, Windy	**EALAB**	
Ent:	TSN **Verf:**	**Secchi Depth (ft):**	7.1 .

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	10.6	8.7	na	518
3.0	10.6	8.6	na	519
6.0	10.5	8.5	na	519
9.0	10.5	8.5	na	519
12.0	10.5	8.4	na	519
15.0	10.5	8.5	na	520
18.0	10.4	8.3	na	519
21.0	10.4	8.3	na	520
24.0	10.3	8.2	na	520
27.0	10.1	8.1	na	519
30.0	10.0	8.0	na	520
33.0	10.0	7.5	na	520
36.0	9.9	7.0	na	521
39.0	9.7	6.5	na	522
42.0	8.4	0.7	na	526
45.0	6.7	0.3	na	531

Parameter	EALS	EALB
Total P (mg/l)		
Dissolved P (mg/l)		
Chl a (µg/l)		
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)		
Calcium (mg/l)		

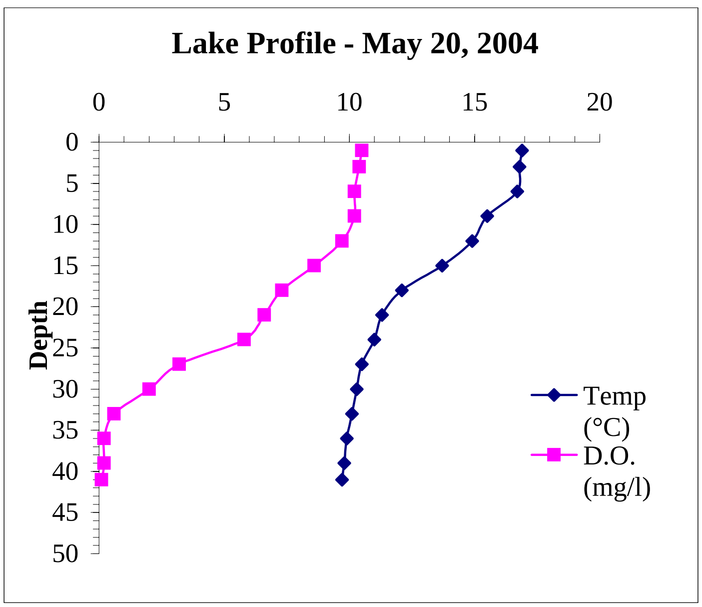


East Alaska Lake

Date: **05-20-04** **Max Depth (ft):** 46.1
Time: 9:54 **EALAS**
Weather: 65F, Windy, Partly Cloudy **EALAB**
Ent: TSN **Verf:** **Secchi Depth (ft):** 12.0 .

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	16.9	10.5	na	515
3.0	16.8	10.4	na	515
6.0	16.7	10.2	na	515
9.0	15.5	10.2	na	516
12.0	14.9	9.7	na	519
15.0	13.7	8.6	na	521
18.0	12.1	7.3	na	522
21.0	11.3	6.6	na	521
24.0	11.0	5.8	na	524
27.0	10.5	3.2	na	528
30.0	10.3	2.0	na	529
33.0	10.1	0.6	na	531
36.0	9.9	0.2	na	533
39.0	9.8	0.2	na	534
41.0	9.7	0.1	na	533

Parameter	EALS	EALB
Total P (mg/l)		
Dissolved P (mg/l)		
Chl a (µg/l)		
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
'otal Susp Sol (mg/l)		
Calcium (mg/l)		

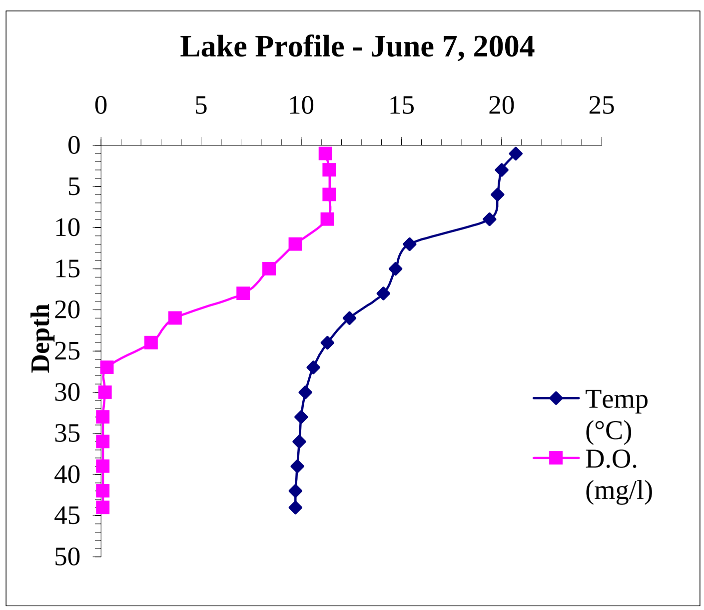


East Alaska Lake

Date:	**06-07-04**	**Max Depth (ft):**	45.0
Time:	11:40	**EALAS**	3.0
Weather:	75F, Windy, Partly Cloudy	**EALAB**	42.0
Ent:	TSN **Verf:**	**Secchi Depth (ft):**	11.0 .

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	20.7	11.2	na	498
3.0	20.0	11.4	na	499
6.0	19.8	11.4	na	499
9.0	19.4	11.3	na	496
12.0	15.4	9.7	na	503
15.0	14.7	8.4	na	507
18.0	14.1	7.1	na	511
21.0	12.4	3.7	na	526
24.0	11.3	2.5	na	528
27.0	10.6	0.3	na	533
30.0	10.2	0.2	na	537
33.0	10.0	0.1	na	537
36.0	9.9	0.1	na	540
39.0	9.8	0.1	na	541
42.0	9.7	0.1	na	542
44.0	9.7	0.1	na	543

Parameter	EALS	EALB
Total P (mg/l)	0.043	0.230
Dissolved P (mg/l)		
Chl a (µg/l)	7.20	
TKN (mg/l)	1.040	2.450
NO_4+NO_3-N (mg/l)	ND	ND
NH_3-N (mg/l)		
Total N (mg/l)	8.240	2.450
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
'otal Susp Sol (mg/l)		
Calcium (mg/l)		

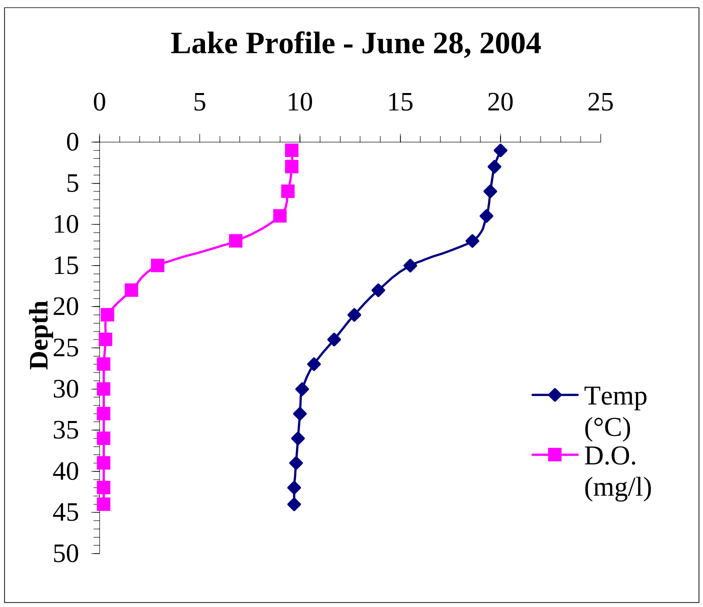


East Alaska Lake

Date:	**06-28-04**	**Max Depth (ft):**	44.8
Time:	8:48	**EALAS**	
Weather:	58F, Clear, Slight Breeze	**EALAB**	
Ent:	TSN **Verf:**	**Secchi Depth (ft):**	6.8 .

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	20.0	9.6	na	492
3.0	19.7	9.6	na	492
6.0	19.5	9.4	na	492
9.0	19.3	9.0	na	493
12.0	18.6	6.8	na	501
15.0	15.5	2.9	na	519
18.0	13.9	1.6	na	520
21.0	12.7	0.4	na	530
24.0	11.7	0.3	na	532
27.0	10.7	0.2	na	535
30.0	10.1	0.2	na	542
33.0	10.0	0.2	na	544
36.0	9.9	0.2	na	547
39.0	9.8	0.2	na	549
42.0	9.7	0.2	na	551
44.0	9.7	0.2	na	553

Parameter	EALS	EALB
Total P (mg/l)		
Dissolved P (mg/l)		
Chl a (µg/l)		
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
'otal Susp Sol (mg/l)		
Calcium (mg/l)		

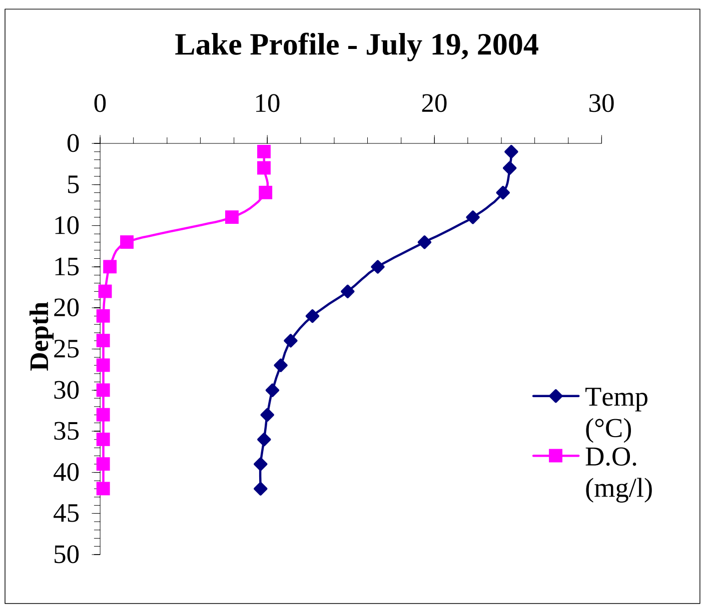


East Alaska Lake

Date:	**07-19-04**	**Max Depth (ft):**	47.2
Time:	13:15	**EALAS**	3.0
Weather:	78F, Partly Cloudy, Windy	**EALAB**	44.0
Ent:	TSN **Verf:**	**Secchi Depth (ft):**	7.3 .

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (μS/cm)
1.0	24.6	9.8	na	485
3.0	24.5	9.8	na	485
6.0	24.1	9.9	na	484
9.0	22.3	7.9	na	490
12.0	19.4	1.6	na	510
15.0	16.6	0.6	na	525
18.0	14.8	0.3	na	524
21.0	12.7	0.2	na	535
24.0	11.4	0.2	na	538
27.0	10.8	0.2	na	544
30.0	10.3	0.2	na	547
33.0	10.0	0.2	na	551
36.0	9.8	0.2	na	557
39.0	9.6	0.2	na	562
42.0	9.6	0.2	na	567

Parameter	EALS	EALB
Total P (mg/l)	0.041	0.543
Dissolved P (mg/l)		
Chl a (μg/l)	7.73	
TKN (mg/l)	1.180	3.920
NO_4+NO_3-N (mg/l)	ND	ND
NH_3-N (mg/l)		
Total N (mg/l)	1.180	3.920
Lab Cond. (μS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)		
Calcium (mg/l)		

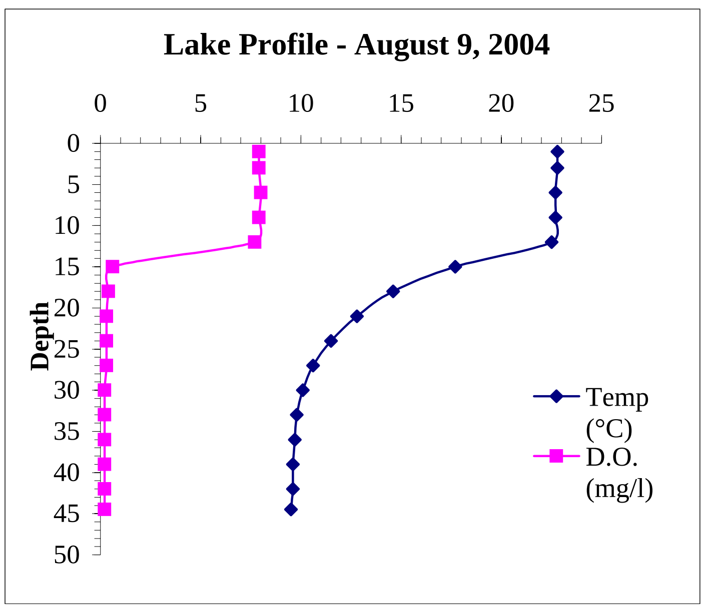


East Alaska Lake

Date:	**08-09-04**	**Max Depth (ft):**	45.4
Time:	11:35	**EALAS**	
Weather:	74F, Overcast, light breeze	**EALAB**	
Ent:	TSN **Verf:**	**Secchi Depth (ft):**	3.7 .

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	22.8	7.9	na	471
3.0	22.8	7.9	na	471
6.0	22.7	8.0	na	471
9.0	22.7	7.9	na	471
12.0	22.5	7.7	na	470
15.0	17.7	0.6	na	529
18.0	14.6	0.4	na	532
21.0	12.8	0.3	na	541
24.0	11.5	0.3	na	543
27.0	10.6	0.3	na	553
30.0	10.1	0.2	na	560
33.0	9.8	0.2	na	570
36.0	9.7	0.2	na	572
39.0	9.6	0.2	na	574
42.0	9.6	0.2	na	578
44.5	9.5	0.2	na	580

Parameter	EALS	EALB
Total P (mg/l)		
Dissolved P (mg/l)		
Chl a (µg/l)		
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
'otal Susp Sol (mg/l)		
Calcium (mg/l)		

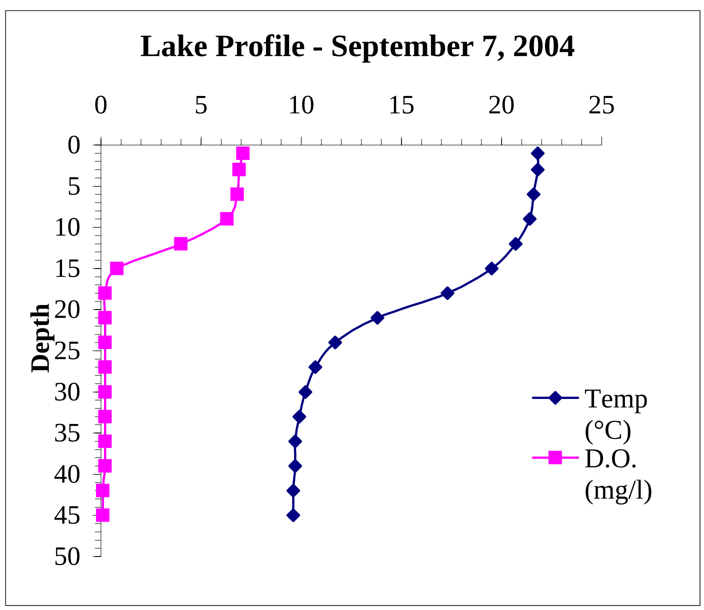


East Alaska Lake

Date:	**09-07-04**	**Max Depth (ft):**	46.0
Time:	12:19	**EALAS**	3.0
Weather:	68F, windy, partly cloudy	**EALAB**	43.0
Ent:	TSN **Verf:**	**Secchi Depth (ft):**	6.3 .

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	21.8	7.1	na	492
3.0	21.8	6.9	na	492
6.0	21.6	6.8	na	492
9.0	21.4	6.3	na	494
12.0	20.7	4.0	na	497
15.0	19.5	0.8	na	501
18.0	17.3	0.2	na	518
21.0	13.8	0.2	na	550
24.0	11.7	0.2	na	554
27.0	10.7	0.2	na	566
30.0	10.2	0.2	na	573
33.0	9.9	0.2	na	580
36.0	9.7	0.2	na	586
39.0	9.7	0.2	na	587
42.0	9.6	0.1	na	590
45.0	9.6	0.1	na	598

Parameter	EALS	EALB
Total P (mg/l)	0.026	0.680
Dissolved P (mg/l)		
Chl a (µg/l)	8.84	
TKN (mg/l)	1.180	5.780
NO_4+NO_3-N (mg/l)	ND	ND
NH_3-N (mg/l)		
Total N (mg/l)	1.180	5.780
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)		
Calcium (mg/l)		

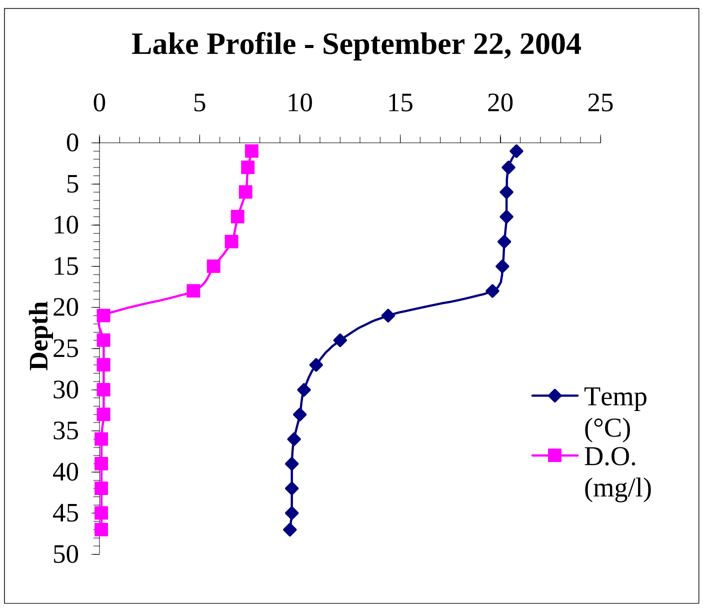


East Alaska Lake

Date: 09-22-04 **Max Depth (ft):** 48.8
Time: 10:27 **EALAS**
Weather: 75F, Clear, Breezy **EALAB**
Ent: TSN **Verf:** **Secchi Depth (ft):** 6.5 .

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	20.8	7.6	NA	500
3.0	20.4	7.4	NA	500
6.0	20.3	7.3	NA	500
9.0	20.3	6.9	NA	501
12.0	20.2	6.6	NA	501
15.0	20.1	5.7	NA	502
18.0	19.6	4.7	NA	505
21.0	14.4	0.2	NA	551
24.0	12.0	0.2	NA	555
27.0	10.8	0.2	NA	568
30.0	10.2	0.2	NA	577
33.0	10.0	0.2	NA	582
36.0	9.7	0.1	NA	589
39.0	9.6	0.1	NA	593
42.0	9.6	0.1	NA	596
45.0	9.6	0.1	NA	599
47.0	9.5	0.1	NA	600

Parameter	EALS	EALB
Total P (mg/l)		
Dissolved P (mg/l)		
Chl a (µg/l)		
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
'otal Susp Sol (mg/l)		
Calcium (mg/l)		

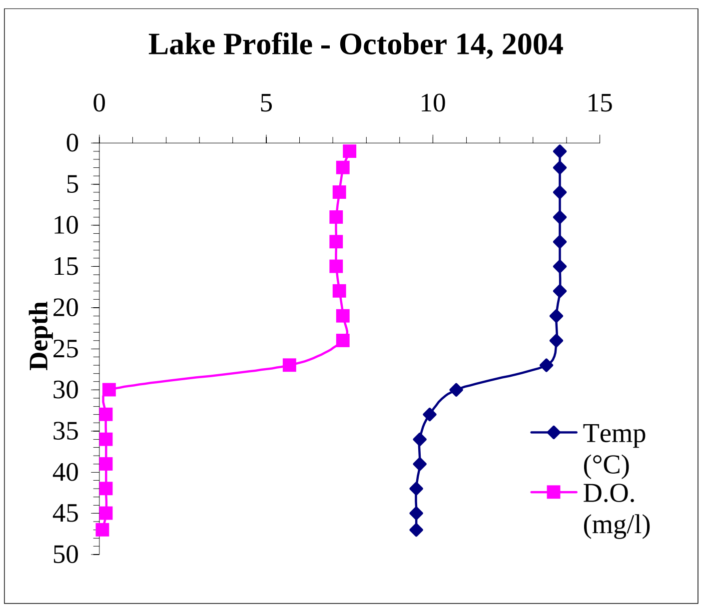


East Alaska Lake

Date:	**10-14-04**	**Max Depth (ft):**	48.2
Time:	8:00	**EALAS**	
Weather:	50F, Breezy, Overcast/Misting	**EALAB**	
Ent:	TSN **Verf:**	**Secchi Depth (ft):**	5.4 .

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	13.8	7.5	NA	509
3.0	13.8	7.3	NA	509
6.0	13.8	7.2	NA	509
9.0	13.8	7.1	NA	509
12.0	13.8	7.1	NA	509
15.0	13.8	7.1	NA	509
18.0	13.8	7.2	NA	509
21.0	13.7	7.3	NA	509
24.0	13.7	7.3	NA	509
27.0	13.4	5.7	NA	517
30.0	10.7	0.3	NA	581
33.0	9.9	0.2	NA	591
36.0	9.6	0.2	NA	599
39.0	9.6	0.2	NA	604
42.0	9.5	0.2	NA	609
45.0	9.5	0.2	NA	611
47.0	9.5	0.1	NA	620

Parameter	EALS	EALB
Total P (mg/l)		
Dissolved P (mg/l)		
Chl a (µg/l)		
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)		
Calcium (mg/l)		

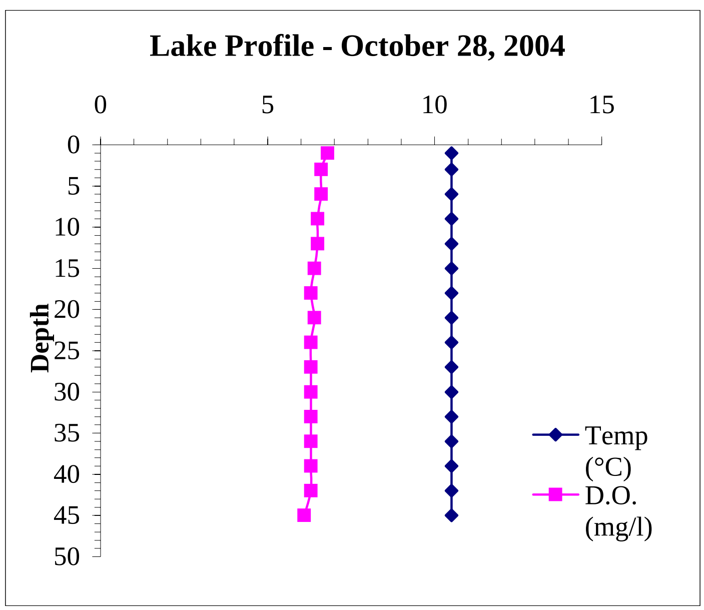


East Alaska Lake

Date:	**10-28-04**		**Max Depth (ft):**	47.4
Time:	9:00		**EALAS**	3.0
Weather:	50F, Breezy, Overcast		**EALAB**	44.0
Ent:	TSN	**Verf:**	**Secchi Depth (ft):**	6.5 .

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	10.5	6.8	NA	516
3.0	10.5	6.6	NA	516
6.0	10.5	6.6	NA	516
9.0	10.5	6.5	NA	516
12.0	10.5	6.5	NA	516
15.0	10.5	6.4	NA	516
18.0	10.5	6.3	NA	516
21.0	10.5	6.4	NA	517
24.0	10.5	6.3	NA	517
27.0	10.5	6.3	NA	517
30.0	10.5	6.3	NA	517
33.0	10.5	6.3	NA	517
36.0	10.5	6.3	NA	517
39.0	10.5	6.3	NA	517
42.0	10.5	6.3	NA	517
45.0	10.5	6.1	NA	518

Parameter	EALS	EALB
Total P (mg/l)	0.091	0.133
Dissolved P (mg/l)		
Chl a (µg/l)	20.80	
TKN (mg/l)	1.660	
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)	0.350	
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
'otal Susp Sol (mg/l)		
Calcium (mg/l)		

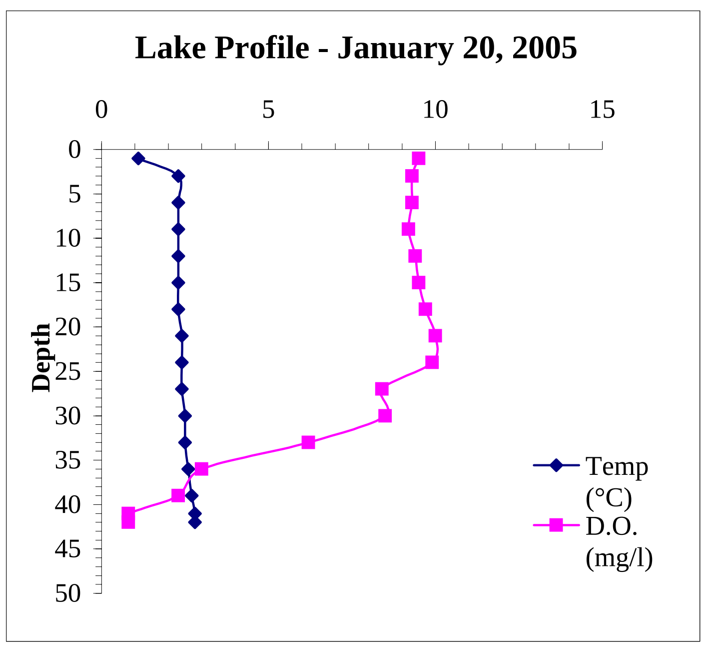


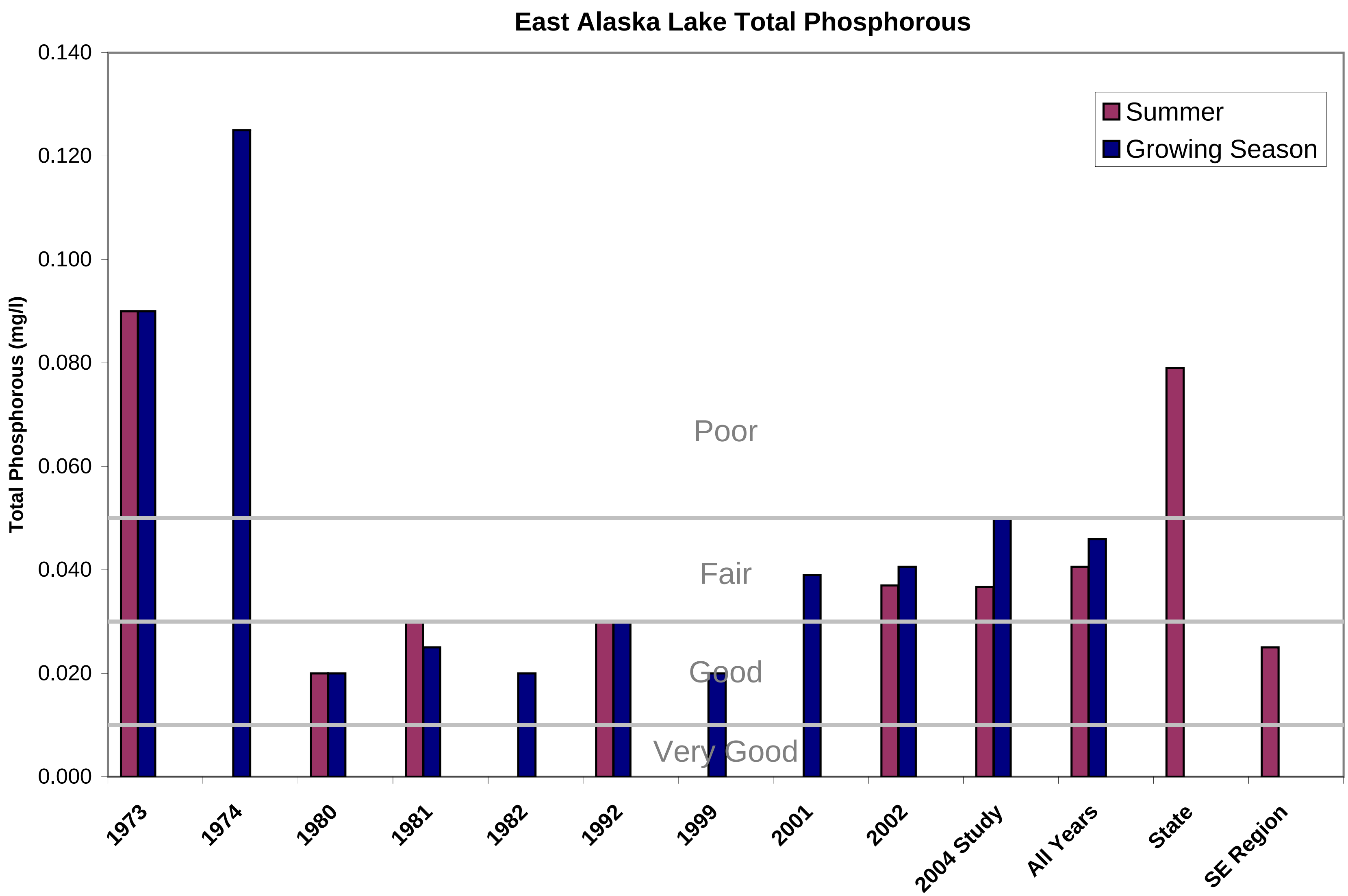
East Alaska Lake

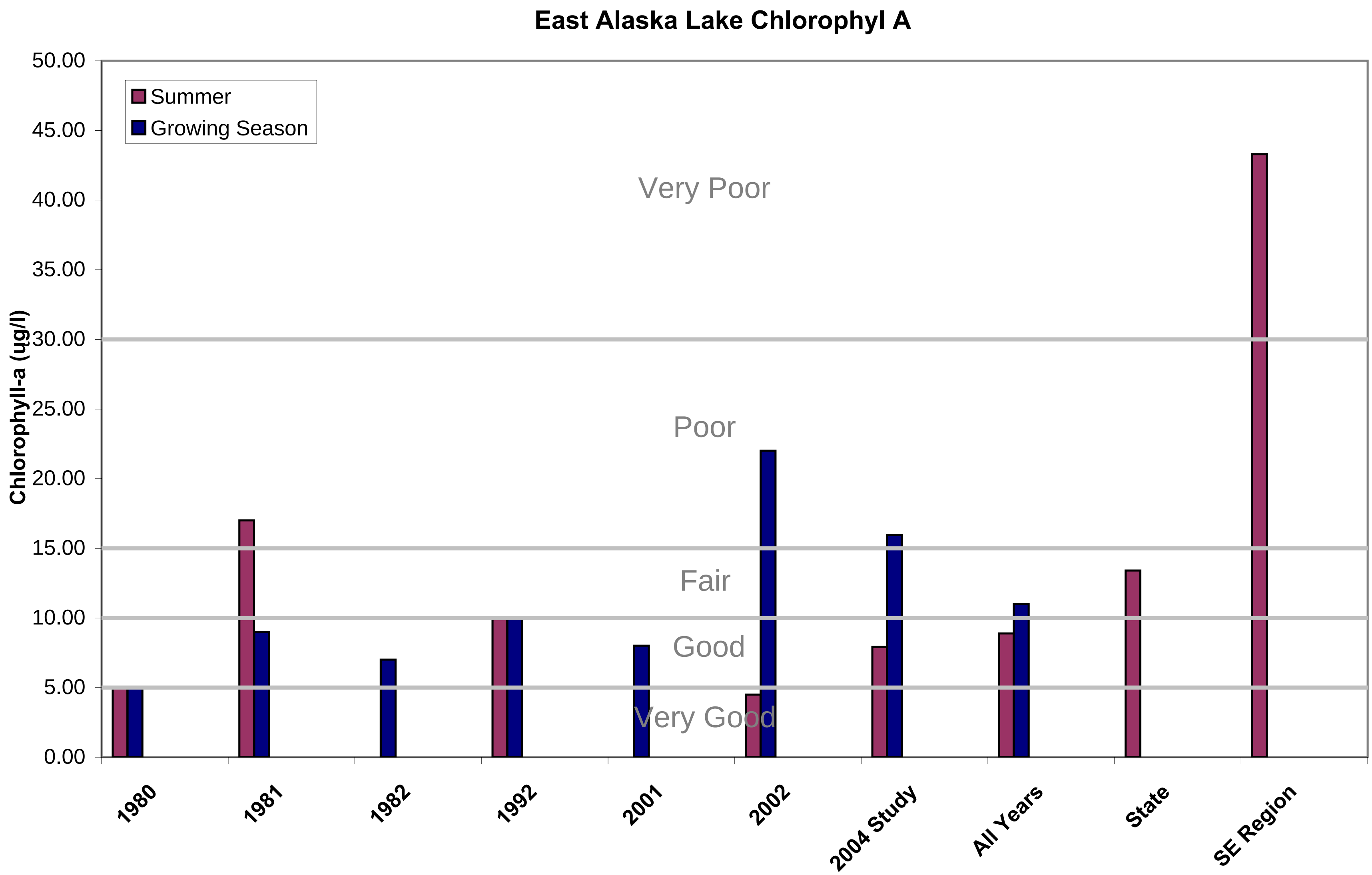
Date:	**01-20-05**	**Max Depth (ft):**	43.8	
Time:	10:55	**EALS**	3.0	
Weather:	~15F, Windy, Snowing Heavily	**EALB**	41.0	
Ent:	TSN **Verf:**	**Secchi Depth (ft):**	7.6	**ICE** 1.0

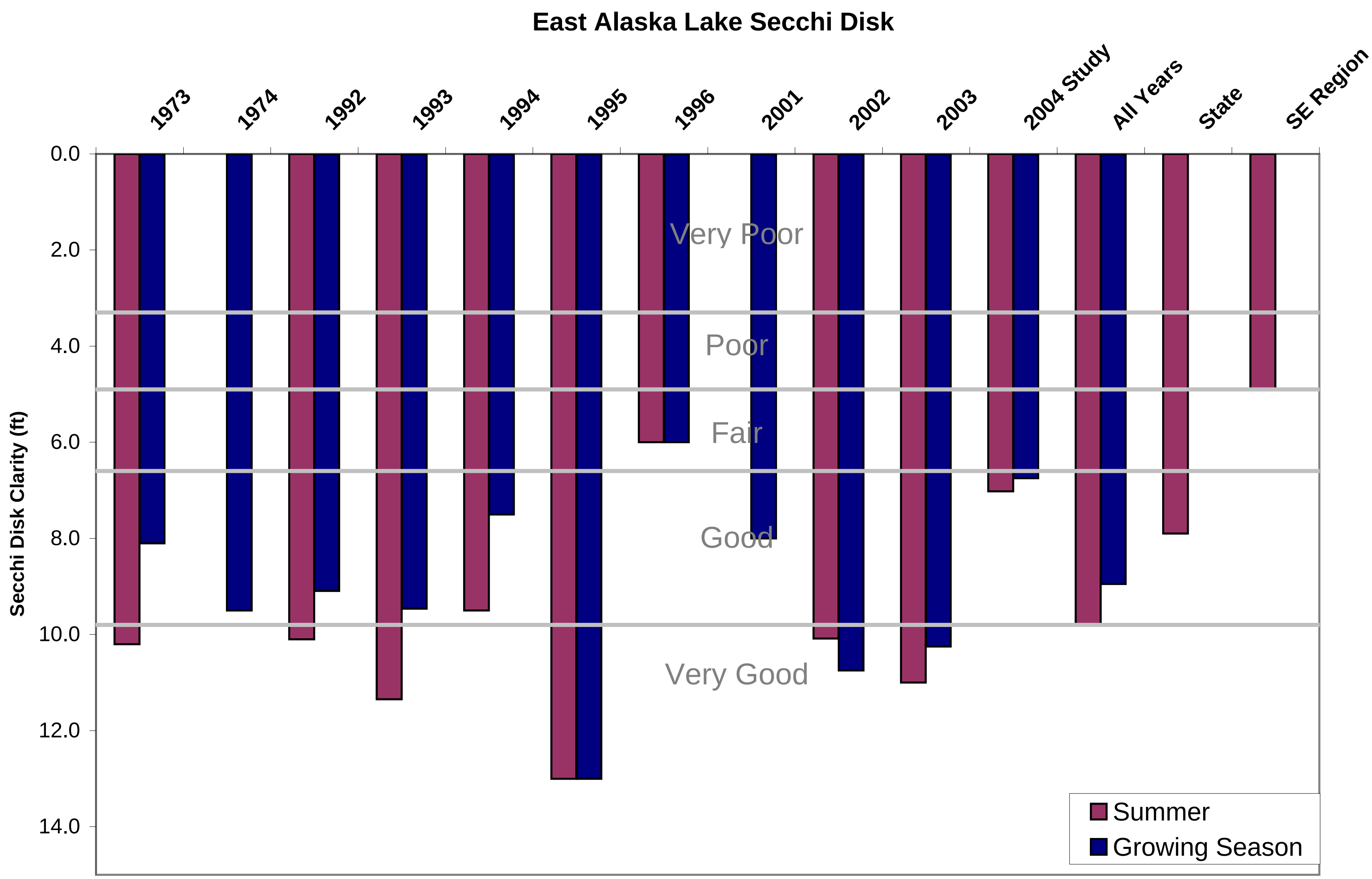
Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	1.1	9.5	NA	46
3.0	2.3	9.3	NA	544
6.0	2.3	9.3	NA	544
9.0	2.3	9.2	NA	544
12.0	2.3	9.4	NA	543
15.0	2.3	9.5	NA	544
18.0	2.3	9.7	NA	547
21.0	2.4	10.0	NA	548
24.0	2.4	9.9	NA	548
27.0	2.4	8.4	NA	550
30.0	2.5	8.5	NA	554
33.0	2.5	6.2	NA	556
36.0	2.6	3.0	NA	558
39.0	2.7	2.3	NA	563
41.0	2.8	0.8	NA	564
42.0	2.8	0.8	NA	564

Parameter	EALS	EALB
Total P (mg/l)	0.094	0.239
Dissolved P (mg/l)		
Chl a (µg/l)	1.34	
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
'otal Susp Sol (mg/l)		
Calcium (mg/l)		




East Alaska Lake Total Phosphorous
Total Phosphorous (mg/l)
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
Summer
Growing Season
Poor
Fair
Good
Very Good
1973
1974
1980
1981
1982
1992
1999
2001
2002
2004 Study
All Years
State
SE Region


East Alaska Lake Chlorophyl A
Summer
Growing Season
Very Poor
Poor
Fair
Good
Very Good
Chlorophyll-a (ug/l)
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
1980
1981
1982
1992
2001
2002
2004 Study
All Years
State
SE Region



East Alaska Lake Secchi Disk
1973
1974
1992
1993
1994
1995
1996
2001
2002
2003
2004 Study
All Years
State
SE Region
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
Secchi Disk Clarity (ft)
Very Poor
Poor
Fair
Good
Very Good
Summer
Growing Season

B

APPENDIX B

Flow and phosphorus values utilized in FLUX modeling and FLUX modeling output.

drain tile site, flows in cfs

date	drain tile	Preciptation (in.)
04/02/04	0.125	0.00
04/03/04	0.075	0.00
04/04/04	0.043	0.00
04/05/04	0.03	0.00
04/06/04	0.047	0.26
04/07/04	0.033	0.00
04/08/04	0.042	0.14
04/09/04	0.03	0.04
04/10/04	0.02	0.00
04/11/04	0.013	
04/12/04	0.01	
04/13/04	0.008	0.00
04/14/04	0.005	0.00
04/15/04	0.005	0.00
04/16/04	0.003	0.08
04/17/04	0.003	0.09
04/18/04	0.003	0.11
04/19/04	0.002	0.04
04/20/04	0.003	0.00
04/21/04	0.022	0.46
04/22/04	0.01	0.03
04/23/04	0.012	0.00
04/24/04	0.017	0.00
04/25/04	0.06	0.32
04/26/04	0.04	0.01
04/27/04	0.025	0.00
04/28/04	0.023	0.11
04/29/04	0.017	
04/30/04	0.013	0.00
05/01/04	0.013	0.11
05/02/04	0.01	T
05/03/04	0.008	0.00
05/04/04	0.008	0.02
05/05/04	0.007	0.00
05/06/04	0.007	0.14
05/07/04	0.005	T
05/08/04	0.452	1.42
05/09/04	0.32	0.38
05/10/04	0.2	0.04
05/11/04	0.138	0.00
05/12/04	0.207	0.00
05/13/04	0.39	0.60
05/14/04	0.428	0.16
05/15/04	0.292	0.30
05/16/04	0.168	0.01
05/17/04	0.122	0.07
05/18/04	0.083	
05/19/04	0.052	0.00
05/20/04	0.327	0.80
05/21/04	0.187	0.20
05/22/04	0.437	0.40
05/23/04	0.548	0.60
05/24/04	0.617	2.38
05/25/04	0.617	0.01
05/26/04	0.617	T
05/27/04	0.598	0.00
05/28/04	0.53	0.05
05/29/04	0.478	0.00
05/30/04	0.447	0.05
05/31/04	0.562	1.03
06/01/04	0.617	0.55
06/02/04	0.587	0.16
06/03/04	0.478	0.00
06/04/04	0.417	0.00
06/05/04	0.37	0.42
06/06/04	0.325	T
06/07/04	0.282	0.00
06/08/04	0.242	0.00
06/09/04	0.323	0.41
06/10/04	0.372	0.40
06/11/04	0.567	0.26
06/12/04	0.507	0.00
06/13/04	0.397	0.71
06/14/04	0.3	0.02
06/15/04	0.28	0.03
06/16/04	0.25	0.00
06/17/04	0.225	0.43
06/18/04	0.205	0.02
06/19/04	0.168	0.00
06/20/04	0.117	0.00
06/21/04	0.078	0.00
06/22/04	0.062	T
06/23/04	0.05	0.00
06/24/04	0.033	0.13
06/25/04	0.023	0.00
06/26/04	0.018	T
06/27/04	0.015	0.00

drain tile site, flows in cfs

date	drain tile	Preciptation (in.)
06/28/04	0.015	0.28
06/29/04	0.027	T
06/30/04	0.027	0.60
07/01/04	0.013	0.00
07/02/04	0.01	0.00
07/03/04	0.008	T
07/04/04	0.012	0.32
07/05/04	0.008	0.04
07/06/04	0.058	0.61
07/07/04	0.027	0.04
07/08/04	0.017	T
07/09/04	0.013	0.00
07/10/04	0.01	0.00
07/11/04	0.008	T
07/12/04	0.007	0.00
07/13/04	0.007	0.00
07/14/04	0.005	0.22
07/15/04	0.003	0.00
07/16/04	0.003	0.00
07/17/04	0.002	0.08
07/18/04	0.002	0.00
07/19/04	0.002	0.00
07/20/04	0	0.00
07/21/04	0.002	t
07/22/04	0	0.19
07/23/04	0	0.00
07/24/04	0	0.00
07/25/04	0	0.00
07/26/04	0	0.00
07/27/04	0	0.00
07/28/04	0	0.00
07/29/04	0.002	0.00
07/30/04	0.002	0.41
07/31/04	0	0.16
08/01/04	0	0.02
08/02/04	0	0.00
08/03/04	0	0.06
08/04/04	0	0.01
08/05/04	0	0.00
08/06/04	0	0.00
08/07/04	0	0.00
08/08/04	0	0.00
08/09/04	0	0.25
08/10/04	0	T
08/11/04	0	T
08/12/04	0	0.05
08/13/04	0	0.14
08/14/04	0	0.00
08/15/04	0	0.00
08/16/04	0	T
08/17/04	0	0.00
08/18/04	0	0.10
08/19/04	0	0.00
08/20/04	0	0.00
08/21/04	0	0.00
08/22/04	0	0.00
08/23/04	0	T
08/24/04	0	0.00
08/25/04	0	0.33
08/26/04	0	0.04
08/27/04	0.005	0.62
08/28/04	0	0.00
08/29/04	0	0.07
08/30/04	0	T
08/31/04	0	T
09/01/04	0	0.02
09/02/04	0	0.00
09/03/04	0	T
09/04/04	0	0.00
09/05/04	0	0.00
09/06/04	0.002	0.34
09/07/04	0	0.00
09/08/04	0	0.04
09/09/04	0	0.00
09/10/04	0	T
09/11/04	0	0.00
09/12/04	0	0.00
09/13/04	0	0.00
09/14/04	0	0.00
09/15/04	0.002	0.00
09/16/04	0	0.38
09/17/04	0	0.00
09/18/04	0	0.00
09/19/04	0	0.00
09/20/04	0	0.00
09/21/04	0	0.00
09/22/04	0	0.00

drain tile site, flows in cfs

date	drain tile	Preciptation (in.)
09/23/04	0	0.00
09/24/04	0	0.00
09/25/04	0	0.00
09/26/04	0	0.00
09/27/04	0	0.00
09/28/04	0	0.10
09/29/04	0	0.00
09/30/04	0	0.00
10/01/04	0	T
10/02/04	0	0.16
10/03/04	0	T
10/04/04	0	0.00
10/05/04	0	0.00
10/06/04	0	0.00
10/07/04	0	T
10/08/04	0.005	0.97
10/09/04	0	0.02
10/10/04	0	0.00
10/11/04	0	0.00
10/12/04	0	T
10/13/04	0	0.00
10/14/04	0	T
10/15/04	0.002	0.02
10/16/04	0.003	0.22
10/17/04	0.002	0.16
10/18/04	0.003	T
10/19/04	0.002	T
10/20/04	0.002	T
10/21/04	0	T
10/22/04	0	0.00
10/23/04	0.022	0.75
10/24/04	0	0.03
10/25/04	0	0.02
10/26/04	0	0.00
10/27/04	0	0.15
10/28/04	0.035	T
10/29/04	0.02	1.02
10/30/04	0.002	0.12
10/31/04	0	T
11/01/04	0	0.00
11/02/04	0.002	0.27
11/03/04	0	T
11/04/04	0	0.00
11/05/04	0	0.00
11/06/04	0	0.02
11/07/04	0	0.00
11/08/04	0	0.00
11/09/04	0	0.00
11/10/04	0	0.00
11/11/04	0	0.00
11/12/04	0	0.15
11/13/04	0	0.00
11/14/04	0	0.00
11/15/04	0	0.00
11/16/04	0	0.08
11/17/04	0	0.08
11/18/04	0	0.01
11/19/04	0.003	T
11/20/04	0.01	0.00
11/21/04	0.002	0.65
11/22/04	0	0.00
11/23/04	0	0.00
11/24/04	0	0.00
11/25/04	0	0.00
11/26/04	0	T
11/27/04	0.032	0.00
11/28/04	0.042	0.53
11/29/04	0.01	0.50
11/30/04	0.005	0.00
12/01/04	0.003	
12/02/04	0.002	
12/03/04	0.002	
12/04/04	0.002	
12/05/04	0	
12/06/04	0.017	
12/07/04	0.137	
12/08/04	0.093	

drain tile flow in cfs, tp in mg/cu.meter

date	**flow**	**tp**
4/2/2004	0.13	192
4/6/2004	0.06	214
4/9/2004	0.03	152
4/19/2004	0.003	138
4/21/2004	0.024	253
4/23/2004	0.01	117
5/3/2004	0.08	100
5/4/2004	0.09	103
5/10/2004	0.214	247
5/13/2004	0.292	335
5/14/2004	0.268	460
5/20/2004	0.267	396
5/24/2004	0.617	396
6/1/2004	0.617	307
6/7/2004	0.283	280
6/9/2004	0.355	840
6/14/2004	0.33	519
6/17/2004	0.248	538
6/28/2004	0.016	211
7/6/2004	0.084	2250
7/19/2004	0.001	154
7/30/2004	0.003	5270
8/9/2004	0.0001	986
8/27/2004	0.0001	2580
9/7/2004	0.0001	1000
9/22/2004	0.0001	267
10/14/2004	0.0001	581
10/28/2004	0.0001	526

Draintile VAR=tp METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	203	14	14	7.8	.006	.009	-.230	.064
2	48	14	14	92.2	.304	.247	.263	.457
***	251	28	28	100.0	.063	.128		

FLOW STATISTICS

FLOW DURATION = 251.0 DAYS = .687 YEARS

MEAN FLOW RATE = .063 HM3/YR

TOTAL FLOW VOLUME = .04 HM3

FLOW DATE RANGE = 20040402 TO 20041208

SAMPLE DATE RANGE = 20040402 TO 20041028

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	16.1	23.4	.1705E+02	371.75	.176
2 Q WTD C	18.8	27.4	.1489E+02	434.64	.141
3 IJC	18.6	27.1	.1400E+02	430.53	.138
4 REG-1	19.9	29.0	.2274E+02	459.91	.165
5 REG-2	19.4	28.3	.2254E+02	449.40	.168
6 REG-3	24.2	35.1	.6144E+02	558.33	.223

Draintile VAR=tp METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	193	13	13	5.0	.004	.006	-.243	.089
2	19	5	5	8.3	.069	.079	-.256	.927
3	39	10	10	86.7	.351	.312	.048	.890
***	251	28	28	100.0	.063	.128		

FLOW STATISTICS
FLOW DURATION = 251.0 DAYS = .687 YEARS
MEAN FLOW RATE = .063 HM3/YR
TOTAL FLOW VOLUME = .04 HM3
FLOW DATE RANGE = 20040402 TO 20041208
SAMPLE DATE RANGE = 20040402 TO 20041028

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	17.7	25.8	.1774E+02	409.34	.163
2 Q WTD C	18.8	27.4	.1415E+02	435.39	.137
3 IJC	18.7	27.2	.1376E+02	431.37	.137
4 REG-1	19.1	27.8	.2230E+02	441.02	.170
5 REG-2	19.0	27.6	.2259E+02	438.23	.172
6 REG-3	20.2	29.3	.4735E+02	466.07	.235

Inlet site, flows in cfs

date	inlet
03/30/04	0.8129
03/31/04	1.9794
04/01/04	1.8315
04/02/04	1.6974
04/03/04	1.6103
04/04/04	1.4844
04/05/04	1.3114
04/06/04	1.3465
04/07/04	1.2684
04/08/04	1.3174
04/09/04	1.2136
04/10/04	1.1187
04/11/04	1.0334
04/12/04	0.9613
04/13/04	0.9091
04/14/04	0.8816
04/15/04	0.8421
04/16/04	0.8453
04/17/04	0.8686
04/18/04	0.8963
04/19/04	0.8973
04/20/04	0.9004
04/21/04	1.0591
04/22/04	0.9982
04/23/04	0.9245
04/24/04	0.863
04/25/04	1.0184
04/26/04	0.9852
04/27/04	0.9174
04/28/04	0.9103
04/29/04	0.8596
04/30/04	0.8209
05/01/04	0.7956
05/02/04	0.7219
05/03/04	0.6702
05/04/04	0.64
05/05/04	0.6288
05/06/04	0.6608
05/07/04	0.6305
05/08/04	1.6053
05/09/04	1.6431
05/10/04	1.5048
05/11/04	1.3472
05/12/04	1.337
05/13/04	1.6641
05/14/04	1.7439
05/15/04	1.6699
05/16/04	1.4801
05/17/04	1.3195

Inlet site, flows in cfs

date	inlet
05/18/04	1.2151
05/19/04	1.1348
05/20/04	1.6192
05/21/04	1.5638
05/22/04	1.8747
05/23/04	3.8229
05/24/04	5.7936
05/25/04	5.1124
05/26/04	3.4811
05/27/04	3.1217
05/28/04	2.741
05/29/04	2.4243
05/30/04	2.2097
05/31/04	2.7581
06/01/04	3.4678
06/02/04	3.4448
06/03/04	3.1467
06/04/04	2.8715
06/05/04	2.6181
06/06/04	2.3872
06/07/04	1.9915
06/08/04	1.6739
06/09/04	2.0826
06/10/04	2.191
06/11/04	2.4779
06/12/04	2.5272
06/13/04	2.4473
06/14/04	2.3601
06/15/04	2.1387
06/16/04	1.9265
06/17/04	2.1191
06/18/04	2.0073
06/19/04	1.8725
06/20/04	1.8278
06/21/04	1.7831
06/22/04	1.7384
06/23/04	1.6937
06/24/04	1.649
06/25/04	1.6043
06/26/04	1.5596
06/27/04	1.5149
06/28/04	1.4702
06/29/04	1.4255
06/30/04	1.3808
07/01/04	1.3361
07/02/04	1.2914
07/03/04	1.2467
07/04/04	1.202
07/05/04	1.1573

Inlet site, flows in cfs

date	inlet
07/06/04	1.1126
07/07/04	1.0679
07/08/04	1.0232
07/09/04	0.9785
07/10/04	0.9338
07/11/04	0.8891
07/12/04	0.8444
07/13/04	0.7997
07/14/04	0.755
07/15/04	0.7103
07/16/04	0.6656
07/17/04	0.6209
07/18/04	0.5762
07/19/04	0.5319
07/20/04	0.6529
07/21/04	0.6586
07/22/04	0.6527
07/23/04	0.6263
07/24/04	0.5936
07/25/04	0.5671
07/26/04	0.5608
07/27/04	0.5595
07/28/04	0.5446
07/29/04	0.559
07/30/04	0.6096
07/31/04	0.6184
08/01/04	0.6014
08/02/04	0.5985
08/03/04	0.5889
08/04/04	0.5606
08/05/04	0.5255
08/06/04	0.5048
08/07/04	0.4986
08/08/04	0.5076
08/09/04	0.5341
08/10/04	0.52
08/11/04	0.5004
08/12/04	0.4923
08/13/04	0.5064
08/14/04	0.5073
08/15/04	0.4981
08/16/04	0.499
08/17/04	0.5123
08/18/04	0.5362
08/19/04	0.5503
08/20/04	0.5316
08/21/04	0.5174
08/22/04	0.5033
08/23/04	0.4833

Inlet site, flows in cfs

date	inlet
08/24/04	0.505
08/25/04	0.5408
08/26/04	0.5519
08/27/04	0.6857
08/28/04	0.6364
08/29/04	0.6181
08/30/04	0.6167
08/31/04	0.6261
09/01/04	0.6173
09/02/04	0.6177
09/03/04	0.6083
09/04/04	0.5974
09/05/04	0.5864
09/06/04	0.6297
09/07/04	0.6158
09/08/04	0.5933
09/09/04	0.5802
09/10/04	0.5659
09/11/04	0.5542
09/12/04	0.5517
09/13/04	0.5456
09/14/04	0.5311
09/15/04	0.5719
09/16/04	0.5833
09/17/04	0.5662
09/18/04	0.5526
09/19/04	0.5179
09/20/04	0.4971
09/21/04	0.482
09/22/04	0.4635
09/23/04	0.4567
09/24/04	0.4487
09/25/04	0.5925
09/26/04	0.5972
09/27/04	0.5347
09/28/04	0.54
09/29/04	0.5426
09/30/04	0.5749
10/01/04	0.5285
10/02/04	0.503
10/03/04	0.5297
10/04/04	0.5818
10/05/04	0.4622
10/06/04	0.4419
10/07/04	0.4361
10/08/04	0.6628
10/09/04	0.8742
10/10/04	0.8102
10/11/04	0.8831

Inlet site, flows in cfs

date	inlet
10/12/04	0.7714
10/13/04	0.7964
10/14/04	0.7252
10/15/04	0.6704
10/16/04	0.6963
10/17/04	0.6772
10/18/04	0.6623
10/19/04	0.6004
10/20/04	0.5549
10/21/04	0.5529
10/22/04	0.5928
10/23/04	0.7157
10/24/04	0.6317
10/25/04	0.5828
10/26/04	0.5117
10/27/04	0.5145
10/28/04	0.6578
10/29/04	0.9007
10/30/04	0.8026
10/31/04	0.7047
11/01/04	0.6919
11/02/04	0.7275
11/03/04	0.7436
11/04/04	0.7383
11/05/04	0.6798
11/06/04	0.6489
11/07/04	0.626
11/08/04	0.588
11/09/04	0.5847
11/10/04	0.5639
11/11/04	0.5556
11/12/04	0.5516
11/13/04	0.5477
11/14/04	0.5398
11/15/04	0.5411
11/16/04	0.5491
11/17/04	0.5666
11/18/04	0.5694
11/19/04	0.6125
11/20/04	0.7486
11/21/04	0.6905
11/22/04	0.6657
11/23/04	0.6441
11/24/04	0.6151
11/25/04	0.5894
11/26/04	0.592
11/27/04	0.8045
11/28/04	0.9479
11/29/04	0.8789

Inlet site, flows in cfs

date	inlet
11/30/04	0.838
12/01/04	0.7951
12/02/04	0.7645
12/03/04	0.718
12/04/04	0.6973
12/05/04	0.6883
12/06/04	0.8544
12/07/04	1.1758
12/08/04	1.3904

Inlet site, flows in cfs

date	flow	tp
04/02/04	1.35	25
04/06/04	1.39	23
04/09/04	1.24	19
04/19/04	0.94	25
04/21/04	1.09	21
04/23/04	0.93	16
05/03/04	0.67	13
05/04/04	0.64	14
05/10/04	1.52	23
05/13/04	1.61	19
05/14/04	1.86	24
05/20/04	1.6	28
05/24/04	1.48	48
06/01/04	1.13	18
06/07/04	1.92	18
06/09/04	2.12	47
06/10/04	2.19	48
06/14/04	2.37	21
06/17/04	2.17	28
06/28/04	1.41	29
07/06/04	1.09	61
07/19/04	0.66	26
07/30/04	0.63	42
08/09/04	0.53	25
08/27/04	0.67	26
09/07/04	0.61	40
09/22/04	0.47	25
10/14/04	0.83	25
10/28/04	0.58	29

East Alaska Inlet VAR=tp METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	253	29	29	100.0	.922	1.100	.103	.502
***	253	29	29	100.0	.922	1.100		

FLOW STATISTICS

FLOW DURATION = 253.0 DAYS = .693 YEARS

MEAN FLOW RATE = .922 HM3/YR

TOTAL FLOW VOLUME = .64 HM3

FLOW DATE RANGE = 20040331 TO 20041208

SAMPLE DATE RANGE = 20040402 TO 20041028

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	21.8	31.4	.1700E+02	34.10	.131
2 Q WTD C	18.2	26.3	.5296E+01	28.57	.087
3 IJC	18.3	26.4	.5384E+01	28.60	.088
4 REG-1	17.9	25.9	.4373E+01	28.05	.081
5 REG-2	18.2	26.3	.5368E+01	28.52	.088
6 REG-3	17.9	25.8	.4420E+01	28.03	.081

East Alaska Inlet VAR=tp METHOD= 2 Q WTD C

COMPARISON OF SAMPLED AND TOTAL FLOW DISTRIBUTIONS

STR	NQ	NC	NE	VOL%	TOTAL FLOW	SAMPLED FLOW	C/Q SLOPE	SIGNIF
1	178	12	12	44.9	.588	.608	-.456	.414
2	75	17	17	55.1	1.714	1.448	.157	.697
***	253	29	29	100.0	.922	1.100		

FLOW STATISTICS
FLOW DURATION = 253.0 DAYS = .693 YEARS
MEAN FLOW RATE = .922 HM3/YR
TOTAL FLOW VOLUME = .64 HM3
FLOW DATE RANGE = 20040331 TO 20041208
SAMPLE DATE RANGE = 20040402 TO 20041028

METHOD	MASS (KG)	FLUX (KG/YR)	FLUX VARIANCE	CONC (PPB)	CV
1 AV LOAD	16.2	23.4	.3757E+01	25.40	.083
2 Q WTD C	17.6	25.4	.3615E+01	27.55	.075
3 IJC	17.6	25.4	.3630E+01	27.54	.075
4 REG-1	18.0	26.0	.6140E+01	28.16	.095
5 REG-2	18.1	26.1	.8453E+01	28.34	.111
6 REG-3	18.0	26.0	.5132E+01	28.22	.087

C

APPENDIX C

Public Participation Materials

East Alaska Lake Alum Treatment Feasibility Study
Update – February 2005

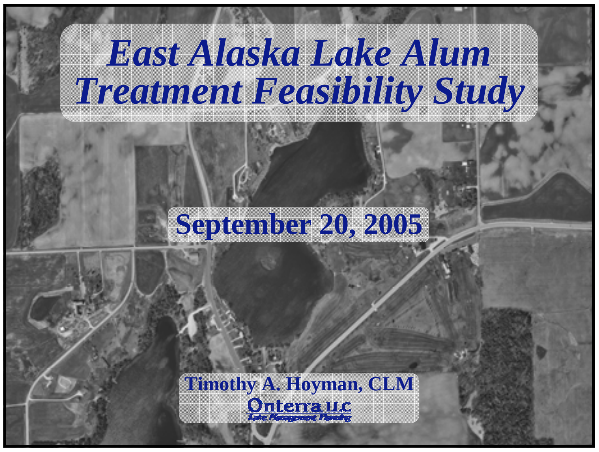
The East Alaska Lake Alum Treatment Feasibility Study is moving along on schedule and in fact, better than planned. All field studies have been completed and the monitoring of the two inlets was actually extended by a few weeks. The ability to extend the field season by just a few short weeks is fortunate because it increases the accuracy of the model, especially concerning the flow data. The next step in the process is to compile three sets of data that will be used in FLUX, the model that will calculate the phosphorus loading estimates for each tributary. Data required includes; average daily flows, phosphorus concentrations of periodic water samples collected at the inlets, and instantaneous flows corresponding to when the water samples were collected. Once these data are compiled and verified with information collected in the field, they will be entered into the model and the estimated loads will be calculated. Furthermore, water quality data collected from the lake will be used to estimate the extent of internal loading within the lake.

Concentration? Flow? Loading? What the…?

Let's say you are on a diet that requires you to count calories, but the only information you keep track of is the calories that each food contains. You know that 10 ounces of steak contains 250 calories, but you do not keep track of how much steak you eat. Without knowing your intake, you cannot truly count your calories. Measuring the concentration of phosphorus without knowing the volume of water entering the system is very much the same. Without both pieces of information, you cannot determine the load of phosphorus entering the lake.

Combining the external loading and internal loading estimates with known lake concentrations of phosphorus will lead to a much clearer understanding of nutrient cycling within East Alaska Lake. If we find there is much more phosphorus in the lake than can be accounted for from the inlets and internal loading, we will then know there must be other sources of phosphorus entering the lake. Examples may include lakeshore septic systems, direct runoff from shoreland properties, or a hidden draintile. In any case, further investigation may be required.

In the end, the study will determine if an alum treatment is feasible to reduce internal phosphorus loading within the lake or if additional steps should be taken to further reduce external loads. These steps could include further investigations to discover unaccounted phosphorus sources, installation of agricultural best management practices, or the creation of a detention basin. The results of the study, along with the options available to the Tri-Lakes Association, will be discussed at a meeting this spring.



East Alaska Lake Alum Treatment Feasibility Study

September 20, 2005

Timothy A. Hoyman, CLM
Onterra LLC
Lake Management Planning

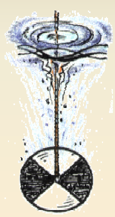
Presentation Outline

- Project Background
- Project Objectives
- Phosphorus & Lakes
- Results and Discussion
- Recommendations

East Alaska Lake

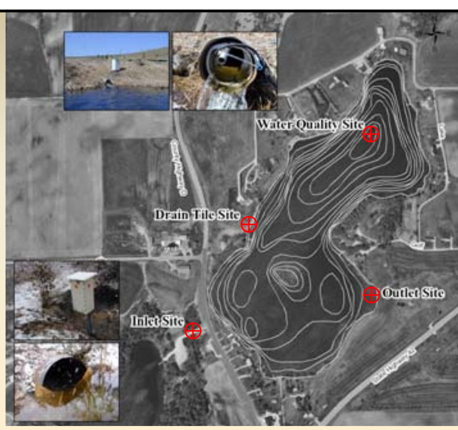
Lake Management Planning Grant Report (1999)

- **Project Findings**
  - *Lake can be highly eutrophic*
  - *Nuisance Algal Blooms*
  - *Historic phosphorus inputs are still causing water quality problems in lake.*
- **Recommendation**
  - *Investigate feasibility of alum treatment.*



Project Objectives

- Investigate Internal Phosphorus Loadings
  - Phosphorus Concentrations
  - Temperature and Dissolved Oxygen Profiles
- Investigate Phosphorus Loads from Tributaries
  - Continuous Flow Monitoring
  - Grab Samples for Phosphorus Analysis



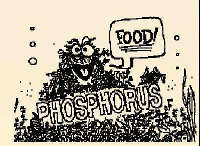
Phosphorus & Lakes

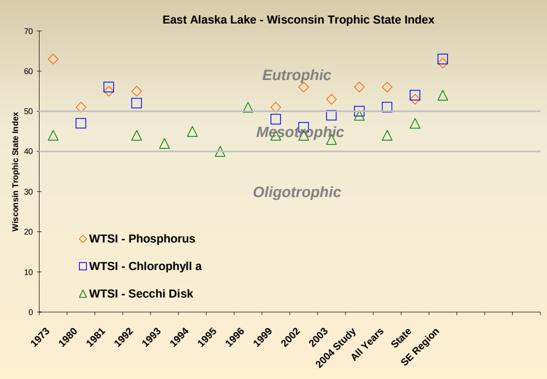
Water Quality

↑ Phosphorus (Limiting Plant Nutrient)

↑ Chlorophyll-*a* (Algal Abundance)

↓ Water Clarity (Secchi Disk)





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Sources of Phosphorus

- **External Sources**
  - *Surface Runoff*
  - *Groundwater*
  - *Precipitation*
  - *Agricultural Drain Tiles*
  - *Faulty Septic Systems*
  - *Lawn Runoff*
- **Internal Loading**

May be a significant source of phosphorus driving algae and other plant growth even after external source are minimized.

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Phosphorus Inactivation

- **Aluminum Sulfate Addition**
  - *Forms aluminum hydroxide floc*
  - *Floc settles to the bottom of lake "dragging" phosphorus with it.*
  - *Floc forms barrier to sediment phosphorus release.*

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Internal Phosphorus Loading

- **Water Quality Monitoring**
  - *High Volumes of Anoxic Water*
  - *High Concentrations of Phosphorus*

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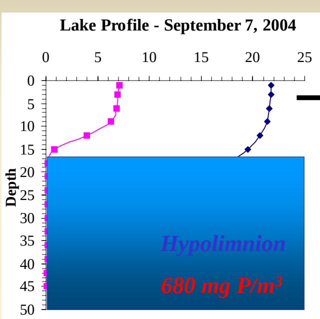
Internal Phosphorus Loading



26 mg P/m³

Fall Turnover

91 mg P/m³ Chlorophyll up 235%

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Internal Phosphorus Loading

- **Water Quality Monitoring**
  - *High Volumes of Anoxic Water*
  - *High Concentrations of Phosphorus*
- **Internal Load Estimation**
  - *Modeling Result: 131 kg/year*
- **Treat internal load as sole source (Scenario 3)**
  - **Secchi = 3.8 feet (poor)**

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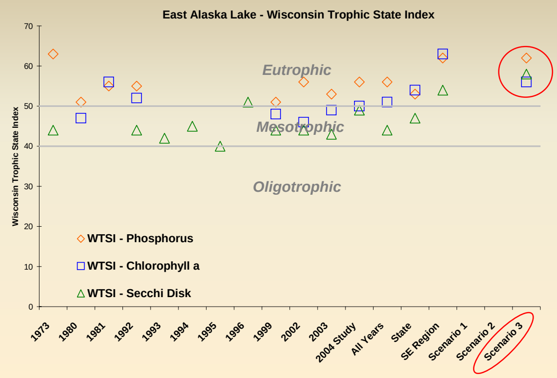


Results & Discussion

Internal Phosphorus Loading

- **Water Quality Monitoring**
  - *High Volumes of Anoxic Water*
  - *High Concentrations of Phosphorus*
- **Internal Load Estimation**
  - *Modeling Result: 131 kg/year*
- **Treat internal load as sole source (Scenario 3)**
  - **Secchi = 3.8 feet (poor)**

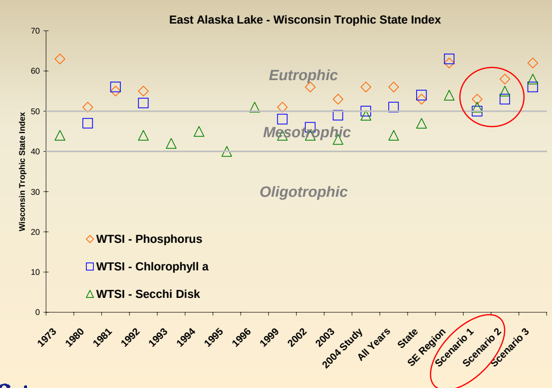
YES!

YES!

Results & Discussion

Tributary Loading

	Inlet	Drain Tile
Est. Phos. Load (kg/yr)	25.4	27.4
Est. Flow (m^3/yr)	922,000	63,000
Flow-weighted Phos. Concentration mg/m^3	276	435



Results & Discussion

Tributary Loading

	Inlet	Drain Tile
Est. Phos. Load (kg/yr)	25.4	27.4
Est. Flow (m^3/yr)	922,000	63,000
Flow-weighted Phos. Concentration mg/m^3	276	435
Phos. Levels after Removing Source From Current Model	↑	↓

Recommendations

- **Do Not Perform Alum Treatment at this Time**
- **Detention Basin Construction**

Recommendations

- **Do Not Perform Alum Treatment at this Time**
- **Detention Basin Construction**
  - *Treat water and reduce phosphorus concentrations of drain tile outputs.*
  - *Increase wildlife habitat.*
- **Septic System Inspections**
  - *Many have been inspected & updated.*
  - *Remaining should follow suit.*

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Lake Management Planning

Thank You

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