East Alaska Lake
Kewaunee County, Wisconsin
Lake Management Plan Addendum
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Created by: Tim Hoyman
Onterra, LLC
De Pere, WI

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Tri-Lakes Association

Patrick Robinson
William Iwen

Wisconsin Dept. of Natural Resources

Mary Gansberg
Paul Garrison

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1.0 INTRODUCTION

East Alaska Lake is a 53-acre drainage lake located less than 1.5 miles from the shores of Lake Michigan in Kewaunee County, WI. The lake has a maximum depth of 50 feet and an average depth of 17 feet. East Alaska Lake was added to Wisconsin's list of impaired waters (303(d)) in 1998 for mercury from atmospheric deposition.

A comprehensive management plan was developed for East Alaska Lake (Map 1) in 1999 (NES 1999). The planning project 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 surveys. The management plan contained several recommendations to improve and protect the lake; including future monitoring needs, work within the lake's watershed aimed at reducing nutrient loads to the lake, and preservation of environmentally sensitive areas.

East Alaska Lake's plan also discusses the lake's potentially high rate of internal phosphorus loading and the use of alum (aluminum sulfate, $Al_2(SO4)_3$) to reduce it. However, the plan recommends that a diagnostic/feasibility study be completed to determine if an alum treatment is the appropriate next step for the lake's management. In the end, while the report obviously supports an investigation regarding the use of an alum treatment, it stops short of recommending it as a part of the actual management plan for the lake.

It is the objective of this document to fulfill the management planning requirements in regards to completing an alum treatment on East Alaska Lake. The sections below contain an updated water quality assessment for the lake, an introduction to the use of alum in lakes to reduce internal nutrient loading, a description of the public's participation in approving the plan, and an implementation plan outlining the steps needed to construct a specific alum treatment plan for East Alaska Lake.

2.0 EAST ALASKA LAKE WATER QUALITY

In 2005, a project to determine the feasibility of using alum for phosphorus inactivation on East Alaska Lake was completed (Onterra 2005). The project focused efforts on determining phosphorus levels entering the lake from its two primary sources, the lake's inlet entering from West Alaska Lake, and an agricultural draintile entering the lake at its west shore. The project also included specific water quality data collection used in modeling of the lake's suspected internal nutrient load.

The results of the 2005 project indicated that while both external sources provide phosphorus to East Alaska Lake, the load originating from the draintile was found to be much more significant in the lake's phosphorus budget than that of the inlet. Essentially, the phosphorus loads from each source were about the same at 17.6 kg (inlet) and 18.8 kg (draintile) during the study period. The annual estimates were also similar at 25.4 and 27.4 kg, respectively. However, to understand each source's contribution to the phosphorus budget of East Alaska Lake, we must also consider the accompanying volume of water each source contributes to the lake. During the study period, the inlet delivered 16 times more water than the draintile (922,000 m^3/yr vs. 63,000 m^3/yr), which of course means that the inlet is contributing much more to the flushing rate of the lake leading to less impact to the lake's production through the inlet's phosphorus contribution.

Phosphorus inputs through internal loading were also found to be significant by the 2005 study. The modeling procedure resulted in an annual load of 131 kg to the lake's phosphorus budget. Further modeling showed that while this estimated load was surely an exaggeration, it was still a considerable indication that significant internal cycling of phosphorus may be occurring in East Alaska Lake. Unfortunately, that modeling procedure was not able to predict an accurate estimate of internal loading to East Alaska Lake or make a determination of how the lake might be improved by reducing the internal load.

In the end, the 2005 report stated that completing an alum treatment would be premature at that time due to the possibility of continued septic system issues around the lake and the high load originating from the draintile. The report went on to recommend septic system inspections around the lake and the construction of a sedimentation basin to treat incoming water from the draintile outfall before it reaches the lake.

The Tri-Lakes Association (TLA) followed through on the recommendations stated in the 2005 report and in 2006, with assistance from Kewaunee County and the US Fish and Wildlife Service, completed construction of an approximate 1-acre sedimentation basin on the lake's west shore to treat water entering the lake from the agricultural draintile. Further, in 2007 the TLA initiated the inspection of all private onsite wastewater treatment systems (POWTS) around the lake. The inspections resulted in 11 corrective actions.

Figures 2.0-1 – 2.0-3 contain historical and recent water quality data collected from East Alaska Lake over the last four decades. A detailed introduction to lake water quality data can be found in Onterra 2005.

The Wisconsin 2010 Consolidated Assessment and Listing Methodology (WisCALM), created by the WDNR, is a process by which the general condition of Wisconsin surface waters are assessed to determine if they meet federal requirements under the Clean Water Act. It is also very useful in helping lake stakeholders understand the health of their lake compared to others within the state. This method incorporates both biological and physical-chemical indicators to assess a given waterbody's condition. One of the assessment methods utilized is Carlson's Trophic State Index (TSI). The WisCALM assessment prioritizes the use of chlorophyll-*a* to calculate TSI values as this is a direct measure of lake productivity. However, if these data are not available, TSI values may be calculated using Secchi disk transparencies.

Once the TSI value has been calculated for a given waterbody, it can be compared to threshold TSI values established for different lake classification categories (Table 2.0-1). Thresholds were established for different lake types because these lakes differ naturally in their nutrient concentrations and natural communities. This allows the trophic state of a given lake to be compared to other lakes in the state with similar morphology and water regimes.

For this assessment, the lakes are classified into two main groups: *shallow (mixed)*, and *deep (stratified)* lakes. Shallow lakes tend to not strongly stratify during the growing season, remain well-oxygenated, and may support aquatic plant growth across most of the lake. Deep lakes tend to stratify during the growing season and have the potential to have low oxygen levels in the bottom layer of water. Aquatic plants are usually restricted to the shallower areas around the perimeter of the lake. The lakes are further divided into classifications based on their hydrology and watershed size:

> **Seepage Lakes** have no surface water inflow or outflow in the form of rivers and/or streams.
>
> **Drainage Lakes** have surface water inflow and/or outflow in the form of rivers and/or streams.
>
> > *Headwater drainage* lakes have a watershed of less than 4 square miles.
> >
> > *Lowland drainage* lakes have a watershed of greater than 4 square miles.

Table 2.0-1. Trophic State Index (TSI) Thresholds for Wisconsin lake classifications. Adapted from WDNR PUB WT- 913 2009.

Condition Level	Shallow (Mixed)			Deep Stratified		
	Drainage			Drainage		
	Headwater	Lowland	Seepage	Headwater	Lowland	Seepage
Excellent	< 53	< 53	< 45	< 48	< 47	< 43
Good	53-61	53-61	45-57	48-55	47-54	43-52
Fair	62-70	62-70	58-70	56-62	55-62	53-62
Poor	≥ 71	≥ 71	≥ 71	≥ 63	≥ 63	≥ 63

East Alaska Lake is considered a deep stratified, headwater drainage lake within the WisCALM classification system. The condition levels found in Table 2.0-1 are also indicated on Figures 2.0-1 – 2.0-3. Please note that the sparse data available for East Alaska did not truly fulfill the standards used during normal WisCALM analysis; therefore, comparisons with that classification scheme should be taken in that light and not held as absolute.

Total phosphorus data has been collected sporadically from East Alaska Lake since the early 1970's. Mean surface value data collected during the growing season months (April – October) and summer months (June – August) can be found in Figure 2.0-1. Total phosphorus data prior to 2002 is limited with each year only containing 1 or 2 sampling events during the summer and/or growing season months. After 2002, the data consistency is better with the exception 2005 and 2006, which again only contain one or two sample events. Overall, the mean surface values are better than those found in the Southeast Region and most would be considered as "Good" to "Fair" based upon WisCALM classifications.

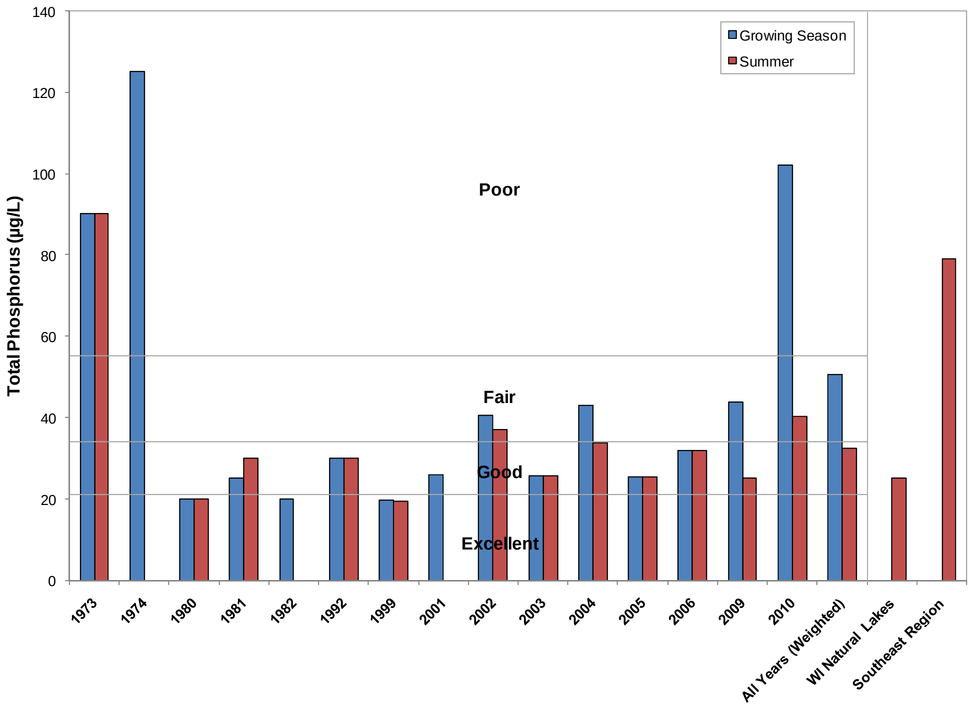

Figure 2.0-1. East Alaska Lake, regional, and state surface total phosphorus concentrations. Mean values calculated with growing season and summer month surface sample data collected at the lake's deep hole. WisCALM narrative classifications from WDNR (2009). State and regional mean values from Lillie and Mason (1983).

The 2009 and 2010 means were determined with data collected by WDNR Water Resource Management Specialist, Mary Gansberg. During both of these years, Ms. Gansberg collected seven samples during the growing season and three during the summer months. While the data were collected in a similar fashion and only one-year apart, they are obviously quite different. Based upon information provided by Paul Garrison, WDNR, the higher concentrations of phosphorus found during 2010 are likely due to increased runoff resulting in greater precipitation rates in 2010 compared to 2009. In fact, climatic data compiled by Garrison from the National Oceanic and Atmospheric Administration station in Green Bay indicates the total rainfall during April-October, 2009 was 19.2 inches while in 2010 the rainfall during the same period was 32.9 inches. This increased rainfall is likely responsible for the elevated phosphorus levels measured in East Alaska Lake during 2010 and is also an indicator that external sources can still have a significant impact on the lake's phosphorus budget.

Summer and growing season chlorophyll-*a* mean values calculated with surface samples from East Alaska Lake can be found in Figure 2.0-2. As with the phosphorus data, the chlorophyll-*a* data are sporadic and with the exception of the 2009 and 2010 data, are composed of one or two samples throughout the growing season. Still, the data available indicates that East Alaska Lake's values are lower than those found in other Southeast Region lakes and primarily remain within the WisCALM range of "Good" and "Fair". Further, due to the direct relationship between phosphorus concentrations and those of chlorophyll-*a*, the values in Figure 2.0-2 closely mimic those in Figure 2.0-1.

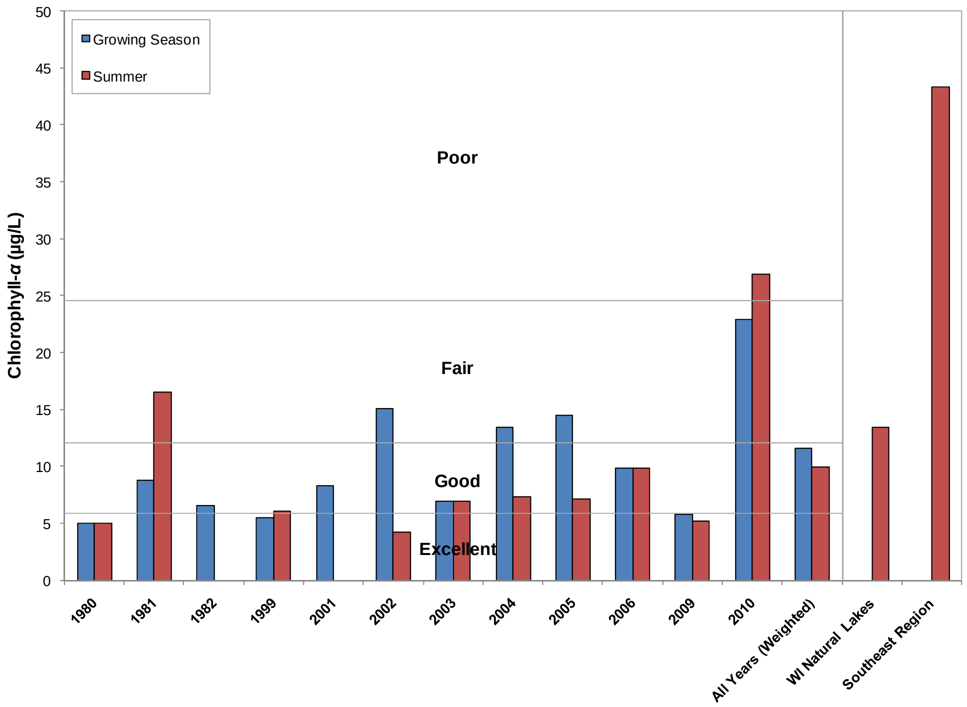

Figure 2.0-2. East Alaska Lake, regional, and state chlorophyll-*a* concentrations. Mean values calculated with growing season and summer month surface sample data collected at the lake's deep hole. WisCALM narrative classifications from WDNR (2009). State and regional mean values from Lillie and Mason (1983).

Secchi disk transparency values have been collected on East Alaska Lake since the early 1990's. Like the phosphorus and chlorophyll-*a* values, transparency fluctuates greatly within East Alaska Lake over the dataset, with some means being calculated with only a single reading. For instance, 1995, 1996, and 2001 only have a single reading each. Since 2002, the data has been collected consistently over the growing season. Within that six year period, only 2005 and 2010 showed transparency levels that would not be considered as "Good" or "Excellent" within WisCALM. Further, all values were higher than Southeast Region averages and many were near or higher than state natural lake averages.

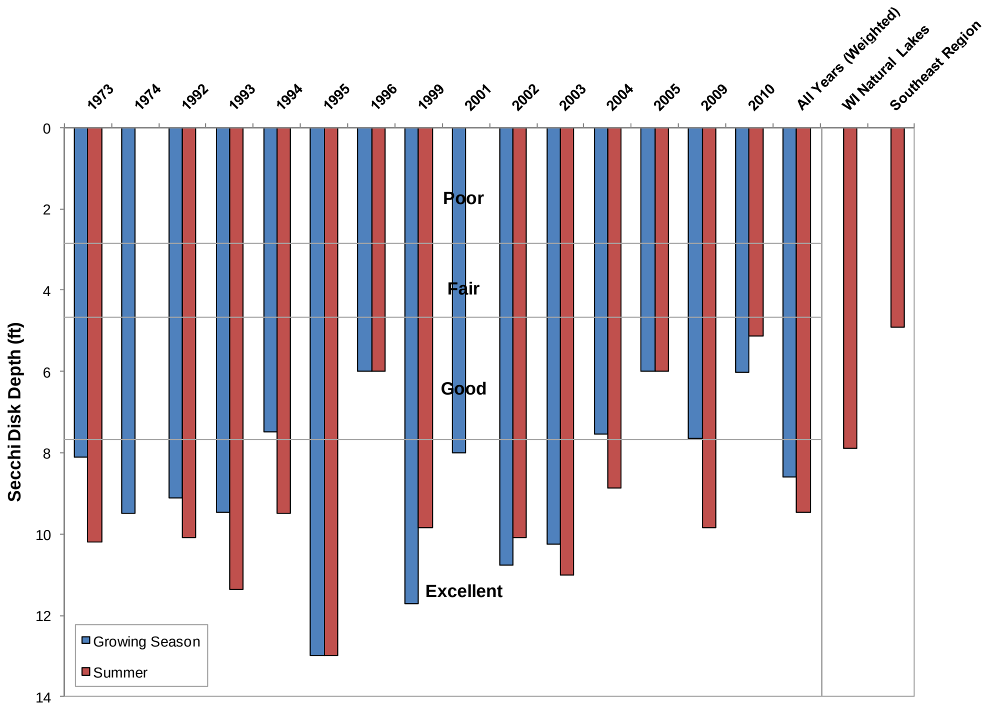

Figure 2.0-3. East Alaska Lake, regional, and state Secchi disk clarity values. Mean values calculated with growing season and summer month sample data collected at the lake's deep hole. WisCALM narrative classifications from WDNR (2009). State and regional mean values from Lillie and Mason (1983).

Overall, East Alaska Lake's water quality is relatively good, especially when compared to other lakes in the Southeast Region as described in Lillie and Mason (1983). Still, a great deal of evidence points to internal nutrient loading as being a significant contributor to the lake's annual phosphorus budget. Some of the most compelling evidence is that of hypolimnetic phosphorus concentrations (Figure 2.0-4). In a personal communication with John Panuska, who at the time was conducting lake and watershed research for the WDNR, Dr. Panuska stated that lakes exhibiting hypolimnetic phosphorus levels of 500 µg/l or greater were sure to have significant levels of internal loading and lakes with concentrations of 300 µg/l or greater where highly suspect. Over the course of the sporadic dataset displayed in Figure 2.0-4, the average growing season phosphorus concentration is 503 µg/l and the summer mean is 606 µg/l. The highest values were collected in the late summer and early fall of 2010 and ranged between 1380 and 1810 µg/l.

While the hypolimnetic phosphorus concentrations in East Alaska Lake are incredibly high, it is not absolutely clear if phosphorus from the hypolimnion is entrained to the epilimnion, especially during the mid summer, where it would fuel algae growth. Based upon the data above, it is clear that spring turnover phosphorus concentrations may be elevated within the water column as hypolimnetic water is mixed throughout the lake. Further, it is likely that these high spring values carry into the summer and fuel algal growth; however, the extent of this carryover has not been well-documented. Nor has the continued entrainment of hypolimnetic phosphorus to the epilimnion during the summer months, which to occur, would require periodic lake mixing during those months. These periodic mixing events may not occur in relatively small, but deep lakes like East Alaska.

Osgood (1988) created an index, which is useful in determining the likelihood of periodic summer mixing in stratified lakes. The Osgood Index uses a ratio of mean depth to square root of lake surface area (mean depth (meters) divided by the square root of lake surface area (square kilometers)). Lakes with ratios exceeding 8 were strongly stratified and exhibit little chance of destratification during summer months, which in turn prevented transport of hypolimnetic phosphorus to the epilimnion. Using East Alaska Lake's mean depth of 17 feet (5.2 m) and surface area of 53 acres (.214 km^2), an Osgood Index of 11 is calculated indicating the lake's strong resistance to summer destratification. Further, if we look simply at the southern basin of the lake, which has two moderately deep holes of 20 feet each, the Osgood Index is still high at 10 (mean depth = 3.2 m, surface area = .103 km^2). This analysis may indicate that while East Alaska Lake may have incredibly high hypolimnetic phosphorus values as shown in Figure 2.0-4, only a portion of that phosphorus may be transported to the epiliminion where it could be utilized by algae during the summer months. Still, the high hypolimnetic phosphorus concentrations may impact surface concentrations during and after seasonal mixing events. In the case of spring turnover, those elevated phosphorus concentrations may sustain higher levels during the remainder of the growing season.

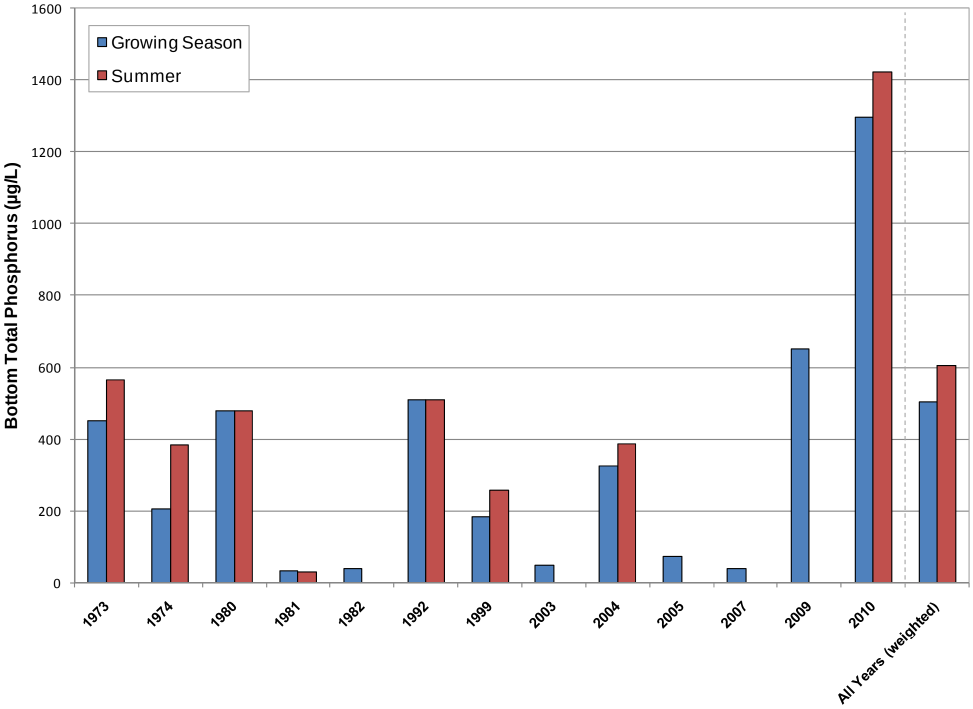

Figure 2.0-4. East Alaska Lake near-bottom total phosphorus concentrations. Mean values calculated with growing season and summer month bottom sample data collected at the lake's deep hole.

During the summer of 2010, WDNR staff members Paul Garrison and Mary Gansberg collected sediment cores from 8 sites throughout East Alaska Lake (Map 1). The cores were analyzed by

Bill James of the US Army Corps of Engineers for different fractions of sediment phosphorus (Table 2.0-2).

Table 2.0-2. East Alaska Lake sediment core analysis results. Sediment textural characteristics, biologically labile phosphorus fraction concentrations and rates of phosphorus release under anoxic conditions. LOI = loss-on-ignition organic matter content, Loose-P = loosely-bound phosphorus, Fe-P = iron-bound phosphorus, Redox-P = sum of loose-P and Fe-P, LOP = labile organic phosphorus.

Site	Depth (ft)	Depth (m)	Moisture (%)	Bulk Density (g/cm^3)	LOI (%)	Loose-P (mg/g)	Fe-P (mg/g)	Redox-P (mg/g)	LOP (mg/g)	P release ($mg/m^2/d^1$)
1	49.7	15.1	94.056	1.038	27.4%	0.239	0.077	0.316	0.159	11.5
2	26.3	8.0	93.126	1.044	29.9%	0.154	0.070	0.224	0.161	2.1
3	38.5	11.7	93.759	1.040	27.7%	0.060	0.016	0.076	0.033	2.5
4	20.3	6.2	95.709	1.027	43.6%	0.166	0.084	0.250	0.226	1.3
5	20.0	6.1	90.558	1.062	27.8%	0.194	0.045	0.239	0.090	0.7
6	12.8	3.9	93.675	1.040	36.0%	0.184	0.048	0.232	0.100	1.3
7	16.1	4.9	92.434	1.049	32.2%	0.170	0.051	0.221	0.130	0.9
8	23.1	7.0	90.223	1.064	25.3%	0.196	0.036	0.232	0.115	3.9
Average			92.943	1.045	31.2%	0.170	0.053	0.224	0.127	3.0

The core analysis results indicate that under anaerobic conditions, all of the site will release phosphorus to the overlaying water. The sediments from the northern basin have the greatest release rates, yet the sites in the southern basin also exhibit significant release. The alum treatment, if completed, would target two fractions of phosphorus found within the sediment; loose-P, and Fe-P. Loose-P is essentially phosphorus that is loosely bound to other chemicals or particulate matter. Fe-P is iron-bound phosphorus. As mentioned above, iron, in the presence of oxygen, will bind phosphorus, but in anoxic conditions, it releases it. Together, these two phosphorus fractions are considered Redox-P, or the phosphorus fraction that is susceptible to being released from the sediment into overlaying waters during anoxia.

An annual internal phosphorus load can be calculated by multiplying a site's release rate by the number of days the site is anoxic and then multiplying that product by the sediment surface area. To estimate the annual internal load in East Alaska Lake, the lake was split into a north and south basin. The north basin included sediment core sites 1-4 and 8. The southern basin included sites 5-7. The release rates for each basin were averaged to represent the basin as a whole (north basin: 4.3 $mg/m^2/d$, south basin: 1.0 $mg/m^2/d$). Using oxygen profiles collected in each basin during 2010, an average depth of anoxia (north basin: 13.4 feet, south basin: 8.2) and average number of days of anoxia (north basin: 184 d, south basin: 104 d) were estimated. The depth of anoxia for each basin was used to estimate area of bottom exposed to anoxic conditions (north basin: 13.4 ac, south basin 8.2 ac).

The analysis resulted in an annual internal load of phosphorus for the north and south basins of 39.2 kg and 3.3 kg, respectively. Therefore, based primarily on the sediment core phosphorus release analysis and profile data collected in 2010, East Alaska Lake's annual internal phosphorus load is estimated to be approximately 43 kg. Actually, this result is likely underestimating the annual load because it does not include the phosphorus that is released from the sediment during the winter months; however, sufficient data was not available to estimate that portion of the load accurately.

As detailed in the beginning of this section, the 2005 study, estimated phosphorus loads entering East Alaska Lake from its two primary external sources; the inlet entering from West Alaska

Lake and the draintile outfalling on the lake's west shore. The study also paired each load with a flow. Using those data in conjunction with an estimated amount of phosphorus and water entering from the atmosphere (6 kg phosphorus and 18,533 m^3 water), and the annual internal load estimated above, a total annual phosphorus load for East Alaska Lake can be estimated. That value can then be used as the basis for changes that may be seen in the lake as a result of a successful alum treatment (Table 2.0-3).

An average growing season surface total phosphorus value can be estimated by inputting the annual hydraulic and phosphorus loads to East Alaska Lake within model developed by Canfield and Bachmann (1981). The result of that modeling scenario calculates an average growing season phosphorus value of approximately 43 µg/l, which is slightly higher than the lake's actual May-September average from 2004-2010 of 37 µg/l (Table 2.0-3). As mentioned above and based upon the results of the Osmond Index calculations, it is likely that only a portion of the phosphorus released to the hypolimnion is actually mixed with waters from the upper layers of the lake where it can be utilized by algae (and would be reflected in the surface phosphorus samples). Therefore, in order to better model the actual surface phosphorus levels, only a portion of the internal load should be added to the model to determine the average surface value.

Reducing the internal load by 40% (25.8 kg) and rerunning the model, an average growing season surface phosphorus value of 37 µg/l is estimated (Table 2.0-3). Using predictive equations developed by Carlson (1977), average chlorophyll-*a* and Secchi disk transparency values can be estimated using the average growing season surface phosphorus value of 37 µg/l. The estimated value for chlorophyll-*a* (17 µg/l) is slightly higher than an average of 12 µg/l calculated with water samples collected at East Alaska Lake during the months of May-September, 2004-2010 (Table 2.0-3). Accounting for this difference is difficult; however, much of it may due to variance in the model and in-lake conditions, such as light availability, sample timing, phosphorus binding, etc.

Utilizing a similar predictive formula from Carlson (1977), an estimated average growing season Secchi disk transparency of 4.5 feet is calculated using the modeled phosphorus average of 37 µg/l. This value is much lower than the actual value of 8 feet measured during the months of May-September 2004-2010. Again, much of this difference can be attributed to error in the model because the relationships used to develop the model were largely based upon the assumption that the lakes were algae-dominated, which is not necessarily the case with East Alaska Lake. Further, we would expect a lower than actual Secchi disk value because a related equation resulted in a higher than actual chlorophyll-*a* value. Higher chlorophyll-*a* values indicate higher algal abundance which results in lower water transparency values.

Although there are obvious discrepancies between modeled values and those measured in East Alaska Lake, the modeling procedures can still shed light on how the lake may change following a successful alum treatment that would reduce the internal loading by 90% (Table 2.0-3). Using the proportional internal load value of 25.8 kg/yr, a 90% reduction would result in a post treatment annual internal load of approximately 2.6 kg. Inputting that figure within the Canfield Bachmann model results in an average phosphorus value of 29 µg/l. Using that value within Carlson's predictive equations results in an average chlorophyll-*a* value of 12 µg/l and an average Secchi disk value of 5.8 feet. In other words, a successful alum treatment may result in an increase in water clarity of nearly 1.5 feet. Considering the underestimation of the predictive models compared to in-lake average values, the actual results after an alum treatment may be greater.

Overall, it is likely that a successful alum treatment at East Alaska Lake would exhibit itself not by showing a dramatic increase in water clarity, year after year. Instead the positive results would be shown by decreased severity and frequency of the years considered "bad" by lake stakeholders.

Table 2.0-3. East Alaska Lake predictive modeling results. External phosphorus values are the sum of annual surface inputs (6 kg) and loads entering from the sources discussed in Onterra 2005 (inlet (25.4 kg) and draintile (27.4 kg)). Target growing season mean phosphorus for calibrating model is 2004-2010 May-September average of 37 µg/l. Predicted in-lake phosphorus estimated using equations from Bachmann & Canfield (1981). Secchi clarities and chlorophyll-*a* values predicted from phosphorus concentrations using equations from Carlson (1977).

	Annual Phosphorus Load (kg)			Predicted In-lake Growing Season Mean Values		
Scenario	**External**	**Internal**	**Total**	**Phosphorus (µg/l)**	**Secchi Clarity (ft)**	**Chlorophyll *a* (µg/l)**
East Alaska Lake Current Model (uncalibrated)	59	43	102	43	4.0	20
East Alaska Lake Calibrated: Current Less 40% of Internal Load	59	26	85	37	4.5	17
East Alaska Lake Calibrated Less 90% of Internal Load	59	3	62	29	5.8	12

3.0 USE OF ALUM TO REDUCE INTERNAL NUTRIENT LOADING IN LAKES

Internal Phosphorus Loading

Internal phosphorus loading, or recycling, occurs when phosphorus is released from a lake's bottom sediments into the overlaying water. Some of that released phosphorus is available for use by aquatic plants and as a result the phosphorus recycled into the lake's flora and fauna. However, this phenomenon occurs only under special circumstances.

When oxygen is present, iron, a common element in most lakes, binds phosphorus, making it biologically unavailable. However, without oxygen (anoxic conditions), iron is reduced and does not bind phosphorus. Further, if iron that is binding phosphorus is placed in an anoxic environment, it will release the phosphorus. In deep lakes that stratify strongly during the winter and summer (dimictic lakes), anoxic conditions often develop in the hypolimnion as the result of decomposition in the bottom sediments. The anoxic environment spurs iron reduction in the sediments, which in turn releases phosphorus into the overlaying water. At times, a great deal of phosphorus can build within the hypolimnion, as demonstrated within East Alaska Lake during the summer of 2010. The same phenomenon often occurs during winter stratification under the ice and when the ice thaws and turnover occurs, the phosphorus-rich bottom waters are mixed throughout the water column. The internally loaded phosphorus can spur algal growth well into the growing season.

A similar form of internal loading can occur in shallow lakes that stratify for short times and mix often throughout the open water season. In these polymictic lakes, there may be short periods of anoxia that spurs sediment phosphorus release several times of the course of the growing season. In these cases, phosphorus can be intermittently "pumped" into the lake fueling algal growth.

In both of these scenarios, the amount of phosphorus that is recycled back into the water column is dependent on numerous variables; for instance, sediment phosphorus levels, extent of anoxia (area of anoxic sediment surface), and duration of anoxia. Most lakes likely have some amount of internal nutrient loading that is a negligible fraction of the lake's annual phosphorus budget. In some lakes, internal nutrient loading may be a significant factor in the lake's annual budget, causing continued algae blooms and poor water quality long after external loading sources have been minimized. It is in lakes such as this that an alum treatment is appropriate.

Phosphorus Inactivation with Alum

The first alum treatment occurred in a Swedish lake in 1968. The first treatment of a lake in the US occurred in 1973 when Horseshoe Lake was treated in Wisconsin. Aluminum, iron, and calcium salts have been used for centuries for drinking water clarification. Aluminum, especially, is essential in today's wastewater and drinking water treatments (Cook et al. 1993).

The use of alum to inactivate sediment phosphorus involves the application of alum over areas of lake bottom determined to be releasing significant amounts of phosphorus. The alum is applied as a liquid and once in enters the water hydrolysis begins and through numerous steps, aluminum hydroxide ($Al(OH)_3$) is produced. As more $Al(OH)_3$ is created, a visible coagulant, or floc appears within the water column. As the floc increases in size and density, so does its mass and eventually it sinks to the bottom. Relatively quickly (within hours), the $Al(OH)_3$ binds with sediment phosphorus and forms a "blanket" that is integrated with the upper layer of the sediment, preventing further release phosphorus to the overlaying water. Unlike iron, aluminum continues to bind with phosphorus during anoxia.

Over time the $Al(OH)_3$ floc becomes buried in a new layer of sediment or all of the aluminum receptors are depleted. In either case the treatment loses its ability to retard sediment phosphorus release and the treatment effectiveness decreases. However, if dosed correctly and if external sources are minimized, the benefits of an alum treatment may last for 15 or more years in dimictic lakes (Welch and Cooke 1999).

While there are obviously great benefits to completing a successful alum treatment, there are risks that need to be considered. Dissolved aluminum is toxic to animals, including insects, fish, and humans. However, by controlling lake water pH, the risk is controlled. At pH levels between 5.5-9.0, insoluble (not dissolved) $Al(OH)_3$ is by far the most dominate form of aluminum. In fact, dissolved aluminum (Al^{3+}) does not form unless the pH is below 5. Still, other forms of soluble (dissolved) aluminum can form at pH levels between 4 and 6 and above 8; therefore, by maintaining pH levels between approximately 6 and 8, toxicity issues are avoided.

As mentioned above, once the alum is added to the lake, hydrolysis begins and $Al(OH)_3$ is formed. Hydrolysis is essentially the release of hydrogen ions (H^+) into the water. As hydrogen ions increase, the pH within the lake falls. In soft water lakes this can be a problem because as the alum is added the pH drops and as described above, once it decreases to 6 or less, toxicity can become an issue. In those lakes, aluminum sulfate may also be added to the lake as it buffers against hydrolysis and prevents the pH from falling.

Lakes with high alkalinities have natural buffering capacity against the addition of acids (hydrogen ions). The treatments of lakes with alkalinities above 75 mg/L as $CaCO_3$ are not expected to have chronic or acute effects to biota because the lake's natural buffering capacity would maintain the pH well above 6. In October 2010, East Alaska Lake's near-surface alkalinity was measured at 209 mg/L as $CaCO_3$, which falls in line with earlier measurements from near bottom collected in 1999 of 187 and 200 mg/L as $CaCO_3$. Overall, lowered pH levels and resulting toxicity should not be an issue on East Alaska Lake if a properly dosed and implemented alum treatment is completed.

Determining the correct dose of an alum treatment is the most difficult aspect of the technique. Completing a treatment at a lower dose than actually needed can cut the longevity of the treatment significantly and only provide a year or so of benefit to the lake. Still, dosing a lake higher than needed could lead to toxicity issues due to decreased pH levels and at the least, would be a waste of funds.

There are always risks in performing any type of lake manipulation, whether it be the addition of an aeration system to reduce winter anoxia, the diversion of an incoming stream to reduce phosphorus loading, the use of herbicides to control aquatic invasive species, or the completion of an alum treatment to minimize internal loading. In the case of East Alaska Lake, the primary risk of developing toxic levels of aluminum as the result of an alum treatment are greatly reduced by the lake's naturally high alkalinity. Correctly calculating and delivering the proper alum dose would bring that risk to essentially zero. If the treatment would work, the benefits of completing the treatment would definitely outweigh the potential risk to the lake's biota. Therefore, the greatest risk that would remain would be the squandering of public and private funds to complete an alum treatment that would not reduce the lake’s average growing season phosphorus concentration.

3.0 ACCEPTANCE OF PLAN

On April 4, 2011, a public information meeting was held at the Town of Peirce town hall to inform East Alaska Lake stakeholders about the possible alum treatment on East Alaska Lake. The meeting included a presentation by Tim Hoyman, Onterra, LLC and a question/answer period. It was attended by approximately 25 stakeholders and Mary Gansberg, Water Resource Specialist, WDNR. The event was advertised in the Kewaunee Star News twice prior to the meeting. Further, a Frequently Asked Questions (FAQ) document (Appendix A) was sent out to all property owners on the three lakes represented by the Tri-Lakes Association; East Alaska, West Alaska, and Krohns Lake.

Ultimately, this plan was accepted by the Tri-Lakes Association on April 25, 2011 by the Tri-Lakes Association Board of Directors. The acceptance is indicated by the project resolution included within the May 1, 2011 Lake Management Protection Grant application.

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4.0 IMPLEMENTATION PLAN

Management Goal 1: Minimize Internal Loading of Phosphorus within East Alaska Lake to reduce the frequency and/or severity of the summer algae blooms

Management Action: Complete alum treatment on East Alaska Lake.
Timeframe: Fall 2011 or spring 2012
Facilitator: Tri-Lakes Association Board of Directors
Potential Funding Source: WDNR Lake Management Protection Grant
Description: With the assistance of the WDNR, Onterra, and a qualified applicator, the Tri-Lakes Association will facilitate an alum treatment on East Alaska Lake. This treatment will be completed with proper planning and monitoring prior to, during, and following the treatment's completion.

The first step in facilitating the alum treatment will be to develop a specific alum treatment plan for East Alaska Lake. The East Alaska Lake Alum Treatment Plan would contain the following elements:

a. Summary of studies and events leading to the decision to treat East Alaska Lake with alum.
b. Methodology and results of sediment core analysis performed on bottom cores collected from East Alaska Lake during May 2010 by WDNR staff.
c. Alum dose recommendations determined through the sediment core analysis.
d. Anticipated results of alum treatment.
e. Specific alum treatment plan, including:
    i. Areas to be treated
    ii. Application timing
    iii. Final dose
    iv. Public notice items and responsibilities
    v. Application equipment specifications
    vi. Treatment day pH and other water quality monitoring
    vii. Post treatment water quality monitoring plan

Action Steps: See description above.
.

5.0 LITERATURE CITED

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

Canfield, D.E., and R.W. Bachmann. 1981. Prediction of total phosphorus concentration, chlorophyll-*a* and Secchi depths in natural and artificial lakes. Can. J. Fish. Aquat. Sci 38: 414-423.

Cooke, G.D., E.B. Welch, S.A. Peterson, and P.R. Newroth. 1993. Restoration and Management of Lake and Reservoirs, Second Edition. Lewis Publishers, Boca Raton, FL.

Lillie, R.A., and J.W. Mason. 1983. Limnological characteristics of Wisconsin lakes. Technical Bulletin No. 138. Wisconsin Department of Natural Resources.

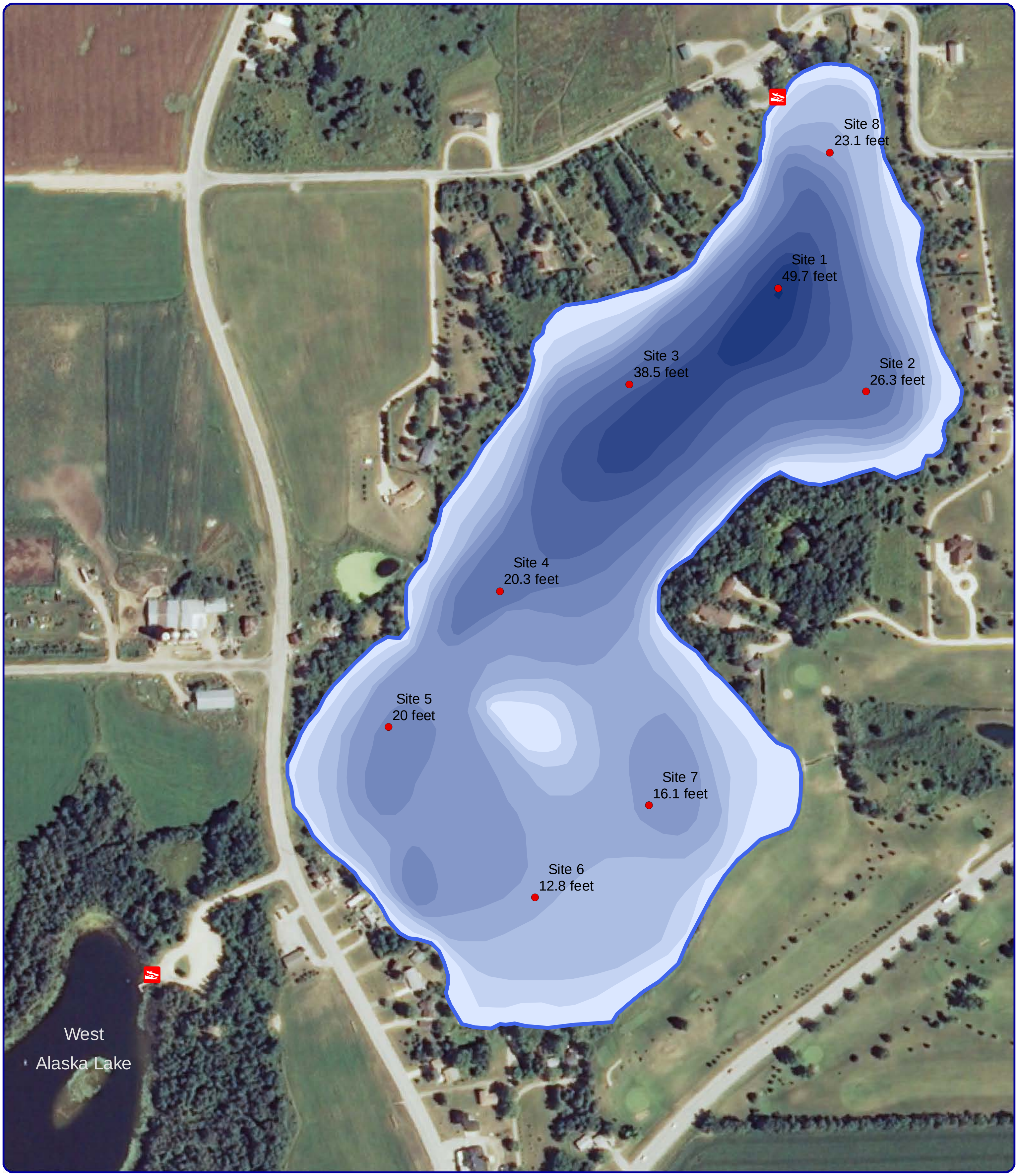
NES 1999. Lake Management Plan for East Alaska Lake, Kewaunee County, WI.

Onterra, LLC. 2005. East Alaska Lake, Kewaunee County, WI, Alum Treatment Feasibility Study.

Osgood, R.A. 1988. Lake mixis and internal phosphorus dynamics. Arch. Hydrobiol. 113:629-638.

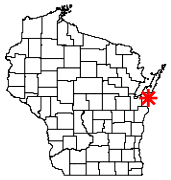
Welch, E.B. and G.D. Cooke. 1999 Effectiveness and longevity of phosphourus inactivation with alum. Lake Reserv. Manage. 15:324-331.

Wisconsin Dept. of Natural Resources. 2009. Wisconsin 2010 Consolidated Assessment and Listing Methodology (WisCALM). Clean Water Act Section 305b, 314, and 303(d) Integrated Reporting. 69pp.



Onterra LLC
Lake Management Planning
135 South Broadway Suite C
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads & Hydro: WDNR
Orthophotography: NAIP, 2005
Map date: February 10, 2011



Project Location in Wisconsin

Legend

- East Alaska Lake~ 50 acres
  WDNR Definition
- ● Sediment Core Sample Site

Map1

East Alaska Lake

Kewaunee County, Wisconsin

Sediment Core Sample Sites

A

APPENDIX A

Stakeholder Participation Materials

Planning Consultant Contact:
Tim Hoyman
Onterra, LLC
135 S. Broadway Suite C
De Pere, WI 54115
Voice: 920.338.8860
Fax: 920.338.8865
Email: thoyman@onterra-eco.com

Lake Group Contact:
Patrick Robinson
Tri-Lakes Association
Voice: 920.465.2175
Email: patrick.robinson@ces.uwex.edu
or
William Iwen
Tri-Lakes Association
Voice: 920.487.7215
Email: iwenwilliam22@gmail.com

Wisconsin DNR Contact:
Mary Gansberg
WI. Dept. of Natural Resources
2984 Shawano Ave.
Green Bay, WI 54307
Voice: 920.662.5489
Fax: 920.662.5413
Email: Mary.Gansberg@Wisconsin.gov

PRESS RELEASE

For Immediate Release

East Alaska Lake Receives State Grant to Complete Alum Treatment Plan

Town of Pierce, WI, January 19, 2010. In the late 1990's, a local group of citizens teamed with the Town of Pierce to study East Alaska Lake and develop a plan for improving the lake's water quality. The project was a result of citizen concerns about algae blooms and the overall health of the lake. The town was awarded a grant through the Wisconsin Department of Natural Resources to collect information about the lake's water, its plant population, and the areas that drain to the lake. The results of those first studies shed light on some of the lake's issues, especially those concerning algae blooms and poor water quality. Those studies found that the water quality problems the lake was facing did not necessarily arise from what was currently occurring around the lake, but more from what had occurred in the lake's history. The Tri-Lakes Association, a nonprofit organization formed in 2001 to help protect and restore East Alaska, West Alaska, and Krohns Lakes, has been working with many partners over the past decade to improve the health of East Alaska Lake.

East Alaska Lake receives much of it water through groundwater seepage, but it also depends on over land flow to maintain its levels as well. In the past, the lake has received nutrient-rich water from a variety of sources. These nutrient-rich waters can fuel algae blooms and lead to poor water quality. Early studies showed that the water that enters East Alaska Lake tends to remain in the lake for quite some time. In fact, if the lake was completely emptied, it would take about 4 years to refill. When a lake has a long water retention time, such as East Alaska Lake's, the basin acts as a nutrient sink and chemicals, such as phosphorus, that fuel algae and other aquatic plant growth, tend to build up in the lake's bottom sediments and can continue to cause problems into the future. This is exactly what is believed to be happening in East Alaska Lake. In other words, high levels of nutrients stored in the sediments from past sources are still impacting the lake to this day and causing periods of poor water quality.

Alum, or aluminum sulfate, can be used to help prevent "stored" phosphorus from continuing to impact a lake by capturing the phosphorus and sealing it in the sediment. Once the alum is applied, it binds with existing phosphorus and is completely used in the reaction. Alum has been safely used to treat many lakes in Wisconsin, including some located close by in Manitowoc County, and numerous lakes across the nation.

In August 2010, the Tri-Lakes Association successfully applied for a grant to help fund a project that will develop a plan for a potential alum treatment on East Alaska Lake. The project will include efforts to provide the public with information about the potential alum treatment and gather their input and thoughts related to the potential plan. A decision regarding whether or not to pursue an alum treatment for the lake will be made based upon the public comments received and the outcomes of the plan.

Feb 12, 2011 Kewaunee Star News

Feb. 12

■ **Radar Run:** 9 a.m. to 4 p.m., Red River Park, Dyckesville. Heated tent, refreshments, food.

■ **Tubing Special:** Starting at 10 a.m., Winter Park Tubing Hill, tubing tickets only $3 for first 100 kids; sponsored by the Kewaunee Optimist Club, Friend of Youth.

■ **Kewaunee Trap Club Deer Show:** 2 p.m. until close. Bring in your mount or set of antlers and have them professionally scored; $5 entry per mount (includes scoring); 100 percent payout. Open to public, no need to enter to view the show. For information, call Mike at (920) 304-0273.

■ **Saturday Mornings at Algoma Youth Club:** Doors open at 9 a.m.; basketball skills, games. 9:30 a.m., younger children; 10:30 a.m., older children: arts and crafts. 9:30-11:30 a.m., coloring, painting, crafts, videos, baking, games, more.

■ **Winter History Series:** 1 p.m., at Kewaunee County History Center, 219 Steele St., Algoma. Topic is "Unwritten Church Histories."

■ **Bay Area Daylily Buds:** 1 p.m., at Green Bay Botanical Garden, 2600 Larsen Road. Meeting followed by club members presenting slides on local or regional gardens. Free. All welcome. Information, (920) 468-6881.

■ **Fundraiser for Myocarditis Foundation in memory of Brad Vanness:** 3 p.m. to midnight at Blue Door Sports Bar, Kewaunee, includes silent auction.

Mike Bloniarz of Kewaunee catches a bluegill Feb. 5 on East Alaska Lake while Mike Case of Seymour looks on. Tri-Lakes Association is planning an alum treatment for East Alaska Lake this fall or spring 2012. An alum treatment would decrease the lake's level of phosphorus and lead to clearer water on the lake. **Tina M. Gohr/Kewaunee County Star-News**

Lake cleanup

Alum treatment may be in East Alaska Lake's future

BY PAMELA PARKS
STAR-NEWS CORRESPONDENT

The nonprofit Tri-Lakes Association (TLA) is planning an alum treatment for East Alaska Lake, having received a Wisconsin Department of Natural Resources Lake Planning grant in August. Improving the water quality of East Alaska Lake, West Alaska Lake and Krohns Lake has been a 20-year journey for residents in the town of Pierce, with most of the recent efforts coordinated by TLA. Lake studies completed in the late 1990s, 2005, and last summer led to the reduction of external sources of phosphorus, such as parking lot, agriculture and septic run off, and controlling invasive species. Now the focus for East Alaska Lake is to reduce the internal nutrient-rich waters.

Motivation to address water quality at East Alaska Lake was spurred by past fish kills on the lake as well as periods of excessive algae bloom, said TLA board member Patrick Robinson. Although there is room for improvement, water quality on East Alaska Lake does not inhibit the lake from recreational use, especially fishing.

East Alaska Lake is the biggest inland lake in Kewaunee County. The lake covers 53 acres and has a relatively small watershed. East Alaska Lake has been, and continues to be, a popular fishing area. In the past, the lake was also used for swimming and water skiing. The lake is a Kewaunee County Park boat launch.

The quest for better water quality on the lakes began in the late 1990s when the town of Pierce was awarded a grant through the DNR to collect information about the lakes' water, plant population, and drainage areas. In 2006, TLA was assisted by Kewaunee County and the U.S. Fish and Wildlife Agency to create a one-acre sedimentation basin on East Alaska Lake's western shore to treat water entering the lake from the agricultural sources. In 2007, all private onsite wastewater treatment systems around the lake were inspected and resulted in 11 corrective actions. Even after correcting external sources, the internal recycling of phosphorus continues to support poor water quality.

East Alaska Lake is rich in nutrients, which is a symptom of its past. Decades earlier, untreated byproducts from a cheese factory emptied into the lake. Phosphorus from the byproducts and the waste from failed septic systems and agricultural runoff is present in the lake's bottom sediment. Left untreated, the lake continues to release the phosphorus each time it "turns over" in spring and fall. Breaking that cycle is what TLA is proposing to do.

"Studies on East Alaska Lake said we may want to consider treating the lake with an alum treatment to bind the nutrients and bury them in the sediment. It would lock up those nutrients that keep cycling over and over again," said Robinson.

According to the Wisconsin DNR website, alum — aluminum sulfate — is a nontoxic material commonly used in water treatment plants to clarify drinking water and is also used to reduce the amount of the nutrient phosphorus in lakes. When alum binds to phosphorous, it sinks to the lake bottom, and does not release the phosphorus back into the water. On East Alaska Lake, alum would be added at three sites determined to have a high phosphorus level in the sediment. After the treatment, the water should be noticeably clearer with less algae blooms, especially in summer.

No easy task

The in-lake technique of applying the alum consists of having several large tanker trucks near the lake and a large boat with booms delivering the alum directly

See LAKE, Page A-6

and English speaking skills.

Without being able to read and write, adults are seriously handicapped. Written communications to schools, elected officials and government offices are nonexistent. Health concerns such as reading labels, signs and prescriptions can be health-threatening.

Literacy Partners of Kewaunee County has more than 20 students on a waiting list for a volunteer tutor. Literacy Partners' "Each One Teach One" is a one-on-one based teaching experience. For many,

started their GED and three have passed the U.S. Citizenship Test. Many others are now able to read to their children.

held from 6 p.m. to 7:30 p.m. March 1. Classes 1 through 4 will be from 6 p.m. to 9:30 p.m. March 8, 15, 22 and 24, respectively.

For information or to register before the orientation, call Bob Garfinkel at (920) 845-2516, e-mail garfinkel.bob@gmail.com, or visit the Literacy Partners website at www.literacykewauneeco.org.

Lake

From Page A-1

into the water. The system is high tech with computers delivering the specific amount needed for each particular area.

"It is really quite the site to see out on a lake and could be very shocking to people if they are not aware of it," said Tim Hoyman, a consulting Aquatic Ecologist for Onterra LLC. "It looks very drastic unless you know that they are doing."

After the treatment plan is completed, TLA can apply for additional state funding for the project, which will cost approximately $60,000. The treatment could take place this fall or spring 2012.

Alum treatments have been safely used to treat lakes across the nation as well as in Wisconsin, including Silver Lake in neighboring Manitowoc County. One risk of the treatment is aluminum toxicity, which occurs when the alum is placed in water with a pH greater than 8. Hoyman said that monitoring pH levels before and after the treatment, as well as adding a buffer to the water if necessary, is part of the treatment process and prevents toxicity.

"We are using good science to come up with how it will be done," said Hoyman. "And, we are working in a lot of stakeholder participation with a public informational meeting later in the spring when the plan is compete."

The meeting is expected to be held in late March. The date has not yet been determined.

East Alaska Lake Alum Treatment Planning Project

Informational Meeting

Monday, April 4, 2011 6:30pm

Town of Pierce Town Hall

N6061 County Hwy. D., Kewaunee, WI

The Tri-Lakes Association will hold a special meeting to present an updated management plan for East Alaska Lake that focuses upon the use of alum to treat internal phosphorus loading in the lake. Tim Hoyman, an aquatic ecologist with Onterra, LLC will present the rational for completing an alum treatment on East Alaska Lake, including the results of the sediment core analysis completed by the Wisconsin Department of Natural Resources and the US Army Corps of Engineers, potential treatment costs, and the pros and cons of completing the treatment. While there will be a question and answer period following the presentation, a list of Frequently Asked Questions is included below.

Question: What is an alum treatment?

Answer: An alum treatment is a technique used by lake managers to reduce the recycling of phosphorus from the bottom of a lake to the waters above where algae can use it to grow. The process involves adding alum (aluminum sulfate) to the lake. As the alum disassociates, it creates a floc that settles to the bottom where the aluminum binds with the phosphorus and creates a barrier preventing it from entering the water above.

Question: *Why would East Alaska Lake need an alum treatment?*

Answer: Studies have shown that East Alaska Lake's water quality is impacted by internal phosphorus loading. In other words, phosphorus, a nutrient that supports algae growth, is recycled from bottom sediments. An alum treatment would reduce the amount of phosphorus released from the lake bottom, which would help reduce algae blooms in the lake.

Question: *Is an alum treatment safe for East Alaska Lake?*

Answer: Yes, alum treatments are safe as long as the lake is properly monitored during the treatment and the chemical is applied correctly to achieve the planned dose. By monitoring the lake's pH during the treatment and assuring that it stays between 5.5 and 9.0, levels of dissolved aluminum will remain at 50 ppb or less, which are well below levels that could harm fish and other wildlife.

Question*: How do they treat the lake with alum?*

Answer: Alum treatments are completed by professional applicators using a barge that injects the alum into the lake water. The proposed treatment on East Alaska Lake would occur in areas of the lake where water depths are 10 feet or greater.

Question: *How will the lake change after the alum treatment and how long will it last?*

Answer: Studies completed on East Alaska Lake have shown that algae growth is limited by the amount of phosphorus in the lake. By reducing the phosphorus available to the algae through an alum treatment, the lake will support less algae and the water will be slightly clearer. Depending on the dose used, the effects could last as long as 20 or more years.

Question: How much will an alum treatment on East Alaska Lake cost?

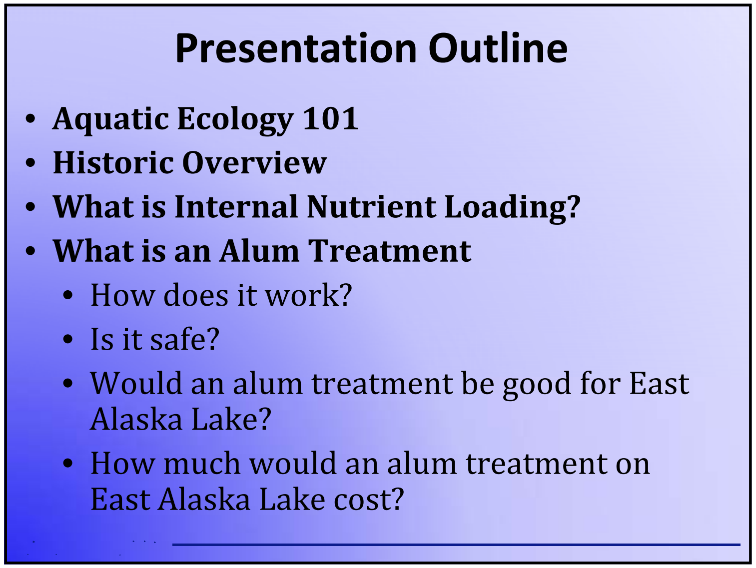
Answer: Depending on the dose used and the acreage of lake bottom treated, the cost of the project would be between $60,000-$125,000. Wisconsin Department of Natural Resources grants are available to fund approximately 75% of the costs.

Tri-Lakes Association

East Alaska Lake

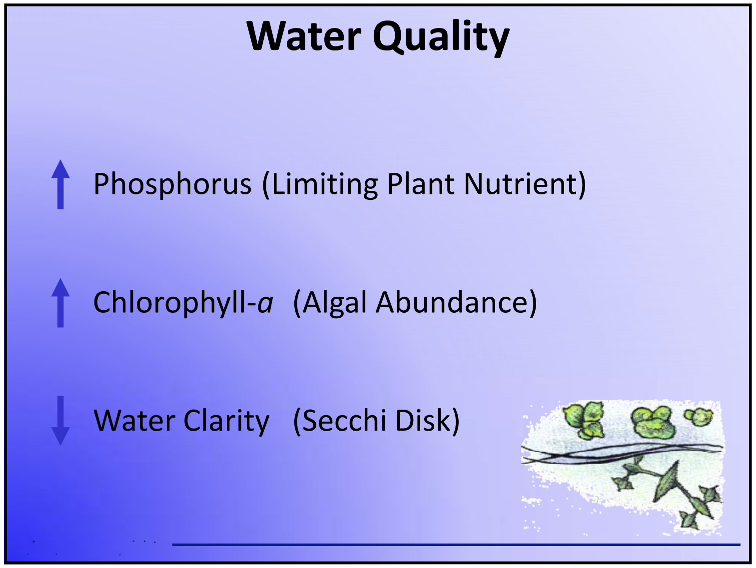
Alum Treatment
Planning Project
April 4, 2011

Tim Hoyman, CLM
Onterra LLC
Lake Management Planning



Presentation Outline

- **Aquatic Ecology 101**
- **Historic Overview**
- **What is Internal Nutrient Loading?**
- **What is an Alum Treatment**
  - How does it work?
  - Is it safe?
  - Would an alum treatment be good for East Alaska Lake?
  - How much would an alum treatment on East Alaska Lake cost?

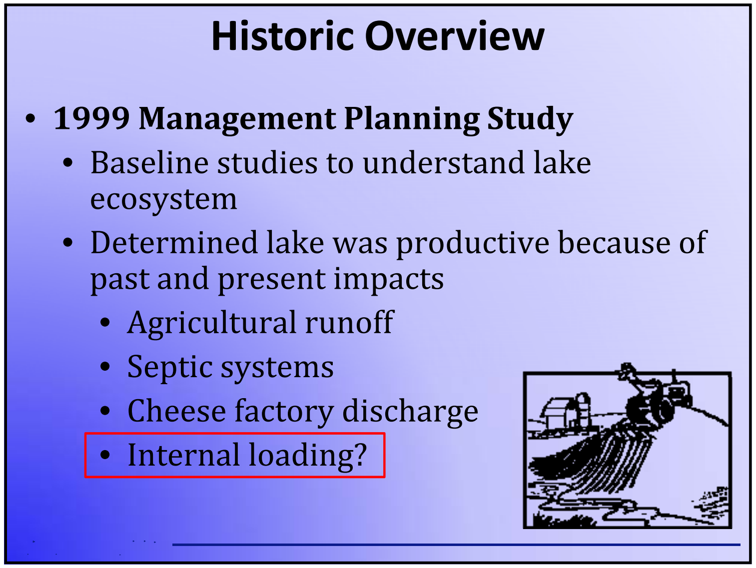


Water Quality

↑ Phosphorus (Limiting Plant Nutrient)

↑ Chlorophyll-*a* (Algal Abundance)

↓ Water Clarity (Secchi Disk)



Historic Overview

- **1999 Management Planning Study**
  - Baseline studies to understand lake ecosystem
  - Determined lake was productive because of past and present impacts
    - Agricultural runoff
    - Septic systems
    - Cheese factory discharge
    - Internal loading?

Historic Overview

- **2005 Alum Treatment Feasibility Study**
    - Measured hydraulic and phosphorus loads entering from inlet (West Alaska outlet) and draintile outfall.
    - Inlet and draintile both add about the same amount of phosphorus to lake each year.

	Phosphorus Load (kg)	Hydraulic Load (m^3)	
Draintile	27.4	63,000	
Inlet	25.4	922,000	**Increases Flushing Rate**

Historic Overview

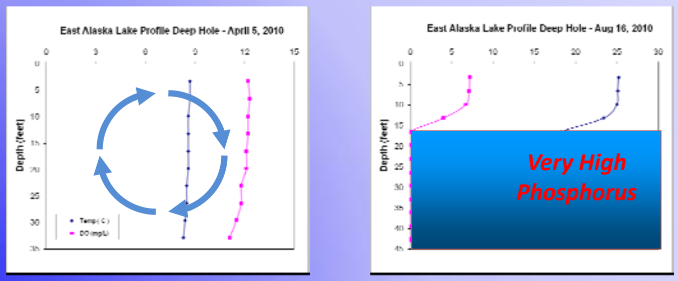
- **2005 Alum Treatment Feasibility Study**
    - Modeled internal phosphorus loading
        - 131kg/year **Over estimated, but important**
    - Overall: Lake not ready for alum treatment
    - Recommended:
        - ✓ Septic inspections and corrections
        - ✓ Construction of sedimentation basin to minimize draintile inputs

What is Internal Nutrient Loading?

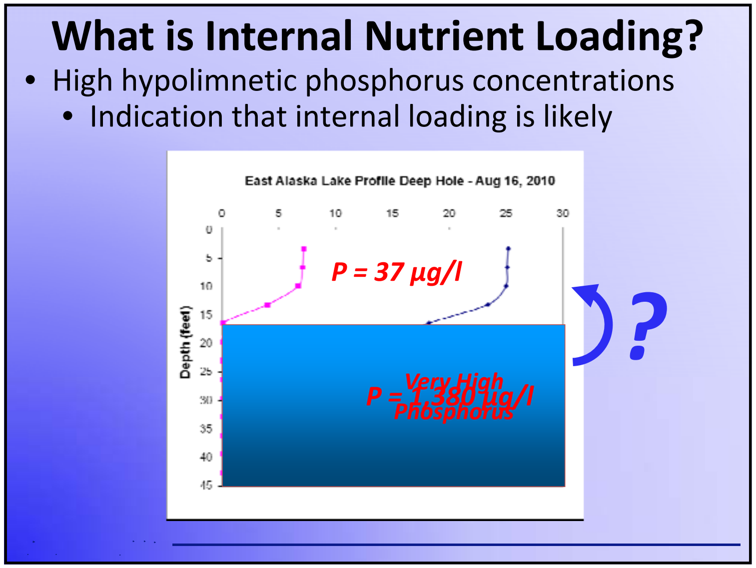
- **In East Alaska Lake: Internal phosphorus loading**
- **External phosphorus sources:**
    - Atmosphere
    - Tributaries
    - Point sources
    - Overland
- **Phosphorus sedimentation:**
    - Biotic absorption, death, and decay
    - Chemical binding and settling

What is Internal Nutrient Loading?

- **Chemical binding**
    - Calcium-carbonate – stable bind
    - Iron
        - Oxic conditions – binds with phosphorus
        - Anoxic conditions – releases phosphorus



Very High Phosphorus

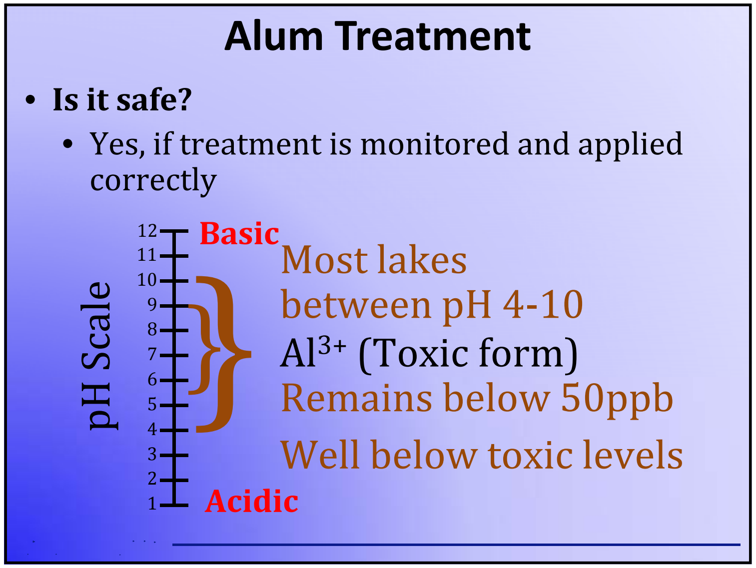


What is Internal Nutrient Loading?

- High hypolimnetic phosphorus concentrations
  - Indication that internal loading is likely

Alum Treatment

- **What is it?**
  - 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
        - Binds sediment phosphorus



Alum Treatment

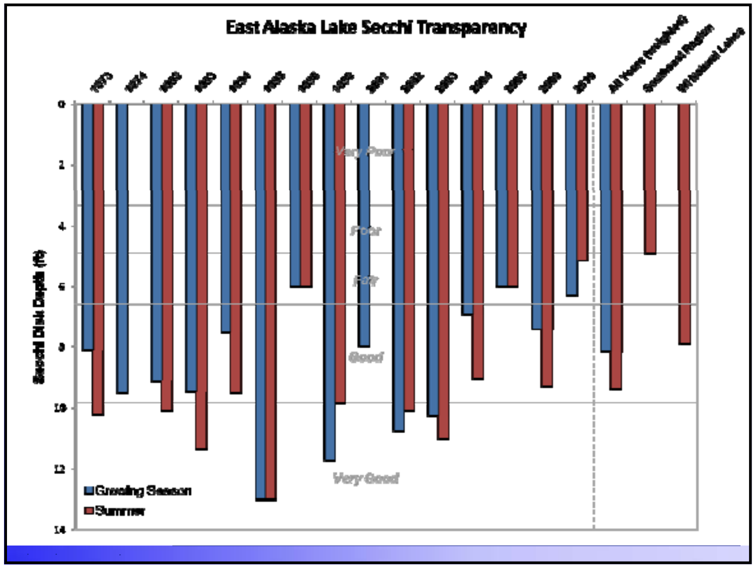
- **Is it safe?**
  - Yes, if treatment is monitored and applied correctly

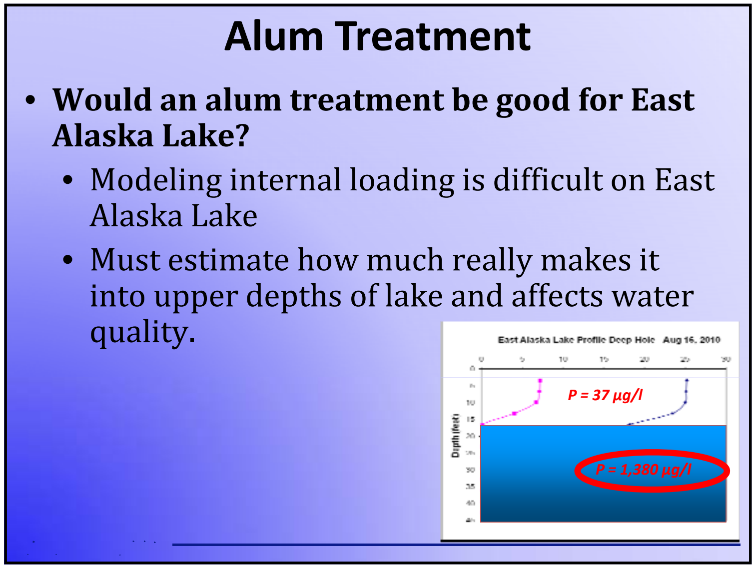
Most lakes between pH 4-10

Al^{3+} (Toxic form)

Remains below 50ppb

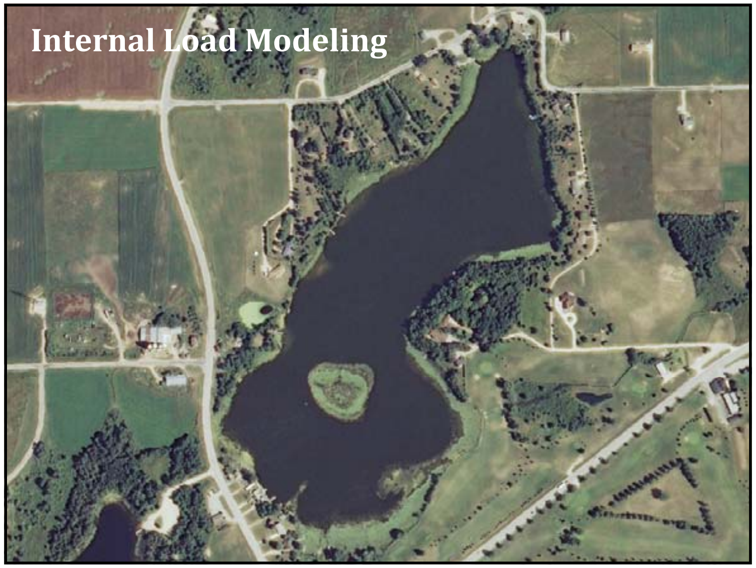
Well below toxic levels



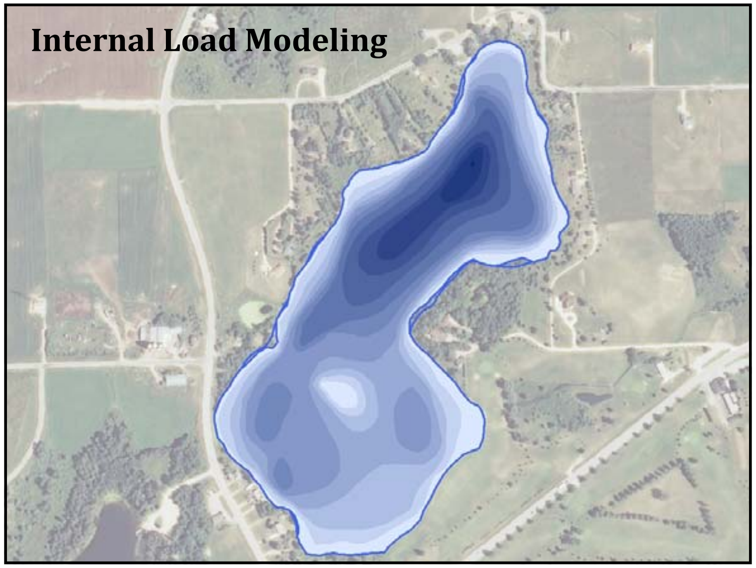


Alum Treatment

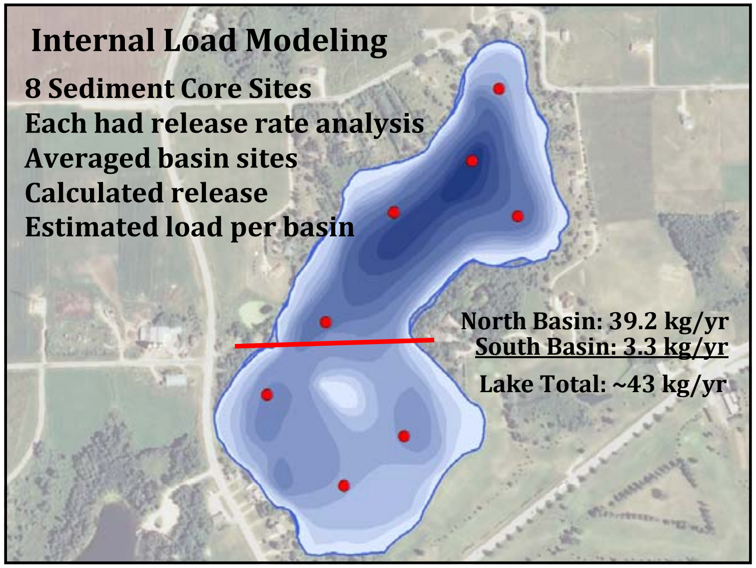
- **Would an alum treatment be good for East Alaska Lake?**
  - Modeling internal loading is difficult on East Alaska Lake
  - Must estimate how much really makes it into upper depths of lake and affects water quality.



Internal Load Modeling



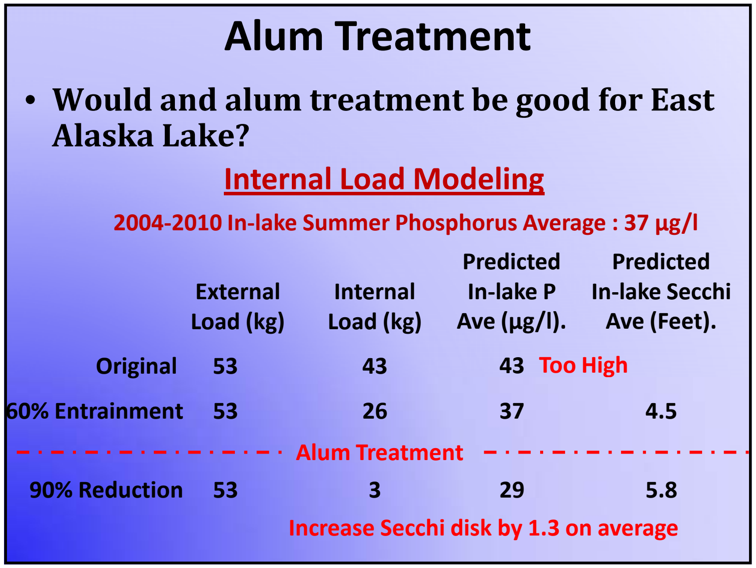
Internal Load Modeling



Internal Load Modeling

8 Sediment Core Sites
Each had release rate analysis
Averaged basin sites
Calculated release
Estimated load per basin

North Basin: 39.2 kg/yr
South Basin: 3.3 kg/yr
Lake Total: ~43 kg/yr



Alum Treatment

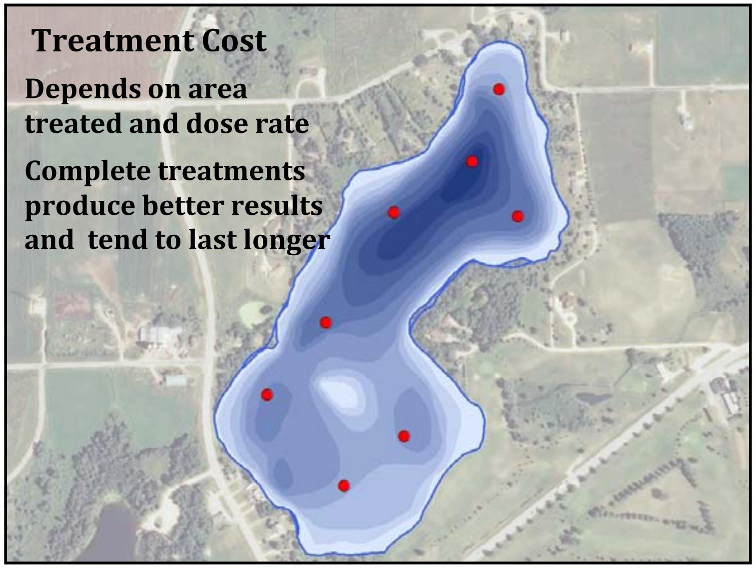
- **Would and alum treatment be good for East Alaska Lake?**

Internal Load Modeling

2004-2010 In-lake Summer Phosphorus Average : 37 µg/l

	External Load (kg)	Internal Load (kg)	Predicted In-lake P Ave (µg/l).	Predicted In-lake Secchi Ave (Feet).
Original	53	43	43	Too High
60% Entrainment	53	26	37	4.5
Alum Treatment				
90% Reduction	53	3	29	5.8

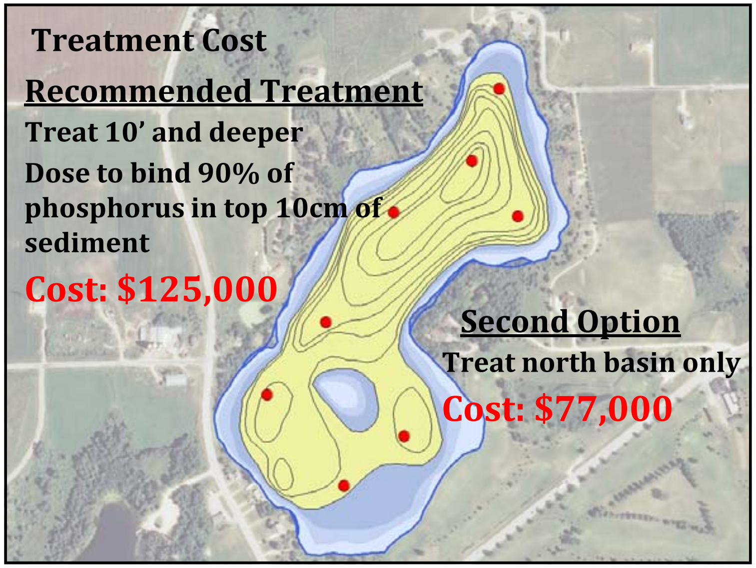
Increase Secchi disk by 1.3 on average



Treatment Cost

Depends on area treated and dose rate

Complete treatments produce better results and tend to last longer



Treatment Cost

Recommended Treatment

Treat 10’ and deeper

Dose to bind 90% of phosphorus in top 10cm of sediment

Cost: $125,000

Second Option

Treat north basin only

Cost: $77,000

Thank You

Many of the graphics used in this presentation were supplied by: