LAKE EAU CLAIRE MANAGEMENT PLAN 2012

Submitted for Consideration to Wisconsin Department of Natural Resources

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LAKE EAU CLAIRE MANAGEMENT PLAN 2012 EXECUTIVE SUMMARY

The Lake Eau Claire Management Plan has been designed to address and stabilize or correct problems that have developed since the Lake was created in 1937. These identified problems range from the lake filling in (becoming smaller) due to sedimentation, to a large increasing potential eutrophication threat due to internal nutrient loading. Coupled with more subtle changes such as the loss of fish habitat (particularly coarse woody debris and macrophytes), and a substantial reduction of fisheries spawning and critical habitat areas, the lake's early reputation as a prime fishing lake has not been sustained. The Management Plan addresses the specific issues of sedimentation and erosion, eutrophication due to internal and external phosphorus loading, and fisheries habitat restoration. Although these problems appear to be distinct and unconnected issues they work in concert to restore the early characteristics of the lake.

Lake Eau Claire (LEC) fits into a category referred to as an impoundment lake that was formed in 1937 as the result of damming the Eau Claire River and flooding about 1100 acres of the river basin above the dam. So in essence the lake is new relative to most natural lakes in the mid-west and is only 75 years old and not thousands of years old. Like most impoundment lakes, LEC is steadily undergoing changes that because of its characteristics, the development around the lake, and the water shed that feeds it are negative changes. In other words, we have seen the best years and the lake is in a state of decline. This is not unusual for impoundment lakes and for that matter for many natural lakes these days. If one carefully studies the brief history of LEC the changes are apparent and with issues like sedimentation were predicable from the lake's inception and inevitable without intervention. This was obvious to the lake's founders and planners who gave the lake a 75 year lifetime. The major problems that confront the lake residents and users today are summarized in the following:

(1) Through sedimentation and erosion the lake's navigable surface area has decreased by as much as 20% over the last 75 years and this is continuing.

(2) Since its inception the lake has become more eutrophic due to internal nutrient loading with dense blooms of phytoplankton frequently appearing during the summer. What were once desirable phytoplankton species have given way to Hazardous Algal Blooms (HAB) that do not occur every year, but only when the conditions are right, usually during warm dry summers. These extreme HAB events destroy existing macrophyte beds and vulnerable shallow water invertebrate populations which in turn set back fish reproduction and development. This alternating saga probably explains to a large extent why the lake is so cyclic in its reputation as a fishery; alternating every few years from excellent fishing to "the dead sea".

(3) During a study in 1998 it was confirmed that during the summer roughly 90% of the algal population in the lake consisted of these HAB organisms and these were identified as a toxic cyanobacteria (blue green algae) called mycrocystis. This organism produces a

chemical toxin called microcystin which affects human health in various ways including gastrointestinal distress, liver toxicity leading to necrosis, and tumor promotion.

(4) The same cyanobacteria can have devastating effects on benthic plant and fish populations by limiting light penetration and by generating excessive concentrations of toxins under the thick blankets that develop along shorelines in the lake. These thick blankets concentrate in the channel above the dam and their transport over the dam probably explains the observed fish kills in the shallow stretches of the river below the lake.

(5) Most of the once abundant fish habitat in the form of coarse woody habitat has disappeared from the lake, and it is not being replaced.

(6) The once very productive fisheries has by all accounts declined dramatically from what it was 40-60 years ago and for that matter of what it was just a few years ago.

(7) Because of the eutrophication in the lake much of the internal volume of the lake is a lifeless dead zone because of rapid anoxic (lack of oxygen) conditions from May to October in most years.

These are the obvious problems that have been identified through observation and scientific studies that have been conducted over the last 15 years. There are other potential problems that may face us in the future such as the introduction of invasive species and these may need to be dealt with as well. So far we have been lucky on this one, perhaps because the LEC Association has been proactive and has instituted a cooperative boat landing survey and education program to try to stop the introduction of invasive species.

The most ominous situation we face now is the continual transport of sand into the main body of the lake. For the last 75 years the head waters of the lake have protected the lake from the intrusion of sand by functioning as a storage area. As of the year 2010 that reservoir has filled and sand is now quickly beginning to flow into Skid Row and the Rookery areas. If nothing is done soon to stop this sand influx the cost to fix it will become prohibitive. If corrective measures are implemented soon the intrusion of sand can be stopped indefinitely, and the situation can be reversed to begin to restore areas of the lake that have already been lost.

One thing is apparent and that is if nothing is done to stop or reverse this situation LEC will continue to decline and so will its recreational and monetary value to local residents, businesses and government. Most of the problems that have been identified here can be dealt with and controlled and in some cases even reversed to restore the lake to conditions that existed many years ago. The LEC Association, Eau Claire County, and local Townships have for many years been proactive in developing a plan of action. Funds and other resources have gone into encouraging and assisting in the support of various scientific and engineering studies to understand the details of the problems and design ways to address them. This has been accomplished through a series of multiple phases that are summarized in the following.

PHASE I: Over the last 15 years numerous scientific and engineering studies have been conducted on LEC. These studies have been costly in terms of time and money and have involved contributions of both from Eau Claire County, DNR, Army Corp Engineers, LEC Association, and non-profit organizations. These studies led to characterizing and assessing the magnitude of the problems and to evaluating potential solutions. That is, what will work and will not. Many of these studies and summary results can be found on the LEC Association web site and are also addressed in the body of 2012 LEC Management Plan.

PHASE II: A preliminary plan was developed for what was labeled the LEC Protection and Rehabilitation Project. This plan took into account the results of the previous 15 years of research and studies and the perceived needs of the LEC community and lake users. In 2009 a mail survey was conducted to determine people's opinions about the lake and prioritize the perceived problems and solutions. This process was further refined in late 2009 to 2010 through a series of five open public steering committee meetings that included lake and local residents, DNR, Eau Claire County officials, and WI extension Service workers. From this process a list of priorities was set and the preliminary LEC Protection and Restoration Project plans were further refined. This is discussed in more detail in Sections III and IV of the management plan.

PHASE III: The outcomes of phases I and II were used next in 2010 to develop a detailed long term Protection and Rehabilitation Plan that was put together by the LEC Association, Eau Claire County, and the WI-DNR. In 2012 this plan was updated and written as the 2012 LEC Management Plan and a budget was developed for consideration for funding from WI DNR. Also during the same period, permits were prepared and submitted to DNR. The permits submitted so far are blanket permits for installation of coarse woody habitat for fisheries restoration, lake-river headwaters restoration to Troubled Waters Bridge, and a lake aeration system to reduce oxygen depletion during the summer in an attempt eliminate the dead zone, reduce eutrophication and improve overall water quality.

PHASE IV: Implementation and maintenance of the proposed projects in the Protection and Rehabilitation Plan are the final step. Part of the plan involving the fisheries habitat installations was initiated in 2011 with planned installations for 2012 and beyond. Twenty modified half-log structures were added to the lake in 2011 and another 50 are planned for 2012. Funds to support these and other ongoing protection and rehabilitation projects come from the Lake Association and LEC Foundation accounts which total roughly $180,000 presently with annual donations and fund raising events being the primary ongoing sources of support. The LEC Association together with Eau Claire County is exploring a number of additional mechanisms of continuing support. These include formation of a LEC Lake District (a petition drive is underway), a county wide referendum, and sales of sand (frac sand quality) from headwater sediment removal operations.

The 2012 LEC Management Plan consists of three main components: (1) Water Quality Proposal, (2) Fisheries and Habitat Proposal, and (3) Sedimentation and Erosion Proposal. Although they are treated separately in the Management Plan they work in unison to indefinitely restore and protect the Lake, to improve water quality and in so doing protect human health. A brief summary of each of the three main components follows. For details on technical issues and arguments, design specifications, and budgets and budget justifications see the main body of the Management Plan.

WATER QUALITY PROPOSAL: A study of phosphorus sources to the lake revealed that roughly 50% comes from internal loading during the summer. A significant reduction of this level of internal load could improve the eutrophic conditions that develop during the summer months. Since most of this internal P arises because anoxic conditions that develop in the western basin of the lake, the efforts concentrated on lowering P levels in the western 200 acres of the lake. Several alternatives to reducing internal P were evaluated and are discussed in the Management Plan. The favored choice because of cost, simplicity and the likelihood of long term success was the installation of a destratification system (Option 3, Section V.A.3c). This system was proposed by the Army Corps of Engineers and involves high pressure compressor driven air injection over a relatively short length of diffuser line located in the deepest portion of the lake. The prediction is that it will destratify most if not all of the deeper portion of the lake where internal P loading is occurring. Modeled estimates from the Army Corps are that this will reduce in-lake TP from105 ug/l to 63 ug/l and that mean chlorophyll a would be reduced from 56 ug/l to 34 ug/l. This TP loading reduction reduces the frequency of exceeding 50 ug/l chla by 61% from a 45% frequency of occurrence to 18% frequency of occurrence. A further reduction in the TP external loading is expected as part of the Lake Eau Claire restoration plan from the spreading of the present river flow over as much as 200 additional acres (810,000 m2). A significant reduction in flow velocity transport and increased residence time through the restored floodplain above the lake should promote aquatic plant growth and nutrient reduction. So assuming uniform biomass (i.e. macrophytes, epiphytes and plankton) coverage over 200 acres and assuming an average depth of 1 meter the daily SRP reduction in external P source should be significant and add to the benefit of the internal P destratification reduction.

FISHERIES AND HABITAT PROPOSAL: The proposal calls for adding coarse woody habitat throughout the lake on a controlled basis through the use of blanket permits from DNR and Eau Claire County where required. This process was initiated in 2011 to install both modified half-log structures and tree falls. This will be a long term ongoing activity since replacement of habitat will be a continuous issue. The LEC Association will set some annual funds aside for this process, but local and state support will be required particularly during the initial phases of the habitat restoration effort. It is expected that most of the labor will be voluntary and come from local invested individuals and organizations like sportsman and fishing clubs. Therefore most of the cost will be for materials and transportation of materials. So far from the first year of operation things have gone according to plans and a pontoon boat has been purchased to help perform the installations. Roughly 50-100 installations are planned per year until adequate habitat has been restored. They will be maintained at a steady state average after that point.

SEDIMENTATION AND EROSION PROPOSAL: An intensive GIS and on the ground evaluation of sediment sources and deposition was conducted over two years for the north shore of the lake and the Eau River. The primary conclusion was that sedimentation from the tributaries along the north lake shoreline and the river could be shut-off by adding new sediment traps in specific locations. For the north shore of the lake two new sediment traps are proposed on Muskrat Creek and NW Creek. This would make five existing traps along the north shore. The main sediment load to the lake comes from the Eau Claire River and three traps are proposed to handle the sediment load there. If the sedimentation levels remain as they have over the last 73 years this would amount to a 6,900-8,500 yd3/year reduction in sediment advancing towards the lake. In Section C three sediment traps are proposed for installed at TWB, GPT and SRT (see Figure 11). Once these traps are installed and maintained as needed the bed load supply of sediment would gradually be reduced between the traps and between SRT and the lake. This is primarily the result of the river deepening as sediment is removed by the traps. As the sediment is removed the flow velocity will diminish and sediment transport will decline below the TWB trap. This will eventually expand navigable areas of the river and also restore original aquatic habitat areas within the flood plain. As an example the main river channel between TWB and GPT would amount to an average annual deepening of the entire width of the river channel of 3.2 to 4.3 inches between these end members. Within three years this could increase the depth of the river by as much as a foot. This should also help to restore some of the valuable fisheries wildlife habitat in the headwaters area of the lake, since the deepening of the main channel could make these areas accessible again.

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I. Introduction

Lake Eau Claire has been a valued recreational resource in Eau Claire County since the lake was created in the mid-1930's. Few natural lakes existed in Eau Claire County before this time and this lake along with Lake Altoona, Coon Fork, Rock Dam and other lakes became part of a chain of man-made impoundment lakes that are all interconnected via the Eau Claire River and its tributaries. Hence these lakes and the stream system that supports them are linked through their fisheries, water quality, aquatic habitat, and all other resources that make them important recreational components of Eau Claire County and the region. Local community members and tourists use the lake and surrounding area for a wide variety of outdoor recreational activities which include: fishing, boating, hunting, picnicking, golf, snowmobiling and camping. These activities provide a major economic base for local businesses and surrounding communities. Because of escalating development and the resulting increasing tax base the lake region has become central to the economy of the surrounding area.

In recent years, there has been a perceived notion by many people in the Lake Eau Claire region that there has seen a noticeable decline in the lake resources. These declines have largely been associated with the fisheries, water quality (e.g. excessive eutrophication), and erosion and sedimentation. Excessive runoff of nutrients from agricultural lands, forested areas and urban development along shorelines has probably contributed significantly to poor water quality. Increased sedimentation has created navigational problems and even significantly limited access to the lake for property owners and visitors. The public perception (see 2009 Public Survey) is that the fisheries is in decline because of major loss of natural habitat for fish reproduction and sustainability at a time when fishing pressure is higher than it has ever been. Another pressing issue is the ever increasing threat of algae blooms caused by nutrient loading, which are dominated by blue-green algae which are known to be deleterious to the fish, other beneficial aquatic plants and animals, and humans (Brand, L.E. 2011 and Zaccaroni, A. & Scaravelli, D. 2008). These algal blooms also have a pronounced negative effect on the environmental aesthetics and water quality (Fig 1).

These concerns have grown in recent years to the point where the Lake Eau Claire Association has taken a proactive stance in attempting to correct and reverse the these negative environmental trends. To this end a Lake Eau Claire Management Plan has been developed as a partnership with community residents, the Lake Eau Claire Association, Wisconsin Department of Natural Resources, Eau Claire County Land Conservation Division, Eau Claire County Parks and Forests, Beaver Creek Reserve, Army Corps of Engineers, faculty from UW Stevens Point and Eau Claire and University of Miami/RSMAS, local township and city government, and various consultants. This Lake Eau Claire Management Plan has been developed by the LEC Restoration Steering Committee working in partnership with the various partners mentioned above This plan outlines a framework of lake stewardship activities which will provide improved recreational opportunities, fish and aquatic life habitats and water quality. This lake management plan includes clearly defined goals and objectives that will be the road map to improve the attributes of Lake Eau Claire that are valued by all who enjoy the this valuable resource.

Figure 1: July 2009 Blue-Green Bloom

II. Background

A. History of Lake Eau Claire:

Lake Eau Claire is an impoundment of the Eau Claire River formed by the flooding in 1937 of what was previously a river bed and associated flood-plain which became the lake basin. The Lake Eau Claire basin was previously mostly forest flood-plain and much of the main lake body area was clear cut although many tree stumps were not removed before flooding. And in some flooded areas the trees were never cut and large areas of flooded forest existed in the lake until well into the 1960's. In shallow regions of the lake large stumps and fallen trees existed for 40-50 years after the lake was flooded. This coarse woody habitat could be found in nearly all regions of the lake and it provided excellent cover to support a very productive fisheries which largely consisted of walleyes, muskellunge, crappies, and some large and small mouth bass and a large population of carp, red horse suckers, and bullheads. In the mid 1950's, in attempt to control the rough fish population and enhance the boating areas within the lake, the lake was partially drained and much of the shallow western portion of the lake was excavated, and the coarse woody habitat was removed so that it was easier to net and remove rough fish. The resulting deposits from the excavation (mostly sand) were used to build the central islands in the lake. As a result much of the shoreline for years to come existed as steep slopes that were largely composed of sand and that were unstable and ended up slumping over the next 30-40 years. Today most of these steep shorelines have slumped and shallowed. The original abundant coarse woody habitat has all but disappeared and there has been virtually no replacement of it. Some of this fish habitat was recovered in the form of benthic plant community development in the 1990 and early 2000's, but for unknown reasons in recent years most of these new communities have nearly disappeared from many areas in the lake. Two theories are that this is the result of light attenuation due to excessive blue-green productivity or is the result of increased boat traffic turbulence throughout the lake.

One of the obvious changes to the lake environment is shallowing of certain parts of the lake. This is certainly noted along the formerly steep shorelines and in those instances is probably mainly due to unstable sediment slumping and wind and wave induced erosion. The shallowing in mouths of tributaries is largely the result of stream sediment transport and is a significant problem for the areas immediately in front of the tributary input to the lake. After year 2000 the LEC Association in cooperation with the county and state begin addressing these problems by first removing much of the deposits by pump-dredging filled areas, then installing sand traps, and finally scheduling regular cleaning of those traps. Four such areas are now being handling in this way and two more need to be dealt with. One of these is a small tributary in the northwest corner of the lake and the other is the Eau Claire River itself.

According to most people who reside near the lake or who use the lake's resources regularly one of the most pressing issues is water quality. In this case water quality is mostly attributed to eutrophication that typically each summer leads to an overwhelming abundance of blue-green algae. During summer and fall these organisms become quite prolific and major blooms can result at any time during this period. Conditions such as rainfall and weather are believed to be implicated in setting off and sustaining these blooms. Therefore every year can be different depending on controlling conditions. This is not a new problem, but the perception is that it is a growing problem. The abundance of nutrients, particularly the limiting nutrients like phosphorous, are essential to kick-off and sustain algal blooms. This is a common problem that many lakes share, but impoundments are different in that nutrient sources can be distant and come from the watershed (for LEC this is about 625 Square miles) or from local ground water or riparian runoff. For LEC there is another significant source and that is mobilization of phosphorus and nitrogen from anoxic bottom water in the lake. In an impoundment lake like LEC there is probably an increasing tendency for internal loading of phosphorus and reduced nitrogen because sediment concentration of nitrogen and phosphorus are increasing with time and so is the tendency for anoxia to develop because of increasing total organic matter levels in the sediments. On the scale of lake development LEC is a relatively young lake (74 years) and internal loading of nutrients will probably increase for some time before reaching a steady state condition. Hence, blooms will probably get worse before they get better.

B: Evolution of Lake Eau Claire Management Plan:

Over the past 20 years a growing concern has developed among the Lake Eau Claire (LEC) community that some of the valued environmental characteristics of the lake have declined. In general, concerns have been raised about declining water quality, dramatic sedimentation increases in some areas of the lake and river system, and declining fisheries habitat and the fishery itself. These concerns led the LEC Association to seek guidance from Eau Claire County Government and the WI Department of Natural Resources. Interactions between these three organizations have led to a series of scientific and engineering studies on LEC that have provided valuable insight on details on the perceived existing problems and potential solutions to their resolution. The perceived problems were further validated by conducting a public sociological survey in the spring of 2009 which helped to establish the priorities for developing a strategic management for LEC. Using the results of the public survey and the preceding 15 or so years of scientific and engineering results a steering committee was convened to assess this information and develop a list of goals and objectives for the management plan. The steering committee was made up of the LEC Broad members, officials from Eau Claire County government and WI DNR, and representatives from local government, sportsman's clubs, local businesses, and other near-by lake associations. This board met five times between July 2009 and January 2010 and at each meeting addressed different management plan subject areas (i.e. water quality, fisheries, habitat, erosion and sedimentation, invasive species control, and recreation). The culmination of this overall effort led to the **Lake Eau Claire Management Plan** which lays out a long term plan for addressing the identified and prioritized problems. The following documents provide information on the various studies and the reports that have resulted in the course of developing this comprehensive management plan for LEC.

Supporting information that was presented to the LEC Restoration Steering Committee and used to develop the following Goals and Objectives in Section III and lake management proposal in Section IV can be found below. All of these resources can be found as links on the Lake Eau Claire Website at http://www.lakeeauclaire.org/LakeRehab.html.

1. ACOE 1998 Report on LEC Water Quality Study

2. 2004 and 2006 LEC Board and Beaver Citizen Science Center Oxygen and Temperature Profiling Studies.

3. Freihoefer, A. and P. McGinley. 2009. Phosphorus Loading Model for Lake Eau Claire and Lake Altoona. Center for Watershed Science and Education Report.

4. 1997 Ayres Sediment Reduction Plan, Ayres Associates, Eau Claire, WI

5. 2007 LEC Preliminary Management Plan as presented to Eau Claire County Department of Planning and Development.

6. 2008 LEC DNR Shocking and Netting Fish Survey Report

7. 2010 LEC DNR Aquatic Plant Community Report (also includes shoreline assessment survey)

8. 2009 ACOE Water Quality Siphoning Model Final Report

9. Summation of results of the 2009 Community Sociological Survey of local residents and users of the LEC resources.

III. Goals and Objectives from 2009-2010 Lake Eau Claire Survey:

A. Water Quality

Goal:

Protect and restore water quality, reduce phosphorus loading (both internal and external), and reduce the occurrence and intensity of blue-green algae blooms

Objectives For Improving Water Quality:

a. *Reduce internal phosphorus loading into Lake Eau Claire through installation of a pipeline aeration system to destabilize the western area of the lake that falls below the 12 foot depths. The Eau Claire County Land Conservation Division (ECC-LCD) and Lake Eau Claire Association (LECA) will apply for a WDNR Lake Restoration/Protection grant to assist with implementation costs. The grant application will be submitted in May 2012. (WDNR, ECC-LCD, LECA)*

b. *The ECC-LCD, in conjunction with WDNR, will work with Eau Claire County landowners in the Lake Eau Claire contributing watershed to ensure cost share dollars are made available to bring the landowners into compliance with NR151 non-point runoff standards and ATCP 50 nutrient management regulations.*

c. *Develop partnerships with other lake districts/lake associations and bordering County Land Conservation Departments within the Eau Claire River watershed in order to take a more watershed approach to dealing with nutrient and sedimentation issues within the watershed. In addition, form partnerships with Rivers Alliance and other NGO's that could assist us in this effort. (ECC-LCD, LECA)*

d. *Utilize the UW-Stevens Point SWAT Model to address implementation of best management practices in land uses, such as agriculture and forestry practices, that have been identified as potential sources of nutrients and sediment to Lake Eau Claire. (WDNR, ECC-LCD, LECA)*

e. *Educate riparian landowners of the importance of managing stormwater runoff from their properties and provide education and technical assistance in the installation shoreline buffers and other best management practices (i.e. rain barrels, rain gardens, etc.) to reduce stormwater runoff from impervious surfaces along shoreland properties. (ECC-LCD, LECA)*

f. *Educate riparian landowners of the importance of regular maintenance of private onsite wastewater systems (septic systems) (ECC-CCHD)*

B. Fisheries

Goal:

Protect and improve the aquatic life of Lake Eau Claire, including a self-sustaining fishery and diverse aquatic plant community.

Objectives to Improve Lake Fisheries:

a. *Monitor the lake's fish population every four years to assess trends in the fish community. Under WDNR's lake monitoring program, the next scheduled survey would take place in 2012. However under WDNR's treaty assessment program, a fisheries survey is planned for 2013. In conjunction with this survey, an angler creel survey also will be conducted. Data from this fish survey will be compared to the 2008 survey, and information gathered from the creel survey will be used to evaluate the desires and perspectives of anglers on Lake Eau Claire as well as the angler's impact on the fish community. (WDNR)*

b. *Adopt an annual voluntary creel/fishing experience survey that will be combined with current invasive species surveillance program at the main* *boat landings. The creel survey will assist by providing more data on fishing experiences of angler's and may assist in overcoming some of the current negative public perception about the lake. (LECA and BCR/CCS oversight by WDNR)*

c. *Within the confines of natural variations, maintain fish populations at densities and size structure that are desirable for anglers when compared to similar waters in western Wisconsin. Using 2008 and 2013 survey data, evaluate population density, size structure, growth and mortality rates of the dominant gamefish and panfish species in Lake Eau Claire to determine whether or not regulation changes are needed to improve the quantity and/or quality of these populations. (WDNR)*
d. *Explore the possibility of establishing slow-no-wake areas around mid-lake plant beds to protect them from boat and jet-ski activity. Develop a boating traffic study that will assess the impact of boating activity on these and other critical plant beds in the lake that may be negatively affected by boating traffic. (LECA, Ludington and Bridge Creek Townships)*

C. Habitat

Goal:

Protect and improve in-lake and shoreline habitat to promote a healthy and diverse community of aquatic life in Lake Eau Claire. (WDNR, ECC-LCD, LECA)

Objectives For Habitat Protection and Improvement:

a. *Educate riparian landowners of the importance of coarse woody habitat (CWH) and aquatic plants in the lake to the community health of fish and other aquatic life in the lake. (ECC-LCD, LECA)*

b. *Develop a plan to increase CWH in the lake. LECA will send letters out to lakeshore property owners about the plan to improve CWH and solicit participation in a voluntary tree drop campaign. The Habitat Committee of LECA conducted a visual survey of the lakeshore and identified trees that are likely to fall into the lake within the next few years. To prevent shoreline erosion problems, these trees could be dropped into the lake to enhance littoral zone habitat. Utilize these structures to stabilize aquatic plant habitat. (LECA, WDNR, ECC-LCD))*

c. *Conduct tree drops along the shoreline to increase the amount of CWH in the littoral zone. Along developed shorelines, it is desirable to have a minimum of 1-2 pieces of CWH per 100 ft. of shoreline. Along undeveloped shorelines, it is desirable to have a minimum of 3-6 pieces of CWH per 100 feet of shoreline. Tree drops should not be used in lake areas with moderate to high density aquatic plant populations. (LECA, WDNR)*

d. *Install log fish cribs in deeper portions of the lake to increase the amount of deep water habitat available to fish. Fish cribs must have a minimum clearance of five feet of water over the top of the structure. Note this will be a long range objective to be implemented once water clarity improvements have been seen. (LECA, WDNR).*

e. *Install half-log structures in the littoral zone to increase spawning habitat for smallmouth bass. These structures must be placed in water less than five feet deep, and will provide spawning habitat along shorelines where tree drops may not be possible or desirable (LECA, WDNR).*

f. *Conduct a critical habitat designation survey of Lake Eau Claire in 2010. WDNR will utilize aquatic plant surveys conducted in 2003 and 2009 and a team of biologists and regulatory staff to determine the type and amount of habitat in the lake that is critical for protecting water quality, wildlife, fish and other aquatic life as well as aesthetics. Once a critical habitat designation has been completed, it can be used as a tool by the lake association, Eau Claire County, WDNR and others to protect these important lake features. (WDNR, ECC-LCD, LECA)*

g. *Educate riparian landowners of the importance of restoring shoreland areas to reduce the amount of sediment and erosion occurring to the lake. Educate landowners as to the importance of a healthy self-sustaining benthic plant community and its influence on improving water quality. The ECC-LCD will provide technical assistance to landowners on installation of proper shoreland buffers and educate the lake community on the importance of restoring and protecting the shoreland. (ECC-LCD, LECA)*

h. *Develop shoreland restoration demonstration projects on at least two different shoreland properties on Lake Eau Claire and conduct a public education effort to educate the riparian landowners on the importance and benefits of shoreland restoration and use of native plants in restoration efforts.*

D: Erosion and Sedimentation

Goal:

Reduce overall erosion and sedimentation occurring in Lake Eau Claire, restore areas within the lake that have been adversely affected by excess sedimentation and assess the amount of sedimentation coming into lake Eau Claire from watershed impacts.

Objectives For Reversing and Preventing Adverse Sedimentation Trends:

a. *Develop sediment traps at 3 sites upstream of Skid Row Boat Landing. The trap should have enough capacity to handle 4,500 cubic yards of sediment, which is the estimated load in the river expected over a 1-3 year period.*

First trap may be installed under WDNR Lake Protection Grant at Skid Row, second would be near original gravel pit, and third at Troubled Waters Bridge (Cty Road G). (WDNR, ECC-LCD, LECA)

b. *Maintain the current sediment traps installed along the north shore of the lake by regular dredging every 1-3 years depending on sediment build-up. (ECC-LCD, LECA)*

c. *Install additional sediment traps on NW corner of lake and on Muskrat Creek to control sediments entering lake from those tributaries. (ECC-LCD, LECA)*

d. *Educate riparian landowners of the importance establishing healthy vegetative buffers along the shoreland to reduce erosion of shoreline areas. Provide technical assistance on slowing the flow of storm water runoff that may accelerate this erosion. (ECC-LCD, LECA)*

e. *Assess stream bank erosion along select sections of the Eau Claire River upstream of Lake Eau Claire. (UWEC-Geog, WDNR, ECC-LCD, LECA)*

f. *Work with USGS to quantify the bedload for the Eau Claire River from upstream land uses. (UWEC-Geog/USGS?, WDNR, ECC-LCD, LECA)*

g. *Dredge out meander loop area upstream of Skid Row Boat landing to avoid future loading threat to lake. (ACOE Ecosystem Restoration Project?,, ECC-LCD, LECA)*

h. *Work with County, state and private forestry departments to ensure proper implementation of BMPs in forestry practices in Lake Eau Claire watershed (WDNR, ECC-LCD, LECA)*

i. *Collect sediment cores in the lake to assess sediment accumulation and sources. (WDNR, ECC-LCD, LECA)*

j. *Stabilize island margins in heavy boating areas to minimize future slumping of sediments. (WDNR, ECC-P&F, ECC-LCD, LECA)*

k. *Conduct a boating impacts study in areas where there is likely sediment mobilization to determine if boating restrictions should be instituted in the future. (WDNR, ECC-LCD, LECA)*

E: Invasive Species Control

Goal:

Prevent the expansion and new infestations of invasive species

Objectives to Prevent Invasive Species Problems:

a. *Utilize the current Clean Boats/Clean Waters program to educate riparian shoreland owners and lake users about the risk of spreading aquatic invasive species from lake to lake and the practices that should be utilized to minimize the spread of invasive species between lakes. (BCR/CCS, ECC-LCD, LECA)*

b. *Continue to recruit volunteers to work in the Clean Boats/Clean Waters program for Lake Eau Claire. (BCR/CCS, LECA)*

c. *Educate riparian landowners of the importance of maintaining a healthy plant community and encourage them to leave aquatic vegetation along their shorelines. (BCR/CCS, ECC-LCD, LECA)*

d. *Recruit volunteers to work with the Beaver Creek Reserve to monitor for all invasive species. Beaver Creek/Citizen's Science Center will train volunteers to detect invasive species and establish a routine monitoring program (BCR/CCS, LECA)*

e. *Conduct aquatic plant surveys utilizing techniques used in 2009 at least every 3 years. Analyze the data collected from the 2009 survey and present it to the Lake Association. (WDNR, BCR/CCS, ECC-LCD, LECA)*

F: Recreation

Goal:

Provide safe and multifaceted recreational opportunities

Objectives to Improve Recreational Opportunities:

a. *Provide appropriate and safe public access though proper maintenance and assessment of beach and boat ramps/docks. (WDNR, ECC-P&F)*

b. *Add signage to islands of where bathroom and garbage facilities are located to minimize the usage of islands for waste disposal sites. (LECA)*

c. *Conduct a boating traffic/usage study to determine if any potential boating impacts may exist to public safety, recreational usage/enjoyment, and/or damage aquatic plant communities in critical habitat areas or cause re-suspension of sediments in shallow areas. (LECA)*

d. *Propose improvements to public restroom facilities and piers for better access at public boat landing and County Park. (LECA, ECC-P&F)*

e. *Educate lake users and riparian land owners on revised shoreland rules (NR115) and revised recreational boating rules and how it could change boating activities near shoreland and islands.*

f. Place blue-green algae warning signs in appropriate locations

IV. A Rationale for the Lake Eau Claire Management Plan

Many of the objectives shown in Section III above are in fact future recommendations or continuations of programs or projects already underway. Most of these are funded under some existing county or state program or can be achieved through the cooperative and volunteer efforts of local lake residents and lake resource users, and various organizations such as environmental non-profit and fishing clubs. For the most part the funds to carry out these objectives are minimal and therefore are not dealt with in this section on the proposal.

Therefore discussion here will primarily be limited to achieving objectives related to water quality, fisheries and habitat, and sedimentation. These are also the areas where the Lake Eau Claire Association is seeking financial and in-kind assistance.

A. Water Quality

Over the past 20 years a number of overlapping studies have helped to provide a fairly comprehensive idea of nutrient loading, physical mixing and the ramifications of these properties as they relate to the microbiology of Lake Eau Claire. Most of this information can be found in the reports, presentations and papers listed in Section II B above and can be viewed or downloaded from the LEC Association website: http://www.lakeeauclaire.org/LakeRehab.html

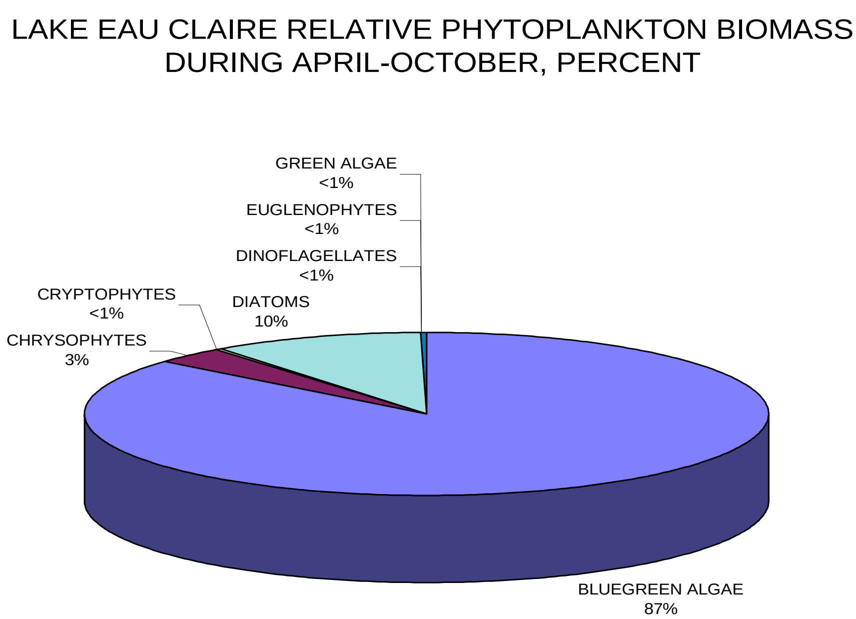

Figure 2: Relative Average Phytoplankton Biomass in 1998

The bottom line of these studies is that Lake Eau Claire is seriously eutrophic for much of the warmer months of the year. Not surprisingly the prevailing conditions during these months result in high levels of planktonic biomass with nearly 90 % being blue-green algae during the months from April to October in 1998 (Fig. 2). The consequences of high blue-green abundances are well documented and characteristics such as greatly reduced water clarity, surface mats of plankton, toxins associated with blue-greens and rapid oxygen depletion in sub-surface waters.

Each year's conditions tend to vary somewhat however in the three years (1998, 2004 and 2006) in during which twice weekly temperature and oxygen profiles were measured the lake's deeper water overturned several times during the summer and into the early fall. Each time one of these overturns occurs a significant amount of phosphate and ammonia are injected into the lake's shallow photic zone and it is believed that these high pluses of nutrients and particularly phosphate induce blooms. On the average from spring to fall the amount of internal phosphorus vs. external from the lake's tributaries are approximately equal (James, W., 1999 ACOE Report) (Fig. 3). However, if one takes

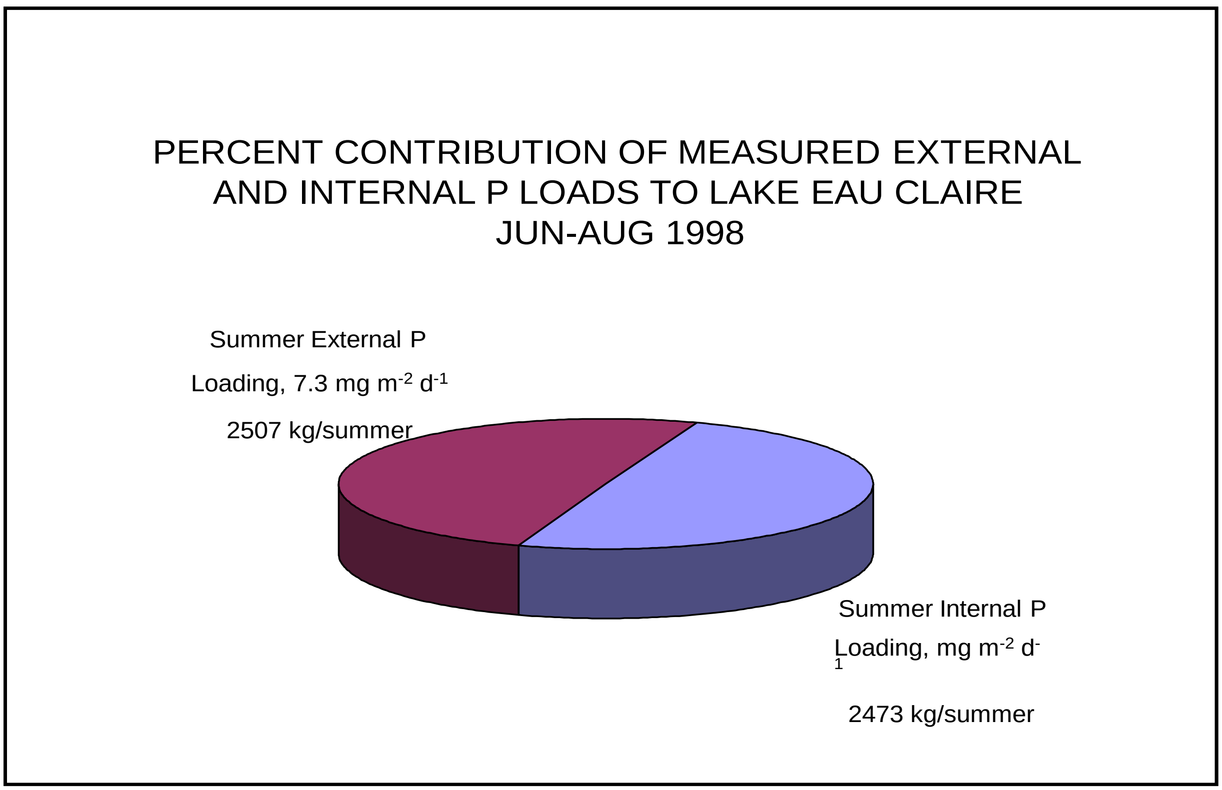

Figure 3: Internal vs. External Phosphorus Loading in 1998

into account the low summer tributary flow rates particularly in recent years and the fact that the internal loading is episodic, the internal source of nutrients may play a dominant role in causing the episodic blooms. If this is the case, a large reduction in internal phosphorus loading may produce a significant benefit in the reduction of blue-green populations. To achieve this ultimate goal a number of possible scenarios were considered of which two appeared to fit best for an impoundment lake with large sources of internal and external nutrient loading.

B. Fisheries and Habitat

This was one of the most important areas for improvement in the sociological survey and probably the most debated during the steering committee meetings. The goals are clear and many of the objectives (see Sections III B&C above) are increased efforts in existing activities or future volunteer activities in the planning and yet to be implemented stages. One additional objective that was not included in the steering committee recommendations, but is being pursued by the local community and is endorsed by the Lake Eau Claire Association is changes to existing bag and size limit regulations that would be more consistent with other area lakes if future fish survey data supports such changes.

Although these regulation changes may take some pressure off the fisheries the most gain will probably come from restoring fisheries habitat. This can be facilitated in a number of ways. One of the most immediately productive ways is to increase the amount of coarse woody debris (CWD) in the lake and particularly along the shorelines. The abundance of CWD that once existed in and around the edges of the lake has all but disappeared. In a shoreline survey in 2009 less than 10 tree falls were counted. Certainly with over 40 miles of largely wooded shoreline many more tree falls must take place, but apparently removal by lake property owners and by ice flows during the spring eliminates most of the tree falls quickly and before they offer much benefit to the fisheries and other wildlife.

C. Sedimentation and Erosion

Addressing sedimentation and erosion concerns were another top priority in both the sociological survey and the steering committee meetings and one that people expressed urgency about. Over the last 10 years three dredging projects have already been tackled: Muskrat and Hay Creek tributaries on the north side of the lake and the area in front of and adjacent to the Skid Row boat landing. The plans for these projects and for more extensive dredging projects for the whole lake and for the area upstream of the Skid Row boat landing were developed by Ayres Engineering (Ayres 1997). The larger projects were not acted upon because of the estimated high costs involved; as much as $33,000,000 for the whole lake dredging project.

The common wisdom today is that much of river and main body of the lake have been filled in by sedimentation since the lake was flooded in 1937. In their analysis Ayres used maps from the early 1960’s and 1990’s to examine this trend and concluded that a major amount of sediment had filled in much of the lake. I n preparing for the 2009 steering committee meeting a problem was discovered with the earlier maps that Ayres used in their analysis. First the geographic coordinates were seriously in error on one of the maps and resolution inferior to a more recent map from 2007. One of the early maps was apparently used by Navionics, Inc. to produce their commercial GPS fishing map for

Lake Eau Claire it was not close to matching the actual lake bathymetry. In addition, if the lake had filled in to the extent suggested in the Ayres report, the river channels would no longer be distinguishable. Yet they are clearly defined throughout the lakes as are other distinct features such as logs and stumps that are not buried in the sediments.

Much of what is believed to be sediment filling is the result of shoreline erosion and slumping of steep sand drop-offs along the shorelines and islands that were created in the 1950's excavation project. Today the primary threats to the lake come from the 5 small tributary streams along the north shoreline. In these cases the problem can be dealt with by installing sand traps that are cleaned out regularly. This has been done for three of these tributaries and two remain to be completed, in the NW corner of the lake and at Muskrat Creek.

V. TECHNICAL DISCUSSION AND DESIGN

A. Water Quality Proposal

1. Scenario One: Siphoning Deep Anoxic Water

A CE-QUAL-W2 water quality model was developed by the Army Corps of Engineers for Lake Eau Claire to help predict the effectiveness of a proposed bottom withdrawal pipe on reducing internal phosphorus loading. In theory, this pipe-scenario would promote mixing throughout the summer and keep water overlaying the profundal sediments' oxic, which limits P flux into the water column. Predicted reductions of anoxic sediment surface area from the model runs varied with the rate of outflow from the pipe. In a 140-acre study area surrounding the withdrawal zone, the maximum "run of river" discharge pipe showed more than a 90 percent reduction from the existing modeled condition during 1998 and 2006 summer time periods. A fixed withdrawal pipe set at 70.8 cfs (2 cms) showed reductions around 87 percent for both summers. A fixed withdrawal pipe set at 35.4 cfs (1 cms) and a 35.4 cfs pipe with 2 intakes spaced 100 meters apart showed nearly the same reductions of about 63 percent and 48 percent for 1998 and 2006, respectively. Although the model predicts a reduction in anoxic build-up in the hypolimnion using a siphon, this study suggests that it is not a practical option for several reasons: the reduction appears to be localized to the pipe's inlet and periods of anoxia still existed under the maximum discharge scenario.

2. Scenario Two: Compressed Air Injection Destratification

To reduce the internal phosphorus loading, we are proposing to install and operate during

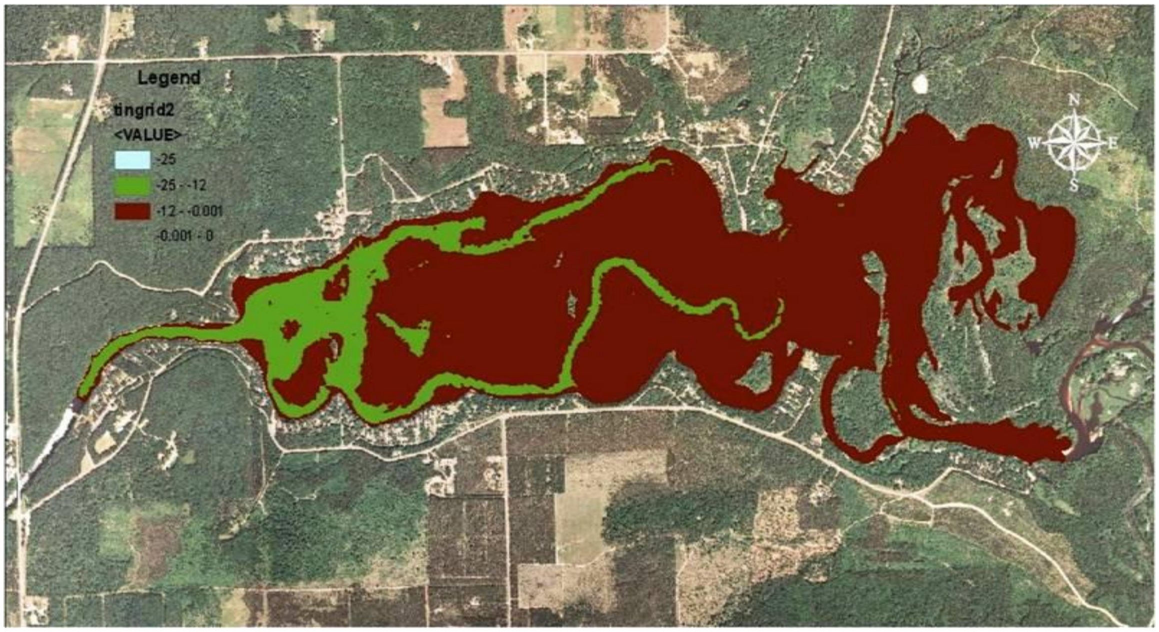

Figure 4: Green Areas Indicate Depths Greater than 12 Feet from 2007 Survey

the open water period of the year a air stream induced destratification system to cover roughly a 200 acre area of the deeper western portion of the lake (Fig. 4). To develop the plan for such a system the Lake Eau Claire Association hired Richard Wedepohl (former-ly with WDNR and now Lake Management Consultants, Inc.) as a consultant and also con-sulted with several corporations with expertise in aeration systems and compressor and blower technology. The destratification system described below takes into account all of the consultant advice plus experience gained from operational systems already used in other lakes in the Wisconsin (Garrison, P. J. 2009 and Sommerfeldt, S. K.

Another similar approach to destratification uses higher forced air pressures (60-80psi) over a more limited aeration pipe expanse **(**Wilhelms,S.C 2012. ERDC-CHL-MS Con-tractor). The main advantages of this approach over low injected air pressure mixing is that shorter diffuser pipe lengths are required and the system is less sensitive to changing bathymetry (variable air flow rates with depth).

3. Proposed Objective: Destratification System Design and Implementation

The preliminary design plan is to provide sufficient mixing to the lower 200 acres on the western end of the lake and the Eau Claire River outlet channel (Figure 5). This will re-quire an estimated 200 to 400 cfm (cubic feet per minute) of air to prevent stratification from occurring in the lower 200 acres of the lake, an area where most of the internal re-cycling of nutrients appears to be occurring. This estimate is based on experience in oth-er lakes and reservoirs and may need to be further refined. Unlike most of the other lakes where destratification systems have been successfully employed Lake Eau has some fea-tures which may help facilitate vertical mixing and sediment phosphate release. First, the lake is an impoundment with a flooded river channel meandering down the length of the lake. This channel provides a continual supply of cold oxygen-rich-water which because of density should be subducted and follow the deeper connected old river channel on the east end of the lake. The deep water residence time is therefore shortened on the east end of the lake and the development of anoxia is limited or non-existent at most times. This was verified by the vertical profiling studies for oxygen and temperature in 2004 and 2006 and by absence of elevated phosphate in this region during 1998 summer study. Field data suggests that the major source of phosphate is coming from the deep water on the west end of the lake and this is consistent with evidence for where the plankton blooms begin and appear to be most intense.

System design must also take into account that since the lake is a stream fed reservoir water residence time and flow rates come into play. According to the recent bathometric map produced by the Wildlands School, the gross storage of Lake Eau Claire at normal pool is 6,400 acre-ft. The drainage area at the Eau Claire River dam is 597 mi2 (USGS Open-File Report 83-933). Using the water yield data from the nearby gages, the mean May 1 to September 30 flow is estimated at between 840 and 880 acre-ft/day. Dividing the gross storage of 6,400 acre-ft by this figure yielded an estimated hydraulic retention time of around 7-8 days. The hydraulic retention increases by about one day if the time period is restricted to June 1 to September 30 time period.

Another unique feature of the lake is its long axis orientation from east to west. Prevailing winds on the lake surface are often easterly or westerly. The long fetch for easterly winds down the lake should enhance destratification measures and in fact even without such measures the lake naturally overturns several times from spring to fall as was seen in the studies in 1998, 2004, and 2006. Although the westerly winds have a shorter fetch they should also aid in destratification. Because of the narrow east-west orientation of the lake basin and the relatively high surrounding shorelines one would also expect that seiches are a common feature in the lake and through pressure gradient fluctuations may induce deep water pumping from the river outlet channel back into lake. Since this channel is the deepest part of the lake and the most anoxic and probably never overturns until the fall density overturn it could represent a significant flux of phosphate into the deep water basin on the east end of the lake.

One of the primary goals of aerating the lake is to stop iron in the system from being reduced from its ferric to ferrous forms. If this occurs because anoxic conditions develop then the phosphate that is bound to the ferric form is released. A constant oxygen supply in the water down to the surface of the sediments will dramatically inhibit this phosphate release, if there is sufficient iron available in the bottom water and sediments. This was tested in August 2011 by sampling the hypolimnion on the west end of the lake and analyzing for iron and phosphorus. The results showed a average concentration of 2.33mg/L for iron and a Fe:P ratio of 11.1/1 (James WF. 2011. Analytical report in supplemental information). The minimum Fe:P ration for complexing phosphorus is 3.6/1 (Gunnars et al., 2002 and Jensen et al., 1992). Hence it is confirmed that there should be amply available iron is bottom waters of Lake Eau Claire to sequester phosphate.

a. Destratification System Option 1

Based on these considerations the design for the destratification system should cover the areas shown in Figure 5. Given the long lengths of piping needed to distribute air over the entire 200 acre area of the lake from a single point, a preliminary design was considered that used two locations for the blowers or compressors sources. The feasibility and cost effectiveness of having two independent pump houses makes this an unlikely scenario. Nevertheless because of significant depth differences between the two destratification areas two separate air supply sources may be required. It is important to keep in mind that smaller size pipes ease installation and shorter pipe runs are more efficient in preventing excessive head losses. Also efficient blowers, as opposed to compressors, could be used to reduce energy requirements. Obviously the ability to find suitable locations for a blower housing and the availability of power are important considerations as well. So balancing these considerations led to the choice of three potential locations for the pump houses which are shown in Figure 6. For the sake of the discussion here we are using the location in the Eau Claire Lake's County Park as one site and a location (yet to be determined) in the NW corner of the lake as the other.

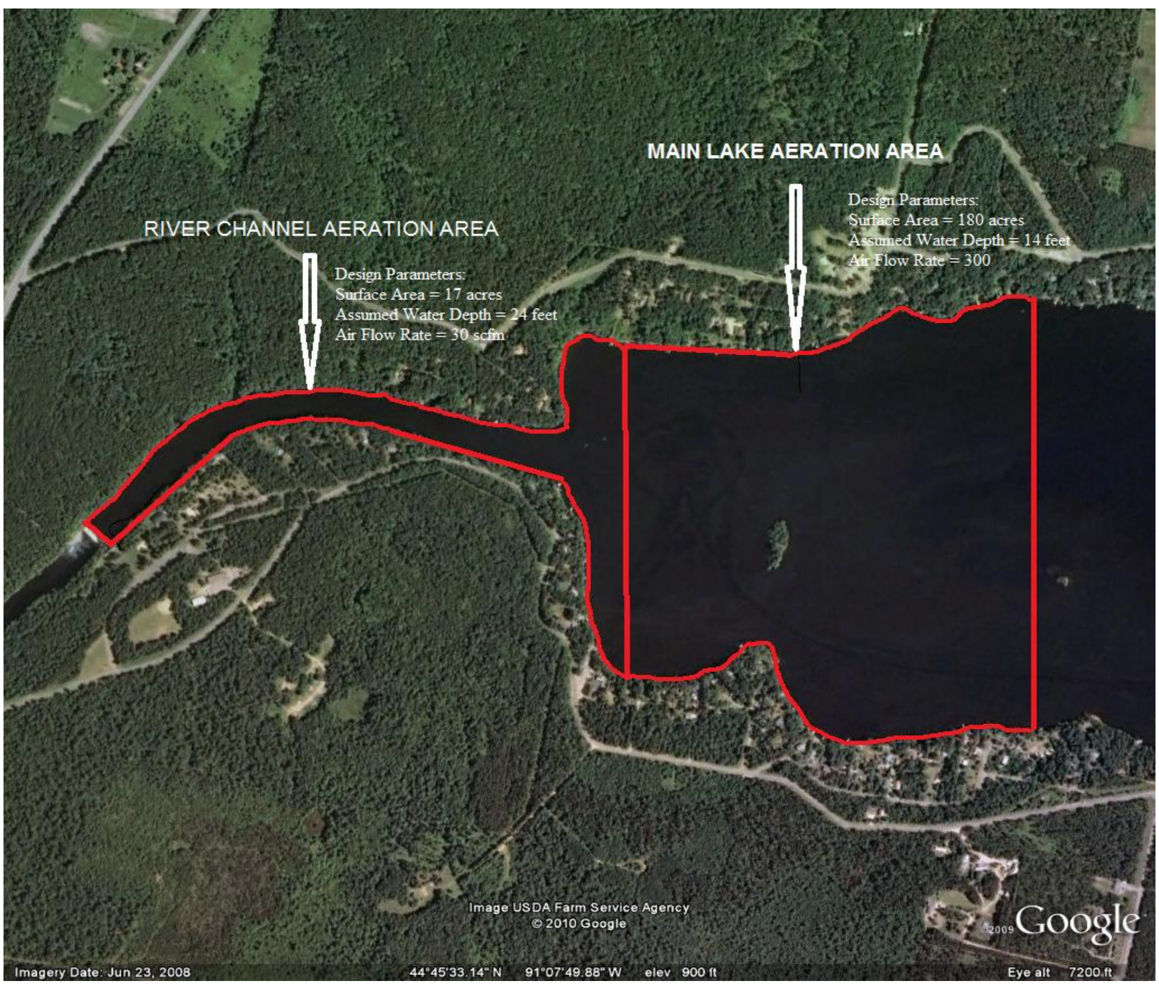

Figure 5: Destratification Areas and Design Parameters

Air Volume Requirements and Discharge Location: Research on lake destratification systems has shown that between 1 and 2 scfm (standard cubic feet) of air, per acre of lake, will provide the energy needed to maintain a destratified system. Air release points are preferably located in the deepest part of the lake to maintain an oxygenated area immediately above the lake sediments. Studies have also shown that lake mixing will not occur in areas deeper than 1 to 2 feet below the point of air release (deeper areas will go anoxic), therefore system piping should generally be located in the deepest possible parts of the lake.

Basic System Components: The basic components of an air distribution system start with a shore based blower or compressor that is housed in a small shelter. The blower or compressor discharges to shore based piping that then connects to polyethylene distribution pipes. Pipes can be weighted in a variety of ways but experience has shown that use of steel reinforcement rod, running the continuous length of the pipe is preferable. This design provides both weight and strength to the line, to the point where even if the lines are accidentally hooked with an anchor and pulled to the surface, they can be released and will simply sink back to the bottom undamaged.

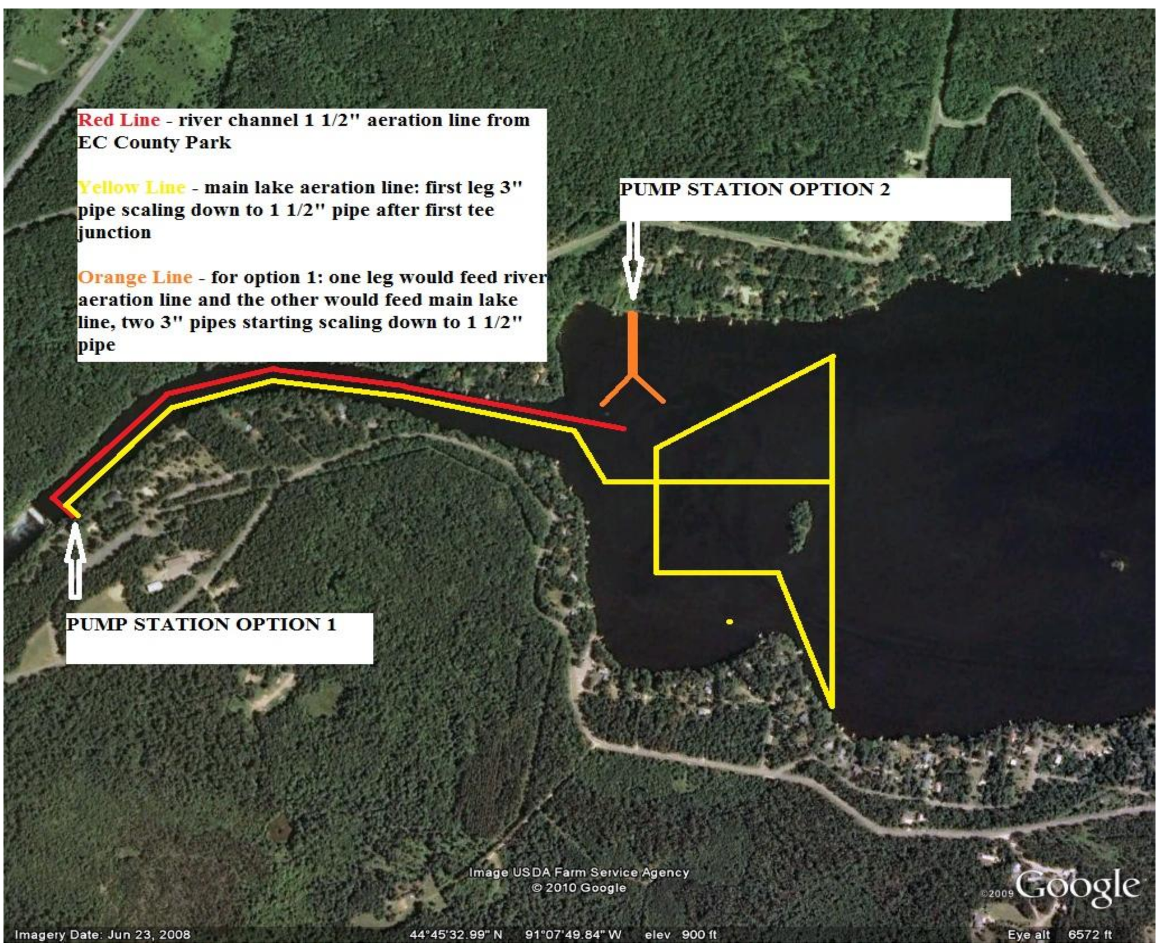

Figure 6: Destratification System Option 1

Air is released from several points along the pipes through drilled holes. Size of the holes can vary and are not critical but use of 1/8" to 3/16" diameter holes is common. Although more complex designs are available that incorporate ceramic stones, micro-diffusers, etc. these systems have been shown to be no more, and even less, effective than the simple drilled hole.

A key requirement of ensuring even airflow distribution along the length of pipe is to ensure air holes are as close as possible to the same depth. Quite simply, more air will be discharged from a hole that is closer to the surface than one that is deeper because of the differential water pressure against the air pressure at the point of release. Typical installations attempt to maintain no more than a 2 foot difference in water depth. As an example, 50% more air will flow out of a 1/8" diameter hole than from one located at a water depth 2 feet lower, possibly resulting in uneven mixing. Although discharge systems can be designed with different sized pipes and orifices to compensate for different over pressures, this level of design detail can usually be avoided by carefully locating the pipe along the same depth contour, again as close to the deepest part of the lake as possible.

In this example a blower/compressor house would be located in the park area preferably near the dam. Two pipes would be run, one down the channel towards the lake and the other down the channel towards and into the main lake. The 1½" weighted polyethylene line would supply approximately 30 scfm over the 17 acres of water area. Another option would be to increase airflow and extend a discharge pipe further into the lake along the current river channel. With the pipes laid at the 24 foot contour, pressure required to overcome 24 feet of water would be approximately 10.4 psi and additional piping and outlet losses would put blower pressure requirements close to 15psi. Although this pressure begins to push the capabilities of blowers, there are certain types of modified blower units which could meet requirements of as much as 18 psi. Blowers, as opposed to compressors, are more reliable and efficient at moving high amounts of air. If higher pressures are required then a compressor design would be needed.

Typical Blower (Options 1 and 2) Requirements:

Outlet Channel: 30 scfm @ 15 psi to 17 psi Gardner Denver CycloBlower, 10 to 15HP

Main Lake: 300 scfm @ 11 psi, Gardner Denver IQ package approx 25HP

Three phase power will probably be required for this pumps. Three phase power is available from supply lines on highway 27. Since getting three phase power to designated pump station sites on the lake may could cost $15-20,000 it could prove more economical to use 3-phase converters at the pump station.

b. Destratification System Option 2

Another option would be to locate the pump station in the NW corner of the lake (see Fig. 6). This site would provide shorter distance supply pipe runs to the destratification zones.

This would be the most desirable approach however costs of land acquisition and site development may make this option prohibitive. The process of acquiring this land is underway and the preliminary land survey is included in the appendix as item A.

In this option a blower/compressor house would be located on the north shore (Fig. 6). Three pipes, each approximately 1900 feet long, would be placed on the bottom at the 14 foot water depth. Three inch (3") diameter polyethylene lines would each carry 100 scfm of air for a total of 300 scfm, mixing approximately 180 acres of water area. With the pipes laid at the 14 foot contour, pressure required to overcome 14 feet of water would be approximately 6.1 psi plus pipe losses and outlet losses, totaling about 11 psi requirement. Again it would be possible to use an air blower rather than a compressor.

A larger number of smaller diameter pipes, as many as 9, 1 ½" could also have been used. Advantages would include more complete mixing (although the aerial extent of mixing provided by 3 pipes would probably be adequate) and ease of handling and installation. Disadvantages would likely relate to higher costs and having more areas of the lake where pipes could be disturbed by anchors, etc.)

c. Destratification System Option 3 (Favored Design Approach)

Destratification options 1 and 2 have for a number of reasons evolved into the favored option 3. Using the data that was supplied Steven Wilhelms a contractor for USACE Water Operations Technical Support (WOTS) program put together estimates for the required energy to overcome summer stratification in Lake Eau Claire. The following is a summary of his approach and findings.

A destratification system design tool (Meyer 1991, Yates 2008) was applied to the characteristics of Lake Eau Claire. The spreadsheet, entitled "DESTRATIFICATION," was based on design equations and graphs by Davis (1980). The procedure computes the potential energy represented by the stratified reservoir, given observed or estimated temperature profiles and the elevation-storage relationship. The spreadsheet also computes the potential energy of the mixed reservoir. The difference between these two potential energies is the theoretical energy input required to destratify the reservoir. However, the spreadsheet procedure also adds heat input from solar radiation during the stratification season. Although wind mixing can significantly contribute to destratification, because of the unreliability of wind, it is not included in the design process. In sizing the compressor pressure requirements, Davis (1980) procedure accounts for:

a. The air flow required for destratification
b. The hydrostatic pressure of the maximum depth of the diffuser
c. Pressure in excess of hydrostatic at the end of the diffuser (assigned)
d. Pressure loss due to pipe friction
e. Pressure drop due to valves, pipe bends, filters etc. (estimated)

In Davis' design procedure, the diffuser pressure is higher than hydrostatic to reduce the pressure differential across the diffuser holes; thus providing a more uniform distribution of air along the diffuser, if the diffuser is not horizontal.

The selection of the temperature profile actually dictates the system size (diffuser length and compressor size). As this implies, using an early-season temperature profile will result in a much smaller system than using one from mid- to late-summer. Of course, a system designed with early spring profiles requires initiation early in the stratification season (longer operating season). However, from a design and risk perspective, we may desire a system that would have sufficient capacity to destratify the reservoir with a late-summer temperature profile, should the occasion arise due to power or equipment failure. Davis recommends design profiles that vary by about 4 ^{o}C (~8 ^{o}F) from surface to hypolimnion. Since Lake Eau Claire is in the northern latitudes, the summer 2006 profiles meet this recommendation, but also represent the strongest stratification occurring in Lake Eau Claire. Thus, profiles were selected from summer 2006 to represent the lake's stratification by maximizing the difference between the near-surface and bottom temperatures.

The depth of water above the diffuser also contributes greatly to the compressor size, particularly for required pressure. In the initially proposed design, the diffuser was to be laid at a depth of about 14 ft in the main portion of the lake. The mixing caused by a pneumatic system usually does not extend to depths below the elevation of the diffuser. This may be more pronounced in Lake Eau Claire, because of the relatively cold inflows that would tend to travel through the reservoir near the bottom. This may result in an anoxic hypolimnion below the diffuser, similar to the existing conditions. Although smaller in volume, this stratified condition may "turn over" during a wind event and could potentially deliver nutrients to the photic zone in quantities sufficient to cause algal blooms. Thus, a diffuser depth of 22 ft was selected for this design evaluation. A revisit to the CE-Qual-W2 model might address this concern and allow a redesign of the system with a shallower diffuser depth and result in a smaller compressor.

The following data were input into the spreadsheet DESTRATIFICATION:

a. Surface area of the reservoir in the summer: 6400 acres
b. Storage capacity versus depth (Table 1, Figure 7)
c. Depth of water above diffuser: 22 ft
d. Days required to achieve destratification: 5 days
e. Internal diameter of diffuser line: 2 inch
f. Internal diameter of supply line: 2 inch
g. Approximate length of supply line: 500-900 ft (assumes compressor on Northwest shore)

h. Typical temperature profiles: Summer 2006 (Table 2[1])

Table 1: Depth Versus Storage Capacity

Top of Depth Interval Meters	Cumulative Storage Meters^3
0	7,896,366
0.5	6,298,945
1	4,762,681
2	2,422,457
3	965,679
4	310,343
5	96,828
6	28,777
7	4,706
8	0

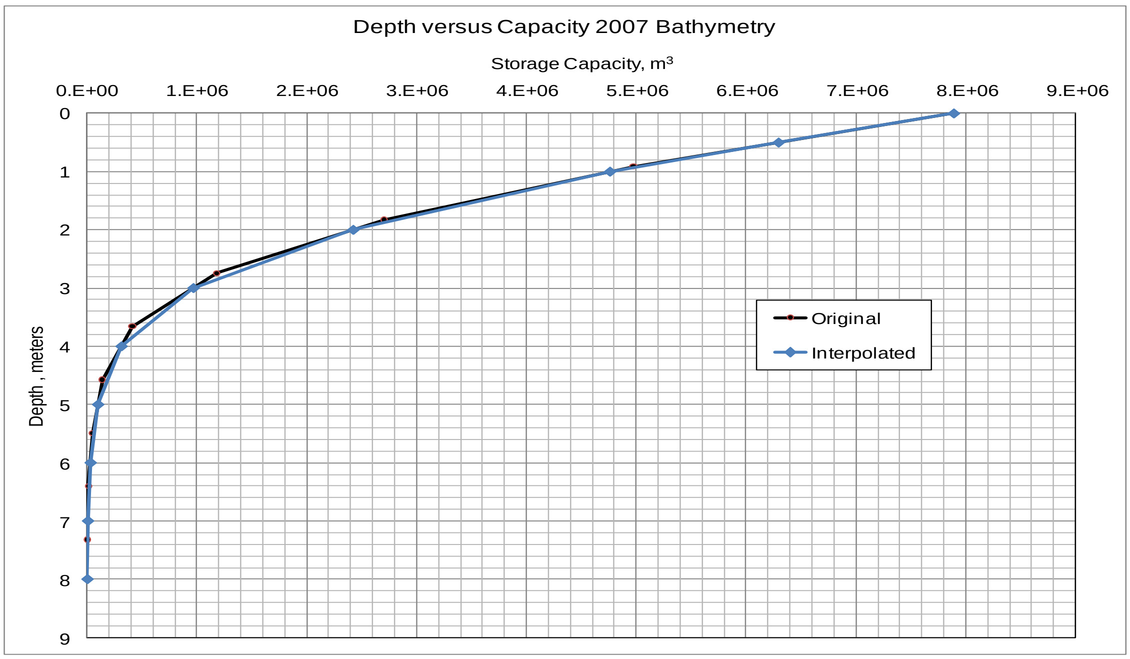

Figure 7: Depth versus Capacity Bathymetry in 2007

Table 2. Lake Eau Claire Temperature Profiles for Destratification System Design*

Date>	6/24/12	6/29/12	7/4/12	7/16/12	7/17/12	7/18/12	Max/min
Depth, m	^oC	^oC	^oC	^oC	^oC	^oC	^oC
0.0	22.9	25.6	26.7	24.8	26.0	25.2	27.4
0.5	22.9	25.6	26.7	24.8	26.0	25.2	27.4
1.0	24.8	27.9	29.1	27.1	27.9	27.1	27.3
2.0	23.2	25.8	26.9	26.7	26.9	26.5	26.0
3.0	22.5	23.6	24.8	26.3	26.0	26.0	24.9
4.0	19.8	21.0	21.7	23.6	22.5	23.6	22.0
5.0	16.4	17.1	18.3	19.8	19.0	19.8	18.4
6.0	13.3	14.9	16.4	15.6	16.4	16.8	15.6
7.0	13.3	14.9	16.4	15.6	16.4	16.8	13.3
8.0	13.3	14.9	16.4	15.6	16.4	16.8	13.0

The spreadsheet provides “instantaneous” results simply by changing the temperature profile, supply line diameter or length, or the depth of water above the diffuser. Table 3 gives the results of the design procedure for the conditions given above. Based on Davis’ (1980) design procedure, the 2-inch-diameter diffuser should be about 290 m (950 ft) long with air supplied at 225 cfm at a pressure of about 70 psi.

Table 3. Destratification system Design from Davis (1980)								
Supply Line	500	ft						Design
Air flow, cfm	200	225	230	176	200	183	233	225
Pressure, psi	65	69	70	62	65	62	70	70
Length, ft	~885	~950	~965	~810	~882	~833	~975	~950
Profile Date>	6/24/12	6/29/12	7/4/12	7/16/12	7/17/12	7/18/12	Max/min	
Supply Line	900	ft						Design
Air flow, cfm	200	225	228	177	200	184	234	225
Pressure, psi	67	71	72	63	67	64	73	70
Length, ft	~885	~953	~962	~813	~882	~833	~975	~950

The perforations in the diffuser pipe should be spaced at 1 ft and drilled on one side of the pipe. The ports should be drilled with a small 1 mm bit, since Davis indicates that smaller diameter ports provide enhanced entrainment in the bubble plume. The air should be filtered to provide particulate-free and oil-free air. Davis recommended high-density polyethylene pipe and that the diffuser be place in the deepest part of the reservoir.

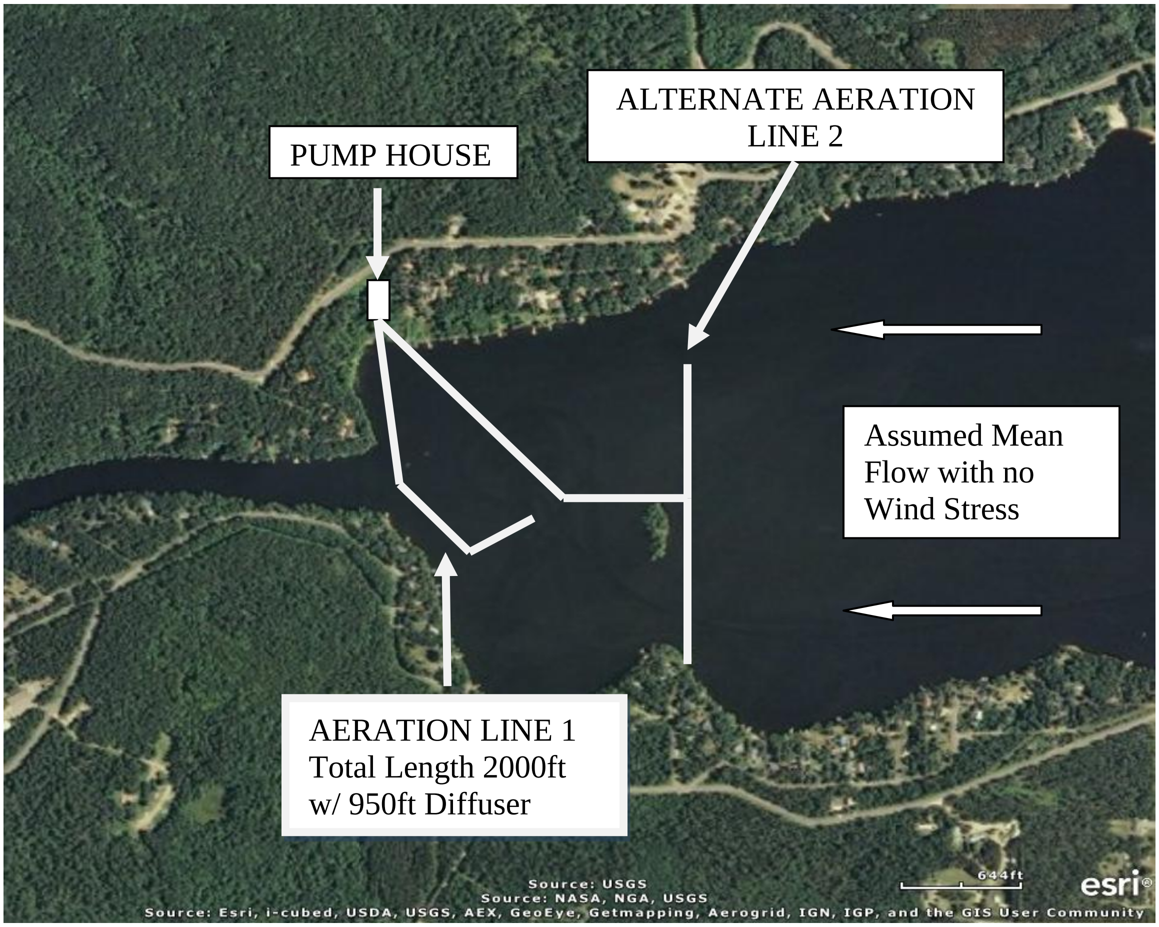

Figure 8: Destratification System Option 3

The model results indicate that 225 cfm at 70 psi are required and that this is to be applied over a continuous length of 950 ft of perforated 2 inch ID line. To meet this design criteria it is proposed that Aeration Line 1 (Figure 8) be installed in the deepest part of lake basin. This will require 1050 feet of 2" supply line from the pump house to the 950 foot length of the diffuser section.

Because of the high head pressures that have to be overcome a high volume rotary screw compressor fits the bill. There are several commercial candidates that are available (see quotation in appendix B for one of these. This 50hp Kaiser rotary screw compressor supplies 236 cfm at 111-125 psig which not accounting for supply line pressure loss translates to 374 to 421 cfm at the head of the diffuser lines. This should provide an ample supply of compressed air without taxing the compressor. The compressor air would first be feed to a 250-500 gallon ballast tank at 111-125 psig. The air would then be dispensed using an adjustable flow controller. If there is a requirement at some point to expand the diffuser network for additional mixing another flow controller can be easily added. Using this design the air supply to the diffuser network would be adjustable and could be fine tuned to provide the optimum mixing characteristics and duty cycle on the compressor to improve energy efficiency and lifetime.

The design for Option 3 is shown in Figure 8 where the diffuser is positioned to follow the deepest part of the submerged river channel. The bathymetry in the west portion of the lake is complicated by the changes in direction of the river channel, by the presence of bars and islands, variable depths (deeper near the river opening), and a predominately mean flow from east to west. The flow will tend to compress the destratification process towards the west end of the lake. Wind stress and night time cooling will probably tend to spread the mixing eastward, but to what extent is hard to estimate, and of course the frequency of such events is difficult to estimate.

The advantage of the system described here is that it is easily upgradable by adding additional supply and diffuser sections. For example to address the differences in depths two separate regulated supply and diffuser lines might originate at the pump house. One would cover the river channel entrance (for 20-25 foot depths) and the other the central and eastern part of the east lake basin (for 12-20 foot depths). These could be designated as aeration line 1 and alternate aeration line 2, respectively in Figure 8. Because of the larger area to be destratified most of the compressor air volume could be supplied to aeration line 2. Another consideration is to design diffusers with segmented flows as a way of providing a more uniform dispersion of mixing energy throughout the destratification area.

High density polyethylene pipe will be used for the supply and diffuser lines. Anchoring the pipe can be accomplished in several ways. In the past, spaced discrete anchors or continuous weighting of the pipe with steel rebar has been used. For the latter, the buoyancy of the 2 inch ID (2.5 inch OD) pipe is approximately 2.13 lb/linear ft not including the weight of the pipe. One-inch diameter reinforcing rod (rebar) provides approximately 2.33 lb/linear ft of negative buoyancy, giving excess ballast of only about 0.4 lb/linear ft including the approximately 0.2 lb/linear ft of pipe, which may not provide sufficient ballast.

Davis provides an equation for computing the size or spacing of anchors for the submerged supply pipe and diffuser. To manually handle a concrete anchor, let's assume a reasonable weight of 33 lb (15.0 kg); cast in a block approximately 5.6 inches (~18 cm) on each side with provisions made to accommodate and hold fast the piping. Based on Davis' equation, spacing for this anchor would be about 8.9 ft (2.7 m). This distribution of weight provides approximately 3.7 lbs/linear ft (~5.5 kg/m) of diffuser, not including the weight of the pipe. To use a rebar and match this weight distribution, a 1.25 inch rebar would be required. Perhaps some trade-offs may be made to reduce the ballast to allow ease of placement and retrieval and allow fishermen to "retrieve" the diffuser to free an anchor.

B. ***Fisheries and Habitat Proposal***

1. Proposed Long-Term Objectives:

The objectives under IIIC above will be organized and overseen by the LEC Association and appointed committee of local appropriate agencies and organizations. Lake wide plans developed and implemented and permits sought by this committee. This will be a long term ongoing activity since replacement of habitat will be a continuous issue. The LEC Association will set some annual funds aside for this process, but local and state support will be required particularly during the initial phases of the habitat restoration effort. It is expected that most of the labor will be voluntary and come from local invested individuals and organizations like sportsman and fishing clubs. Therefore most of the cost will be for materials and transportation of materials.

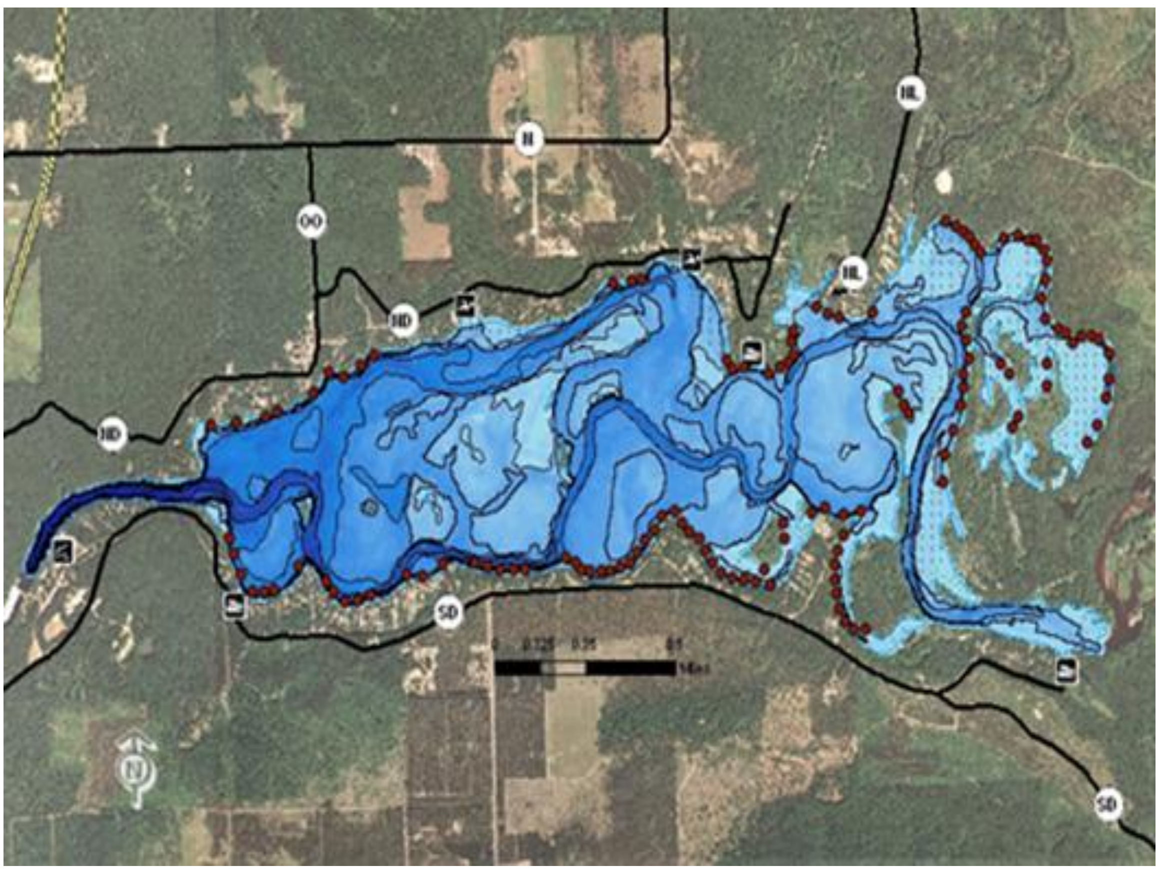

Figure 9: Red Dots Shown 2009 Locations for Potential Tree Falls for CWD

2. Near-term objectives:

1) In 2011 a blanket permit through DNR was initiated to begin to add CWD to areas around the lake.
2) During the 2009 shoreline survey roughly 75 trees that met the approved criteria for CWD (see LECA website). These are indicated by red dots along the shoreline on the

map in Figure 9. These trees are all close to falling and before this happens we propose to fall them and anchor them to the shoreline and plant a replacement tree in their place at the site. Only trees that are in locations were ice removal is unlikely will be used for this purpose.

3) Where CWD structure placements are susceptible ice or high water removal we will use anchored subsurface structures which are referred to as half-log or modified half-log structures and these will only be located in shallow water in the littoral zone. In October of 2011 20 of these modified half-log structures were placed in various locations around the lake. More are planned for 2012 and every year into the future. Modified half-log structures consist of a typical half-log structure with as many as 8-10 2 inch diameter trees or limbs stuck through the open cells in the ballast concrete blocks.

4) Although in the past log cribs were installed throughout the lake in the deeper water they had little beneficial effect because of low oxygen levels at depths greater than 8 feet. This condition was not understood at the time these cribs were installed. Side scanning sonar images taken last year indicate many of these deeper cribs appearing in groups of three are still intact even after 20-40 years. The addition of the destratification system should make these cribs viable and improve the fisheries on the west end of the lake. Experience in all lakes show that the more the groupings of cribs are concentrated, the more the more beneficial are the results. Hence we propose that the existing cribs be supplemented with additional cribs after the destratification is operational.

C. Sedimentation and Erosion

1. Background

Addressing sedimentation and erosion concerns were another top priority in both the sociological survey and the steering committee meetings and one that people expressed an urgency about. Over the last 10 years three dredging projects have already been tackled: Muskrat and Hay Creek tributaries on the north side of the lake and the area in front of and adjacent to the Skid Row boat landing. The plans for these projects and for more extensive dredging projects for the whole lake and for the area upstream of the Skid Row boat landing were developed by Ayres Engineering (Ayres 1997). The larger projects were not acted upon because of the estimated high costs involved; as much as $33,000,000 for the whole lake dredging project.

The common wisdom today is that much of river and main body of the lake have been filled in by sedimentation since the lake was flooded in 1937. The extend of that filling as determined by Ayres in their 1997 report is shown in Table 4. Ayres used maps from the early 1960's and 1990's to examine this trend and concluded that a major amount of sediment had filled in much of the lake. In preparing for the 2009 steering committee meeting a problem was discovered with the earlier maps that Ayres used in their analysis. First the geographic coordinates were seriously in error on one of the maps and resolution was inferior to a more recent map from 2007. One of the earlier maps was apparently used by Navionics, Inc. to produce their commercial GPS fishing map for Lake Eau Claire, however details on the map were found not to be close to matching the actual lake bathymetry. In addition if the lake had filled in to the extent believed and suggested in the Ayres report the flooded river channels in the lake and particularly on the east end would no longer be distinguishable and yet they are clearly defined throughout the lake, as are other distinct features such as logs, fish cribs and stumps that are not yet buried in the sediments. Not only would these features have been buried, but the navigable regions of the lake would have largely disappeared with the addition of 6,000,000 yd3 of sediment to a lake basin with an estimated total volume of less than 10 million yd3. If the Ayres estimates were correct there would be clear evidence of substantial progressive shallowing in bathometric charts from 1952, 1960 and 2007. This clearly is not the case.

TABLE 4: DREDGING VOLUMES IN CUBIC YARDS FROM AYRES REPORT 1997

AREA RESTORED	TOTAL RESTORATION TO RETURN TO 1937	LIMITED RESTORATION TO RETURN TO 1960
Total Lake*	6,000,000	3,000,000
SE Boat Landing	18,500	5,000
Hay Creek Estuary	70,000	24,000
Muskrat Creek Estuary	120,000	33,000
EC River Upstream of SE Boat Landing	300,000	163,000

* Includes dredging all lake areas, including the sub-projects, to the 1937 condition and the 1960 condition.

The discrepancies in sediment deposition estimates made by Ayres is also supported by the characteristics of sediment dredged from the mouth of tributaries, sediment coring, and seismic profiling studies of the main body of the lake. Table 5 provides information on particle size and elemental composition of dredged sediments from a tributary deposition area. It is clear that most (98.5%) of the deposit is silica sand with particle sizes greater than 0.1 mm and the remainder is mostly clays. This data implies that most of the sedimentation from tributaries is sand of particle size greater than 0.1 mm which should be removed immediately adjacent to the point where water flow velocity drops below 1 cm/sec (from Hjulstrom Plot). This data suggests that only 1.5% of the total sediment load from the tributaries would penetrate into the lake. Of course there is no way of telling how much of the sediment load not collected at the dredge site did deposit in the lake. However other data indicates that this is a minimal process. A core sample from a low energy area of the lake and seismic profiles indicate somewhere between 30-40 cm of fine slits have collected over a 50 year period. The high organic content of this layer suggests that much of it is accumulating as the result of internal trophic production.

TABLE 5: ANALYSIS OF DREDGED SEDIMENTS

Component	% by Weight			USA Sieve #	Size in mm	Percent Retained			
Na2O(wt %)	0.0153			8	2.38	2.6			
MgO(wt %)	0.1882			10	2.00	1.5			
Al2O3(wt %)	5.0739			12	1.68	1.9			
SiO2(wt %)	92.130			16	1.19	5.4			
K2O(wt %)	0.8730			20	.841	8.2			
CaO(wt %)	0.2889			30	.595	12.4			
TiO2(wt %)	0.1896			35	.500	9.9			
Fe2O3(wt %)	1.2443			40	.420	9.2			
				50	.297	21.8			
				70	.210	15.9			
				100	.149	7.2			
CONGOLMERATE				140	.105	2.5			
				200	.074	1.0			
				270	.053	0.4			
				Pan		0.1			

Because of the characteristics of the sediments in the Eau Claire River it appears that most of the sediment transport is from the bed load. Therefore the bottomset (fine) sediment is minimal relative to the foreset (coarse and heavy) sediment beds.   This is the opposite of rivers like the Mississippi where a large delta of fine bottomset layers precede the foreset layers. The sediment advance in the Eau Claire floodplain region displays a sharp steep frontal wall of sand built over a thin bottomset layer of fine sediments. Therefore there is little swallowing of the river or lake ahead of the progressing frontal wall. This process has been clearly evident for many years.

It is likely that much of what is believed to be sediment filling is due to shoreline erosion and slumping of steep sand drop-offs along the shorelines and islands that were created in the 1950’s excavation project.   Today the primary threats to the lake come from the 5 small tributary streams along the north shoreline and the Eau Claire River input on the east.. In these cases the problem can be dealt with by installing sediment traps that are cleaned out regularly. This has been done for three of these tributaries and three remain to be completed: one in the NW corner of the lake, Muskrat Creek, and the Eau Claire River.

2. Proposed Objectives

The primary objective is to stop further intrusion of sediment into the lake and the eastern flood plain through the use of sediment traps, erosion protection through bank and shoreline stabilization, and where possible reducing the tributary's flow velocity. The composition of the sediment from each tributary appears to be mainly silica sand (>90%) in a size range where rapid settling is the primary removal mechanism. These characteristics suggest that sediment traps should be an efficient means of removing the bulk of the bed load transport.

a. North Shore Sediment Traps

Five small tributaries enter directly into the lake along its northern shore. Each of these tributaries is contributing a significant sediment load that is causing adverse habitat effects at mouths of the tributaries. The Beach Creek, Sandy Point Creek and Hay Creek are three of the tributaries in question and all three currently have active sediment trap installations. These have been installed for at least several years at each site and they are functioning very efficiently. It is proposed that two more such traps be added at NW Creek and at Muskrat Creek. The operational and proposed sediment locations are shown in Figure 8. Although not part of immediate plans it would desirable to institute measures to restore the aquatic habitat and wetlands areas that once existed on three of these tributaries: namely Hay Creek, Muskrat Creek and NW Creek.

i. Maintain Existing Traps

Under this plan the three existing sediment traps at Hay Creek, the Beach Creek, and Sandy Point Creek (see Figure 10) will be maintained and serviced as needed. For the past 5 years of operation the average cost of maintaining these three traps has been roughly $6070 /year (this includes installation and clean outs over 5 years with half paid by LEC Association). These clean out costs could be eliminated or at least substantially reduced by initiating bank erosion measures upstream of each trap.

ii. Muskrat Creek Trap

The Muskrat Creek flood plain area was cleaned out by hydraulic dredging in 2004-2005 with recovered sediment moved to a dredge spoil area (see Figure 10). Unfortunately because of access issues upstream of dredge area no trap was installed although it was called for in the original plan (see Ayres Report 1997). As a result the flood plain has begun filling in again. It is therefore proposed that a new trap be added adjacent to and just to the west of the dredge spoil area. The distance between the two would be roughly 100 yards and the sediment removed would

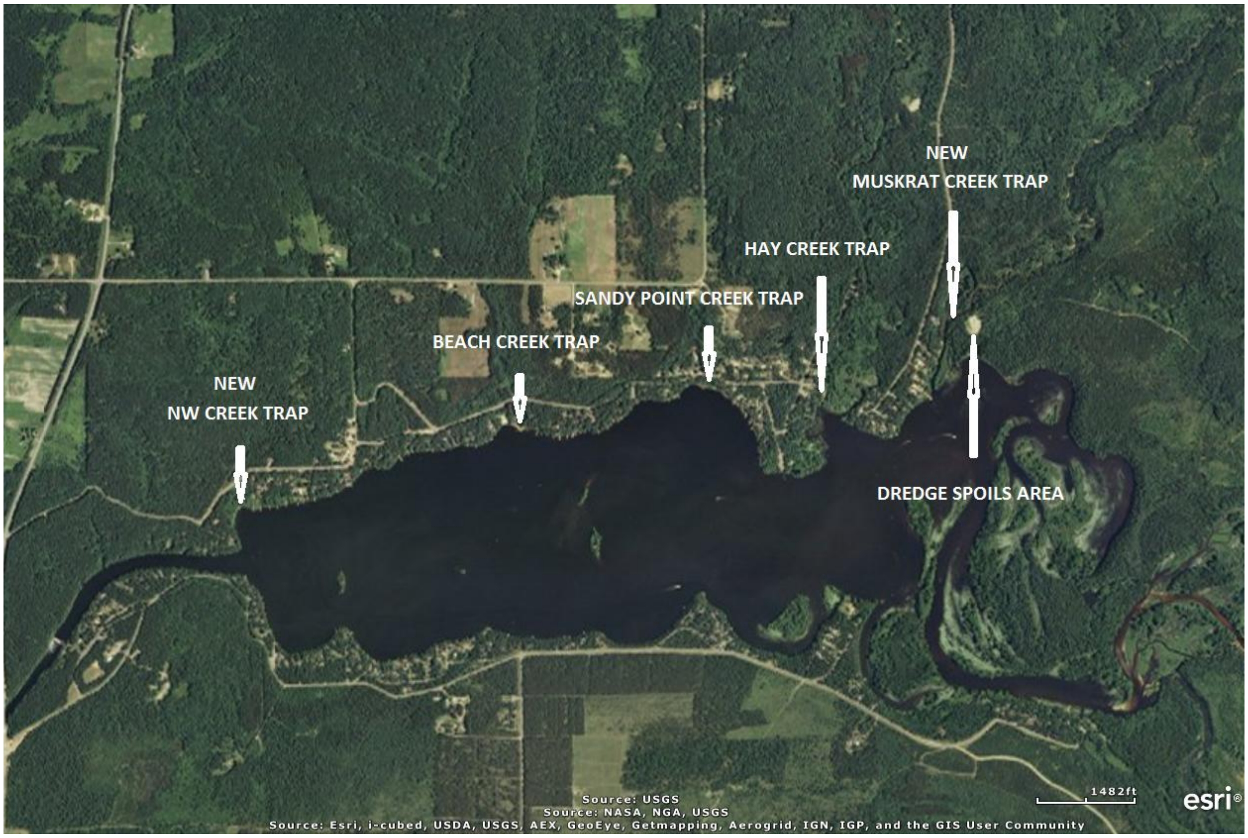

Figure 10: Location of 5 north shore lake sediment traps

be placed in the dredge spoil site. An active permit is still in effect for this site and this will need to be renewed. As with the existing traps above, bank and gulley erosion measures of Muskrat Creek above the flood plain area could dramatically reduce the sediment load. Also further restoration of the head of the flood plain could improve fisheries and wetland habitat in Muskrat and Hay Creek. This subject should be revisited down the road.

iii. NW Creek Trap

A new trap in the Northwest corner of the lake is proposed. A small 1-2 acre biologically productive marsh existed in this area for roughly the first 50 years of the lake's 74 year history. During the last 20 years, the marsh has filled in with sediment and the resulting land area has given way to Tag Alders and thick brush. In addition now that the marsh has filled in the sediment is developing a shallow sediment intrusion into the lake. A trap is proposed in the hill just above the sediment filled area to stop further loss of wetland and lake acreage. If and when resources become available the marsh should be restored and measures taken to limit erosion of the creek bed. At least part of what appears to be accelerated loss of wetland over the last 20 years may be connected to highway modifications on the North Shore Drive of the lake and land clearing. A review of these changes should also be made.

b. Eau Claire River Flood Plane Area

The Eau Claire River remains as the main threat for sedimentation in the eastern part of the lake. There are two main paths for the sediment flow into the lake: (1) filling the main river channel along Skid-Row and (2) the channel through Lost Lake into the critical habitat area of the Rookery. To access the sources for this sedimentation a review of aerial images of the headwaters region of the lake was made back to 1938, one year after the lake was created. In addition field surveys of the flood plain area were used to better define the progress and extent of erosion and sedimentation. Bathymetric data was obtained from charts from 1952 and 1960 and from personal interviews with people familiar with the area prior to and after 1960. Analysis of this data and observations led to developing a plan which calls for adding three sediment traps along the river course and slowing the flow velocity of the water.

i. Troubled Water Bridge Sediment Trap

An analysis of aerial images revealed that much of the sediment that has accumulated over the past 50 to 70 years came from east of Troubled Water Bridge. Therefore a sediment trap at the bridge (see Figure 11) will limit the intrusion of further new sediment into the flood plain area west of the bridge. This is a strategic site for a trap since the road bed and bridge structure eliminates the possibility of river channel rerouting and the fixed narrows creates a choke point for increasing flow velocity and therefore sediment transport a distance below the bridge. These characteristics should lead to a rapid restoration of the river below the bridges and provide river frontage benefits to property owners along this stretch of river.

ii. Gravel Pit Sediment Trap

It is proposed that another sediment trap will be added in the main river channel upstream from the Skid Row site at a location near an abandoned gravel pit. It is proposed that the gravel pit is used as the deposit site for the river sediments. This site is close enough to the proposed river sand trap so that sediments can easily be transported to the gravel pit. Since there is also an existing road to the gravel pit and to the river at this location access to the river will be fairly straight forward. The Gravel Pit Trap (Figure 11) will be used to stop additional sand from further up the river from entering into the sediment storage area. Removing sand from this trap on a regular basis should gradually deepen the river channel between the GPT and the SRT sites by natural river bed load transport. The GPT trap will also serve to stop sediment transport into source C (Figure 12). This is important because it eliminates a new source of sediment to the storage area above SRT and should allow restoration of the old source C river channel to begin. This process could be accelerated by clearing log dams and other flow blockages along the source C channel. This would in short order restore a substantial acreage of prime aquatic habitat and reconnect it to the lake and main river channel.

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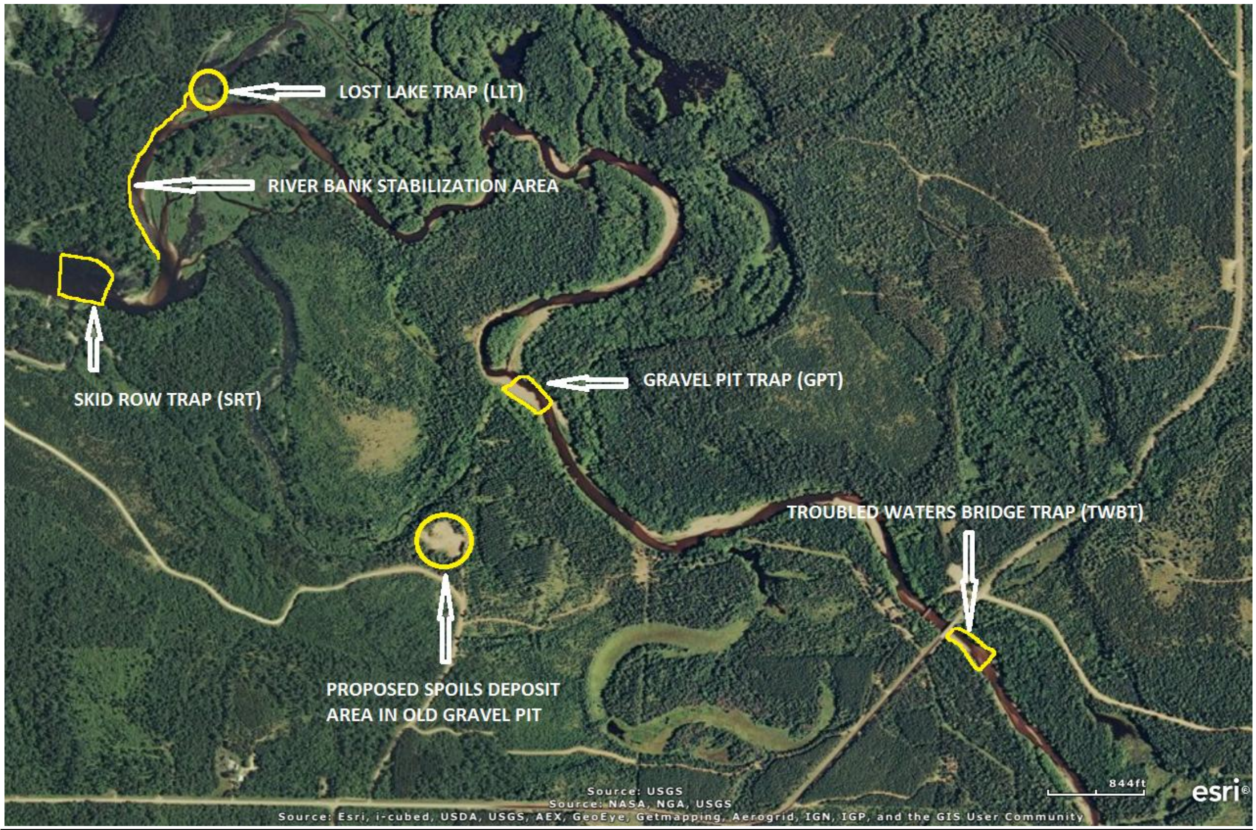


Figure 11: Eau Claire River Sediment Trap Locations

iii. Skid Row Sediment Trap

Add a sediment trap (SRT) at the Skid Row boat landing to stop further intrusion of sediment into the upper region of the lake. It is important that this trap should be added soon to stop further loss of frontage access for riparian property owners in Skid Row. The location of the trap is shown in Figure 11. In the 2010 version of this proposal the SRT Trap was elongated and extended the full distance between the traps SRT and LLT in shown in Figure 11. The terrain immediately south and north of SRT and LLT have elevations that confines the flood plain to the distance between them. It is within this distance that new delta channels could form (particularly during flood events). There is evidence that this is already taking place at several sites along this stretch of river. The most pronounced of these is the channel that is developing between LLT and Lost Lake (see Figure11). At elevated flows about 25-30% of the river is being diverted from the main river through Lost Lake and into Rookery. The Rookery is a critical habitat area with relatively shallow water and with the increase in sediment load it could be lost in a short period of time.

The elongated trap in the 2010 version of the proposal was designed to prevent breakthrough of sediment anywhere between the ends at SRT and LLT (Figure 11). This trap was to be cleaned out by hydraulic dredging and this would still probably be the best although most expensive approach. In the 2012 plan a principal objective was to lower costs and hence the use of mechanical sediment removal methods such as backhoes and draglines was proposed as a cheaper alternative. The idea is to temporally divert the river using chauffer dams and haul the excavated sediments to nearby dredge spoil sites. This does not appear to be a problem at SRT, but its utility for building an elongated trap between SRT and LLT has yet to be determined.

Another alternative is to install a smaller trap at LLT and stabilize the lower stretches of the river bank between SRT and LLT using sediment spoils from both traps as fill and standard bank stabilization techniques. The trap at LLT would have the added benefit of accelerating the deepening of the river channel between LLT and SRT.

iv. River Flow Reduction and Habitat Restoration

The analysis of dredged sediment samples (see Table 5) indicates that the composition is mainly silica sand with particle diameter greater than .1 mm. Therefore this material has high settling velocities and sediment transport will be highly dependent on flow velocities in the river. Therefore sediment transport towards the lake can be reduced by increasing channel displacement volume through the delta portion of the flood plain. It appears from observations that changes to the river bed have occurred (see Figure 12 D, C, and E) over the years and that

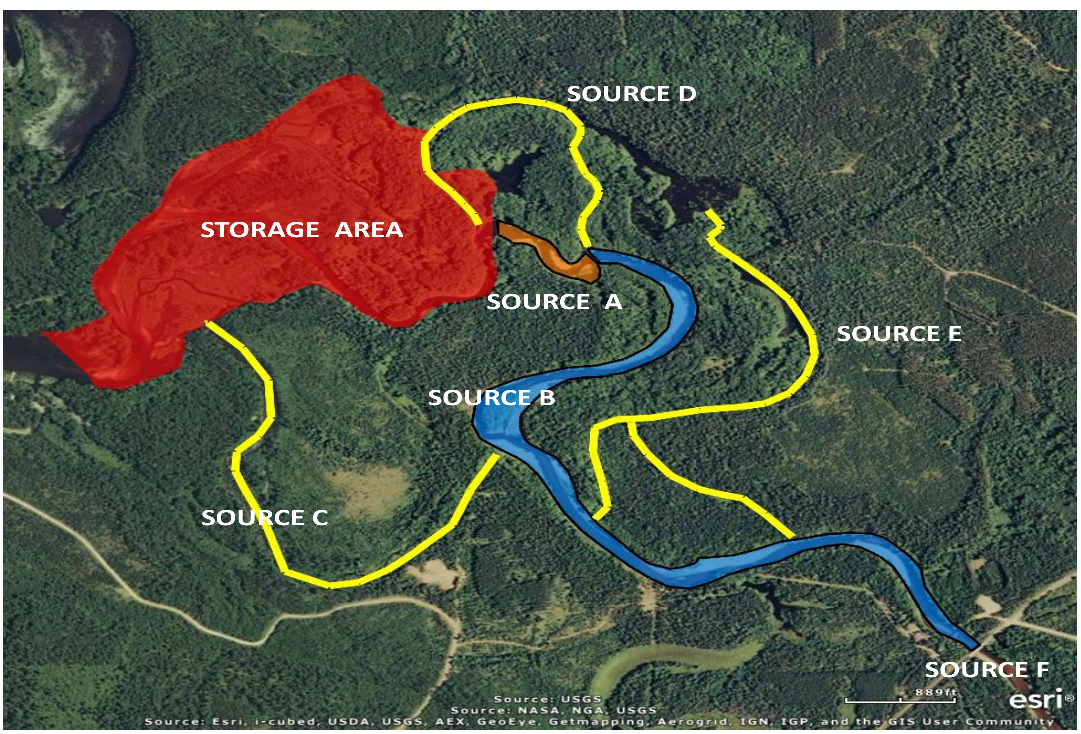


Figure 12: Sediment Storage Area's Primary Sources

these changes correlate to large tree jams that force the river to change course, particularly during high volume flows.

If this is the case, removing these jams would be beneficial in stabilizing the main river channel and recovering much of valuable wetlands and fish spawning areas which have been isolated from the main river system over the last 50 years.

3. Justification of Sediment Trap Volumes and Locations

a. North Shore Sediment Traps

Estimates for sediment removal volumes for the sediment traps shown Figure 10 are given in Table 6. The future estimates for the three currently functional traps are based on their short term histories of operation and the projected numbers from the 1997 Ayres report. Clearly large differences between the two estimates exist and although the operational removal records are short term their reliability is hard to question. Based on this the sediment trap size and removal volumes for all five traps (including new traps at NW Creek and Muskrat Creek) are based on the more conservative operational records going forward.

TABLE 6: CHARACTERISTICS NORTH SHORE SEDIMENT TRAPS

TRAP NAME	YEAR STARTED	TRAP VOLUME Proposed/Actual* YD3	AVERAGE REMOVAL VOLUME, Proposed/Actual* YD3	AVERAGE CLEAN OUT TIME Proposed/Actual* YEARS
Hay Creek	2007	1500	750	2
Sandy Point Creek	2007	600	200	3
Beach	2008	600	200	3
Muskrat Creek	2013 proposed	6,450	2150	3
NW Corner Creek	2014 proposed	1000	200	5

- Actual are based on operating values from 2006 to present. Proposed traps at Muskrat Creek and NW Corner Creek are based on calculated estimates.

These sediment traps serve as a protective measure to stop further intrusion of sediment into the lake and critical habitat areas of the lake and estuaries. They should not be considered as the only part of a long term solution of this problem. It may be possible to eliminate or at least reduce the cost of sediment traps by taking measures to reduce erosion upstream and sediment transport in all of the five tributaries. This in the long run may be far more cost effective and beneficial to overall estuary area than sediment traps alone.

b. Eau Claire River Flood Plane Area

i. Determination of Sediment Influx Since 1938

Since the lake reservoir was flooded in 1937 the region just above the Skid Row Boat Landing has served as a sediment storage reservoir (see Figure 12) where most of the sediment from upstream has accumulated. The overall storage area is roughly 138 acres or 668,000 yd^2 in size and is clearly defined in today's aerial images and from existing features such as characterization of topographic elevations and from vegetation which exists in the fill areas that have formed since 1938. The existing dry areas such as islands and elevated river banks are clearly delineated from what was the river bed 50 and more years ago and today. Such dry areas total 42.9 acres. When this area is subtracted from the overall 138 acres the estimated flooded area in 1938 reduces to 95.1 acres or 460,300 yd^2.

The mean water depth of this flooded 95.1 acres was determined by estimating the relative percentages of the overall area that fell into different depth ranges between 1 and 12 feet. Bathymetric data was obtained from charts from 1952 and 1960 and from personal interviews with people familiar with the area prior to and after 1960. These different depth ranges are shown in Table 7. The area with an average depth of 8 feet was estimated at 22.5 acres. The area with a mean depth of 6 feet was estimated at 13 acres. The area with a mean depth of 5 feet was 8.2 acres. The area with a mean depth of 3 feet was estimated at 51.4 acres.

<u>TABLE 7: 1938 APPORTIONED MEAN DEPTH OF STORAGE AREA</u>

AREA IN ACRES	AVERAGE DEPTH, FEET	APPORTIONED DEPTHS	CALCULATED AVERAGE DEPTH FOR 95.1 ACRES HIGH VALUE	CALCULATED AVERAGE DEPTH FOR 95.1 ACRES LOW VALUE
22.5	8.0	22.5/95.1X8 =	1.89	1.89
13.0	6.0	13.0/95.1X6 =	0.82	0.82
8.2	5.0	8.2/95.1X5 =	0.43	0.43
51.4	3.0	51.4/95.1X3 =	1.62	------
51.4	1.5	51.4/95.1X1.5 =	------	0.81
Average Depth			4.76	3.95

Because this area is by far the largest and is the most uncertain in terms of assigning an average depth, a range between 1.5 and 3 feet was determined. This provided a high and low average depth range for the storage area in 1938, 4.76 feet to 3.95 feet, respectively.

The next step is to determine the volume of sediment that has accumulated in the storage area since 1938. Since much of this area (43.7 acres) today is still covered with a thin lens of water, it is necessary to subtract the average depth of this water today from the average depths in 1938 for the 95.1 acres. Also the average depth of water over the 43.7 acres today is 1.5 ft as determined by field surveying. Also assume that the remaining 51.4 acres is 0 ft at normal flood stage . Using these approximations the correction for sediment deposition can be calculated as follows:

(43.7 acres/95.1 acres X 1.5 ft) + (51.4 acres/95.1 acres X 0.0 ft) = 0.69 ft.

Applying this correction, the mean amount of sediment filling over the 95.1 acres of the storage area since 1938 is the following.

High value: 4.76 ft - .69 ft = 4.05 ft or 1.35 yards

Low value: 3.95 ft - .69 ft = 3.26 ft or 1.09 yards

To determine the average annual volume of sediment influx to the storage area since 1938 the following calculations were performed:

High value volume of sediment = 95.1 acres X 4840 yd2/acre X 1.35 yd = 621,000 yd3
Therefore the Annual Average = 621,000 yd3/73 years = 8,512 yd3/year

Low value volume of sediment = 95.1 acres X 4840 yd2 / acre X 1.09 yd = 502,000 yd3
Therefore the Annual Average = 502,000 yd3 / 73 years = 6872 yd3/year

This same approach was applied to determining annual averages in the period between 1960 and 2010 with the result that a roughly 4600 yd3/year annual average was determined. In another similar estimate (Ayres 1997) found a value of 4000 yd3/year. These recent averages for annual sediment load should be more accurate, but the differences between the 73 year and 50 year averages could also indicate that sediment transport was significantly higher prior to 1960. Whatever the reasons for these differences it is safer to err on the side of caution and use the higher sediment influx values for determining sediment trap volumes.

ii. Sediment Sources and Volumes

The rational for determining the volume of the three proposed river sediment traps (Figure 11) is largely based on estimating the sediment sources to the storage area over the last 73 years. To do this, aerial images from 1938 and after (primarily 2010) were used to determine what significant changes have taken place to the course of the river, new channel and sandbar formations, river width and any other features which indicate potential sediment sources. Overlays of the 1938 onto the 2010 aerial images indicate that there have been 6 potentially significant sediment sources over the last 73 years. These are shown in Figure 12 as source A to F. Supplemental and confirmation information on each of these sources was established through field observations and site surveys.

A brief description and analysis of findings for each of the identified potential sources follows.

Source A: Today this is the main channel of the river. It began forming in the early 1950's and grew to its current width and depth over many years. A GIS and field analysis of this new stretch of river indicates that roughly 38,000 yd3 of sediment was supplied to the storage area.

Source B: The main river channel between Troubled Waters Bridge (TWB) and the storage area. Overlays from 1938 and 2010 indicate the course of the river over this stretch has not changed much. The river is today somewhat wider than in 1938, but the most potentially significant sediment sources in this stretch are bends with high banks were high erosion rates might be expected. However from the GIS and field analysis this apparently has not been the case. This is confirmed by the fact that large trees and an old logging road along the river edge are still intact. The fact that these features are at least 60 years old suggests little substantial erosion. Assuming that river bedload transport has been at steady state for many years the primary source of sediment to the storage area comes from bank erosion. This was estimated to be between 23,000and 69,000 yd3 over 73 years. (Update Note: An October 2012 field survey, roughly 3 years after the original survey, revealed that the a large tree and a portion of the logging road mentioned above were lost to erosion. This probably happened during the multi-year event in 2010.)

Source C: An old oxbow of the river which during high water events transports significant volumes of water and sediment towards the storage area. About half of the length of this old stretch of river has depths similar to what they were 60 years ago. There is a clearly delineated sediment front moving down this channel towards the storage area, but since it has not yet reached there the assumption is that its source of sediment is zero.

Source D: An oxbow that was closed between somewhere between 1970 and 1990. This appears to have been sealed off by multiple large log dams, formed during high water events. Prior to 1970 this was the main channel of the river that was diverted to what is now the main channel or source A in Figure 12. There is an oxbow lake in this stretch which still has depths of > 8 feet. So the sediment front as in source C above has not yet begun to fill the storage area. However during flood conditions sediment is being transported into the storage area through gulleys across the oxbow terrain. This is estimated at 20,000 to 30,000 yd3 total.

Source E: A sealed off stretch of old river bed with multiple small ponds and lakes that are isolated during normal flow, but transport water and sediment during flood conditions. As in the case of source C the sediment front has not yet reached the storage area but is with each passing year destroying excellent aquatic habitat.

Source F: The main river channel east of Troubled Waters Bridge on County Highway G. This is by far the main source of sediment to the storage area with between 365,000-484,000 yd3 of sediment supplied to the storage area since 1938. This number was obtained by difference and not by GIS and field analysis upstream of TWB.

TABLE 8: SOURCES AND VOLUMES OF SEDIMENT TO STORAGE AREA

SOURCE	WEST OF TWB CUBIC YARDS	EAST OF TWB CUBIC YARDS
A	38,000	---------------------
B	23,000-69,000	---------------------
C	0	---------------------
D	20,000-30,000	---------------------
E	0	---------------------
F	------------------	365,000-484,000
TOTALS	81,000-137,000	365,000-484,000

Summarizing the results of TABLE 8 it was found that sources below TWB supply somewhere between 81,000 and 134,000 yd3 and sources above (to the east) of TWB supply 365,000 to 484,000 yd3 of sediment. So the annual average volumes of sediment coming from east of TWB is 1110-1880 yd3 and from west of TWB is 5000-6630 yd3.

iii. Proposed Sediment Trap Volumes

Under this proposal the recommended minimum trap volumes and estimated clean times for these minimum volumes are listed in Table 9. If the assumptions are correct and most of the sediment is coming from east of TWB as bed load than roughly 5000 to 6700 yd3 on average per year will need to be removed from a trap at TWB. At a minimum a trap of 7,000 yd3 will be required at the bridge. To provide a reasonable safety factor the trap should be at least 15,000 yd3 to provide protection from 10 year flood episodes. This would then provide a two year window at average influx rate. More than likely the sediment transport is variable from year to year and episodic with much higher levels being transported during flood events and high precipitation years. Therefore required trap clean out times could vary from a year to multiple years depending largely on precipitation in the river water shed area above the lake. As a rule of thumb, it is best to make the sediment traps as large as the budget can reasonably accommodate at the project outset.

The GPT trap should be a minimum of 7000 yd3 to start with and after several years the size of the trap could be reduced. It is difficult to estimate with any certainty how fast the sediment supply to the second trap at GPT will fall off. A 10,000 yd3 trap should provide at least a couple years between clean outs and this span should increase to 10 years or more with time.

It is difficult to estimate the minimum trap volume for the SRT trap because of the large amount of sediment in the storage area immediately above the trap. Also by opening old river channels and backwater areas stream velocity should drop substantially which could reduce sediment influx to the SRT trap. This is a complex and non-linear process, however with time as the river channels deepen and the stream velocity decreases the influx to the SRT trap will certainly decline. This will reduce frequency of clean outs and operating costs. Sediment reduction in the storage area and restoration of the aquatic habitat there will be a slow process. It took 73 years to fill the area and it will certainly take a long time to naturally remove the stored sediment. To facilitate a faster recovery of the area, means should be sought to accelerate the sediment removal processes, for instance through mechanical sediment removal.

Table 9: Recommended Trap Volumes and Clean Out Times

TRAP	PROPOSED IN-STALLATION DATE	MINIMUM VOLUME YD3	VOLUME TO ACCOMMODATE 10 YEAR FLOOD*	CLEAN OUT TIME FOR AV-ERAGE SEDI-MENT INPUT
TWB	2012	7,000	15,000	annual
SRT	2012-13	7,000	15,000	annual
GPT	2012-13	7,000	10,000	annual
TOTAL		21,000	40,000	

- Volumes are based on sediment accumulated between June 2010 and June 2011. This year long period had one of the highest measured flood crests and was one of the longest periods of continuous flood conditions on record. The area at SRT was surveyed before and after the flood conditions subsided and the sediment in-flux was determined to be 12,000 yd3 for this one exceptional year.

iv. Projected Long-Term Benefits of Sediment Traps and Flood Plain Channel Restorations

If sedimentation levels remain as they have over the last 73 years this would amount to a 6,900-8,500 yd3/year reduction in sediment entering the storage area. Since the storage area is largely full, this would also be the amount entering the main body of the lake. With the sediment traps installed at TWB, GPT and SRT, the bed load supply of sediment would gradually be reduced between the traps and between SRT and the lake. This is primarily the result of the river deepening as sediment is removed by the traps. As the sediment is removed the flow velocity will diminish and sediment transport will decline below the TWB trap. This will eventually expand navigable areas of the river and also restore original aquatic habitat areas within the flood plain. As an example, the main river channel between TWB and GPT would amount to an average annual deepening of the entire width of the river channel of 3.2 to 4.3 inches between these end members. Within three years this could increase the depth of the river by as much as a foot. This should also help to restore some of the valuable fisheries wildlife habitat in the headwaters area of the lake, since the deepening of the main channel could make these areas accessible again.

V. Educational and Community Involvement

The Lake Eau Claire Association has strived over many years to involve local educators and their students other members of the community in environmental studies and various environmental programs related to the Eau Claire Lake and River. Much of the scientific evidence that has been used in the preparation of the Lake Management Plan was provided through studies that involved high school students, college students and local lay people. Studies include water profiling for light attenuation, oxygen and nutrient, and sediment profiling. These type studies will once again be invaluable in this Lake Management Plan for evaluating and adjusting the operation parameters for the proposed aeration system. Since one of the primary goals of this Management Plan is to improve the fisheries by improving water quality and habitat, studies on the success of these efforts will be conducted by using ongoing creel surveys and tagging larger fish with transponders to determine survival rates and fishing pressure. These studies will be conducted in conjunction with Beaver Creek Reserve and the Wildland School.

The Lake Association also plays a strong rule in empowering local lay people to be actively involved in environmental matters such as shoreline restoration and assisting in establishing and preserving habitat. An active education system is provided through mechanisms such as spring and fall seminars on various topics such as the use of native vegetation, shore land restoration, erosion prevention through landscaping, rain gardens, creating fish habitat, creating bird and wildlife friendly lake buffers, and vegetation to attract butterflies.

The Association also provides literature and works closely with county in providing advice on a wide variety of lake relative topics such as the following.

Pesticide free Gardening (Audubon)
Lake Tides (WAL)
Invasive Species Identification cards
Owning Lake Front Property
Clean Boats – Clean Waters Guide
Life on the Edge
Sensible Shore land Lighting
Maintain your Septic System

The Lake Association is also very active in other state and county environmental organizations such as WAL and the River Alliance. Members of the Lake Association Board Participate in Wisconsin Association of Lakes meetings, the Wisconsin Lakes Convention, and Lake Leaders Program. The Lake Association also hosts various meetings and events during the year which are directed at public awareness of environmental issues and raising funds specifically for environmental causes.

News and information on most of these activities are available through a quarterly newsletter and the Association's website at http://www.lakeeauclaire.org

VI. References

Ayres, 1997. Ayres Sediment Reduction Plan, Ayres Associates, Eau Claire, WI

Brand, L. E. 2011. Toxic Harmful Algal Blooms: Natural and Anthropogenic Causes. In A. G. Cabado and J. M. Vieites (Eds.), New Trends in Marine Freshwater Toxins. Chap 2, 33 p. Nova Scotia Publishers, Inc.

Davis, J. M. 1980. "Destratification of reservoirs – a design approach for perforated-pipe compressed-air systems," Water Services, August 1980, pp 497-504

Garrison, Paul J. Fall 2009. Destratifying Moderately Shallow Lakes. Lakeline

Gunnars A, Blomqvist S, Johansson P, Anderson C. 2002. Formation of Fe(III) oxyhydroxide colloids in freshwater and brackish seawater, with incorporation of phosphate and calcium. *Geochim Cosmochim Acta* 66:745-758.

Jensen, H.S., Kristensen, P., Jeppesen, E., and Skytthe, A. 1992. Iron:phosphorus ratio in surface sediment as an indicator of phosphate release from aerobic sediments in shallow lakes. *Hydrobiologia* 235/236:731-743.

Meyer, E. B. 1991. "Pneumatic Destratification System Design Using a Spreadsheet Program," March WOTS Information Exchange Bulletin, Vol E-91-1, Coastal and Hydraulics Laboratory, US Army Engineer Research and Development Center, Vicksburg, MS

Sommerfeldt, Skip (Thomas). Fall 2009. Wisconsin: Overcoming Winterkill. Lakline

Wedepohl, R. 2010. Lake Management Consultants, Inc. (formerly with WDNR).

Wilhelms, Steven C 2012. ERDC-CHL-MS Contractor through USACE Water Operations Technical Support (WOTS) program, St. Paul District.

Yates, L. I. 2008. "Spreadsheet DESTRATIFICATION," July Fact Sheet, Coastal and Hydraulics Laboratory, US Army Engineer Research and Development Center, Vicksburg, MS

Zaccaroni, A. & Scaravelli, D. 2008. Toxicity of fresh water algal toxins to humans and animals. In V. Evangelisa et al. (Eds.), *Algal Toxins: Nature, Occurrence, Effect and Detection* (pp. 45-89). Springer Science + Business Media B.V.

VII. Project Budgets

A. Water Quality – Aeration System for Destratification

	Project Costs		
Items	**Requested Funds**	**Cost-Share Value**	**Total Costs**
1. Salaries and benefits[1]		$10,000	$10,000
2. Consulting Services[2]	$4000	$4,000	$8,000
3. Purchased services[3]		$400	$400
4. Other purchased services[4]	$6,000	$6,000	$12000
5. Plant material			
6. Supplies[5]	$70,000	$10,000	$80,000
7. Depreciation			
8. Hourly equipment charges			
9. State Lab of Hygiene Costs			
10.Non-SLOH Lab costs[6]	$2,000	$9,000	$11,000
11.Land or easement acquisition value		$8,000	$8,000
12.Associated acquisition costs		$2,000	$2,000
13.Other[7]		$850	$850
TOTALS	$82,000	$50,250	$132,250

B. Fisheries and Habitat

	Project Costs		
Items	**Requested Funds**	**Cost-Share Value**	**Total Costs**
1. Salaries and benefits[1]		$6,000	$6,000
2. Consulting Services			
3. Purchased services[3]		$200	$200
4. Other purchased services			
5. Plant material[8]	$2,500	$3,000	$5,500
6. Supplies[9]	$3,000	$2,000	$5,000
7. Depreciation			
8. Hourly equipment charges[10]	$2,475		$2,475
9. State Lab of Hygiene Costs			
10.Non-SLOH Lab costs			
11.Land or easement acquisition value			
12.Associated acquisition costs			
13.Other[7]		$850	$850
SUBTOTALS	$7,975	$12,050	$20,025

C. Sedimentation and Erosion

	Project Costs		
Items	**Requested Funds**	**Cost-Share Value**	**Total Costs**
1. Salaries and benefits[1]		**$4,000**	**$4,000**
2. Consulting Services			
3. Purchased services[3]		**$400**	**$400**
4. Other purchased services[11]	**$110,000**	**$113,000**	**$223,000**
5. Plant material			
6. Supplies			
7. Depreciation			
8. Hourly equipment charges			
9. State Lab of Hygiene Costs			
10.Non-SLOH Lab costs			
11.Land or easement acquisition value			
12.Associated acquisition costs			
13.Other			
TOTALS	**$110,000**	**$117,400**	**$227,400**

GRAND TOTAL FOR A, B, and C	**$199,975**	**$179,700**	**$379,675**

D. Budget Justification for Footnotes in Budgets A, B, and C Above

1. Salary and Benefits: This is cost sharing for Dr. Zika's time in overseeing this project. As a professional consultant for industry and government agencies such as the EPA he normally receives daily consulting fees of $500-$1000 plus expenses. Therefore at $500/day for the duration of this project he is committed to 40 days. He is currently a professor at the University of Miami and this amount of time consulting is legally provided under contract terms of employment with the University. This consulting time will be subdivided between the separate projects.

2. Consulting services: This is for having an engineering consultant familiar with installation of lake aeration systems provide oversite in the design and construction of aeration system for the lake. The LEC Association has already employed Mr. James Wedepohl (formally with DNR) as a consultant in the design of the lake aeration system. He has agreed to continue in a consultant capacity during the construction and startup phases.

3. Purchased services: Mainly for office related costs, communications, and shipping costs.

4. Other purchased services: These are costs for equipment and personnel for installation of aeration pipe line and for diver expenses. Two weeks have been scheduled for the installation time.

5. Supplies: This includes all the material costs for the aeration system (i.e compressor, 3-phase power converter and other electrical hardware, valves, piping, iron ballast, strapping, etc.)

6. Non-SLOH Lab costs: To determine the operating parameters and establish the effectiveness of the aeration system pre-installation and post-installtion monitoring will be conducted. This will be done as it has been in the past with members from the Beaver Creek Reserve and Wildland School in Eau Claire County. Dr. Zika will supply some of necessary equipment and supplies from his lab at the University of Miami. Among the measured parameters oxygen, phopshate, light penetration, and phytoplankton speciation will be evaluated.

7. Other: These funds will be used to cover insurance costs for liability exposure to the Lake Association. Of the activites the Association is promoting through the management plan, the liability risks associated with them increase.

8. Plant material: As discussed in the objectives section, tree falls will be widely used around the lake to increase CWH. Where existing shoreline trees are used for CWH, they will be replaced with newly planted shoreline trees. In addition in certain location selected shoreline or aquatic plants such as bull rushes will be established as shoreline habitat and for shoreline erosion protection.

9. Supplies: These funds are to be used for installation of tree falls and half log structures for fish habitat. Included in the list of supplies are strapping , concrete block, etc.

10. Hourly equipment charges: Some funds will be required for moving and installing trees for tree falls. Some of these trees will be moved and installed during the winter months to take advantage of ice cover.

11. Other purchased services: Paying for sediment removal in the two traps in the river above the lake. The lowest price we have been quoted by one company is $4.00/yd^3. A price of $4 to $5 was used to determine the size and cost of the upstream sediment traps at SRT and GPT sites (see Table 9).

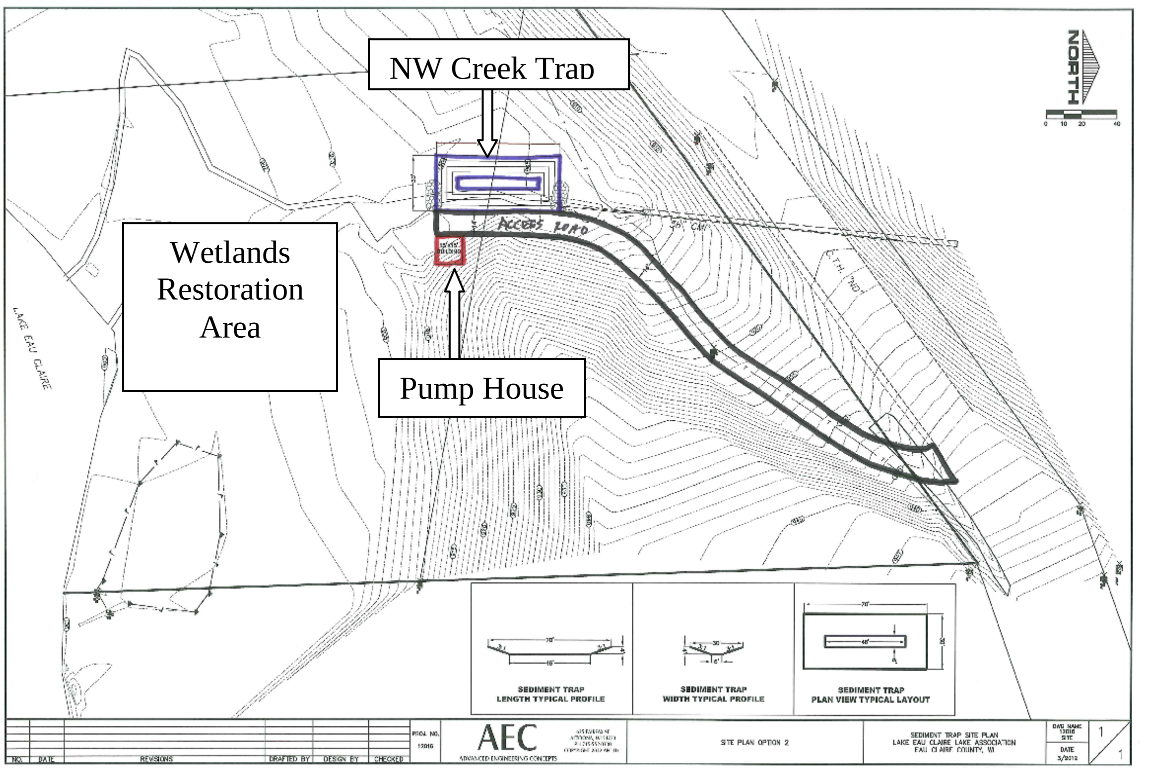
VII. Project Timelines

This project is designed to be started in the late Summer of 2012 and completed over a two year period. Assumming that the project begins on schedule the major tasks are projected for completion by September 30, 2014. See Appendix C for timeline details.

APPENDICES

A. Aeration System Land Acquisition

1. Topographic Survey Map of NW Creek Property



B. Rotary Screw Compressor Quotation for Aeration System.

AIR
COMPRESSOR
WORKS, Inc.

Toll Free (800) 345-4364
Palm Beaches (561) 844-4559
Stuart (772) 781-1300
Miami (305) 650-8869
Fax (561) 844-8247

3/12/2012 www.AirCompressorWorks.com 1956 West 9th Street, Riviera Beach, FL 33404
QUOTE #TT031212,2

LEC Association
17150 SW 232nd St.
Miami, FL, 33170

ATTN: Rod Zika **Phone:** 305-586-4248 **Email: rzika@rsmas.miami.edu**
Project: Lake sparging, location Unknown

Rod, as per your request, Air Compressor Works is pleased to offer the following equipment package for your consideration. As per our conversation, this is a basic system with start up fee for the local distributor. Once again, I will only be able to sell this product to you if the Purchase Order and payment originate from Miami-Dade. Otherwise I will have to pass you on to the local Kaeser distributor where the product will finally end up.
As per our conversation, this is a redundant compressor system to balance load hours, allow for maintenance and repair with one unit in reserve.
These are budgetary prices to help you determine your project costs.

PRICING SUMMARY

QUANTITY	ITEM DESCRIPTION	PRICE EACH	TOTAL PRICE
2	KAESER MODEL BSD 50, 530 HP ROTARY SCREW COMPRESSOR, 236 CFM @ 125 PSIG, DIRECT DRIVE ROTARY SCREW COMPRESSOR, SIGMA CONTROL MICROPROCESSOR	$19,166.00	$19,166.00
2	208-230/3/60 OPTIONAL ADDER	$1,189.00	
2	MODULATION CONTROL ADDER	$1,107.00	
2	CABINET HEATER OPTION	$2,022.00	
1	KAESER MODEL KOR-250, COALESCING FILTER. OIL CONTAMINANT REMOVAL TO 0.001 PPM. UNIT COMPLETE WITH INTERNAL FLOAT DRAIN AND DIFFERENTIAL PRESSURE INDICATOR	$634.00	$634.00
1	KAESER MODEL KCF-100, OIL/WATER CONDENSATE SEPARATOR. MEETS FEDERAL GUIDELINES FOR THE RELEASE OF COMPRESSOR CONDENSATE INTO THE ENVIRONMENT	$768.00	$768.00
1	PENWAY RECEIVER, 500 GALLON, 165 PSIG, COMPLETE SET UP, INCLUDES SAFETY RELIEF VALVE, GAUGE AND ZERO AIR LOSS KAESER AMD6550 DRAIN.	$2,967.00	$2,967.00
1	INSTALLATION ESTIMATE, MATERIAL AND LABOR (TYPICAL), INCLUDES START UP, TO BE PERFORMED BY OTHERS	$2,400.00	$2,400.00

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Mechanical Contractors – License #CMC1249580

C. Project Timelines

NUMBER	TASK	RESOURCE	START	END	DURATION
1	Boat Landing Invasive Species Creel Reporting Surveys and Education	Beaver Creek & LEC Volunteers	10/01/2012	11/01/2014	525
2	Aeration Detail Design	Engineering Consultants	11/01/2012	02/02/2013	63
3	Aeration Construction Phase – Pipe Line Installation	TBD & Volunteers	07/01/2013	07/01/2014	165
4	Aeration Pump House Construction	TBD & Volunteers	07/01/2013	10/31/2013	85
5	Aeration System Startup & Testing Phase	LEC Assoc. & Beaver Creek Reserve & Wildland School	05/01/2014	11/01/2014	128
6	Install Tree Falls and Half-Log Structures – Ungoing Program	LEC Assoc., DNR, Local Volunteers	10/01/2012	12/31/2014	564
7	Sediment Removal Engineering Completion Design Phase & Contract Development	TBD & LEC Assoc.	10/01/2012	04/01/2013	124
8	Sediment Removal Projects	TBD, DNR, LEC Assoc.	05/15/2013	11/01/2014	369
9	River Flood Plain Restoration Flow Study & Deposition Rate Surveys	DNR & LEC Assoc.	10/01/2012	12/31/2014	564
10	Submit Project Final Report	LEC Assoc.	-	01/31/2015	-