Clam Lakes - Interim Lake Management Plan

Aquatic Plant/Water Quality Management

Burnett County, Wisconsin

DNR No. LPL-1318-10
SEH No. CLAML 106825

March 3, 2014

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RE: Clam Lakes - Interim Lake Management Plan
Burnett County, Wisconsin
DNR Project No. LPL-1318-10
SEH No. CLAML 106825

Mr. Tom Stoffel
Clam Lakes Protection and Rehabilitation District
398 Queenan Avenue South
Lakeland, MN 55043

Dear Tom:

The following document is considered an Interim Lake Management Plan for the Clam Lakes. Specific recommendations for completing aquatic plant management and water quality management actions are not made. Instead, general recommendations that can be implemented, and that are not dependent on the status of the current carp issue have been made. This document and the accompanying data disk should be considered the final deliverable of the SEH/Clam Lakes Protection and Rehabilitation District agreement for services, and the final deliverable required by the WDNR for reimbursement purposes.

Sincerely,

Dave Blumer
Lake Scientist/Project Manager

DLB
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Clam Lakes - Interim Lake Management Plan

Aquatic Plant/Water Quality Management
Burnett County, Wisconsin

Prepared for:
Clam Lakes Protection and Rehabilitation District
Siren, Wisconsin

Prepared by:
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Executive Summary

In 2009, the Clam Lakes Protection and Rehabilitation District (CLPRD) applied for and received a multi-phase lake management planning grant to address the need for a revised Aquatic Plant Management Plan (APMP) originally focused on their on-going curly-leaf pondweed (CLP) large scale harvesting program; and to gather information pertaining to the state of the water quality in Lower and Upper Clam Lakes.

Data collection began in 2009 with full point-intercept aquatic plant surveys including early season CLP and mid season all plant surveys on both lakes. Dense infestations of CLP were identified on Lower Clam Lake and to a lesser degree in Upper Clam Lake. Native plants were present and diverse, but sparse in density, confirming anecdotal observations by the local lake community that over the previous 3-5 years dense native plant beds were disappearing. Also noted in this plant survey were large schools of young carp that "…were everywhere in both lakes" leading the plant survey specialist to characterize the state of the aquatic plant community in 2009 as being "under siege by invasive species", most notably CLP and carp (1). Perhaps most impacted was the high quality wild rice beds historically and commonly present in Upper Clam Lake. Not only had there been a noticeable decline in total acreage of wild rice, additional CLP survey work to estimate the number of CLP turions in the sediment noted little to no wild rice seed in the bottom sediments where these large beds previously existed. This was confirmed by survey work later in 2009, specifically to look at wild rice seed in the lakes, indicating that the observed multi year decline in wild rice was more than just natural variance, and may not be able to correct itself.

Issues impacting the Clam Lakes are wide ranging. First and foremost is managing the carp population so that management of wild rice, aquatic plants (native and non-native), fisheries, and the watershed can actually make a difference. EWM has not been identified in either lake to date and a plan needs to be in place as to how to prevent it from being introduced. Reducing nutrient loading to the system through shoreland restoration planning, septic system maintenance, and watershed improvements will help maintain or improve the current water quality status. As the carp population is brought under control, there will be a great opportunity to restore native aquatic plants before non-natives like CLP can get well-established again. Implementing aquatic plant management strategies that will also support the recovery of the panfish population will also help keep future carp populations under control. Being aware of how different lake uses, particularly large boats in shallow waters, impact water quality and making changes to reduce these impacts will also help maintain or improve water quality and aquatic plants.

Based on data collected, conversations with the CLPRD, St. Croix Tribal Environmental Services, and the Wisconsin Department of Natural Resources, the following eight general lake management and management related goals have been established. Each goal has an associated list of objectives, and the actions necessary to reach the objective, and ultimately the goals.

1) Protect, preserve, and enhance native aquatic plant communities in the Clam Lakes
2) Complete annual monitoring and management of aquatic invasive species currently identified in the Clam Lakes
3) Complete aquatic invasive species education, monitoring, and prevention
4) Improve in-lake habitat for fish and wildlife and for reducing available nutrients
5) Reduce nutrient loading to the Clam Lakes
6) Provide property owner and lake user education and awareness of issues impacting the Clam Lakes
7) Collect lake related data to enhance and support current and future lake management planning and implementation
8) Implement this plan following adaptive management practices

Executive Summary (Continued)

Appendix G provides a detailed list of the management goals, objectives, and actions included in this plan. This plan is intended to be a tool for use by the LRPD to move forward with aquatic plant management actions that will improve issues of concern as they pertain to Lake Redstone. However this plan is not intended to be a static document, but rather it is a living document that will be evaluated on an annual basis and updated as necessary to ensure goals and community expectations are being met. This plan is also not intended to be put up on a shelf and ignored. Implementation of the actions in this plan is highly recommended. An Implementation and Funding Matrix is provided in Appendix H.

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Clam Lakes - Interim Lake Management Plan

Aquatic Plant/Water Quality Management

Prepared for Clam Lakes Protection and Rehabilitation District

1.0 Introduction

In 2009, the Clam Lakes Protection and Rehabilitation District (CLPRD) applied for and received a multi-phase lake management planning grant to address the need for a revised Aquatic Plant Management Plan (APMP) originally focused on their on-going curly-leaf pondweed (CLP) large scale harvesting program; and to gather information pertaining to the state of the water quality in Lower and Upper Clam Lakes.

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In 2010 and 2011, the CLPRD, working with the Wisconsin Department of Natural Resources (WDNR) and St. Croix Tribal Environmental Services (SCTES), and with assistance from two different consulting firms and the University of Minnesota, embarked on several projects to determine the extent of the noticeable carp population increase. It was documented that the population of carp had indeed exploded in the lakes with a huge year class of young carp. Also documented in 2010 was a severe decline in CLP. Management of CLP that had previously dominated large areas of both lakes became unnecessary as the carp severely curtailed its growth and reproduction. Three large-scale aquatic plant harvesters owned and operated by the CLPRD have remained idle since 2009. Wild rice and other native aquatic plants were almost completely wiped out in 2010 and 2011. Water quality worsened as there was little aquatic vegetation to absorb nutrients in the system, and turbidity levels increased as carp stirred up and re-suspended bottom sediments in both lakes. At the same time, fisherman and resort owners noticed significantly fewer panfish being caught in the lakes. As a result, the final goals of this project were put on hold, pending the outcome of management efforts spear-headed by SCTES to protect and enhance the remaining wild rice and to reduce the carp population. Because of the direct impact of carp on both aquatic plants and water quality, management of both is considered secondary until the carp population is brought under control.

Since 2010, many actions have been implemented to reduce the carp population and to protect and enhance the wild rice population. Although these actions have been considered successful to date, there is much more to be done. The final deliverable of this project was to include a single lake management plan that includes methodologies, results, and management alternatives along with an implementation plan. In light of the current status of the lakes, this plan will now be a large summary of the data gathered, actions taken, and results achieved with recommendations for both aquatic plant and water quality management actions to consider as the CLPRD moves forward. Interim deliverables for each phase of the project including maps, spreadsheets, and other data collected during the given phase are included in the data disk that accompanies this final deliverable.

2.0 Aquatic Plant Management Strategy

All existing and new APMPs and the associated management permits (chemical or harvesting) are reviewed by the WDNR. APMP developed for northern Wisconsin lakes are evaluated according to guidelines provided in the WDNR Northern Region Aquatic Plant Management Strategy that went into effect in 2007. Additional review is completed by the Voigt Intertribal Task Force (VITF) in cooperation with the Great Lakes Indian Fish and Wildlife Commission (GLIFWC).

The VITF addresses matters that affect the treaty rights of the member tribes in the 1837 and 1842 Treaty ceded territories. The VITF is composed of nine Tribal members plus the chairperson. The VITF recommends policy regarding inland harvest seasons, resource management issues, and budgetary matters to the Board of Commissioners. Those recommendations are then taken to the respective tribal councils for ratification prior to becoming an ordinance.

Formed in 1984, GLIFWC is an agency of eleven Ojibwa nations in Minnesota, Wisconsin, and Michigan, who retain off-reservation treaty rights to hunt, fish, and gather in treaty-ceded lands. It exercises powers delegated by its member tribes. GLIFWC assists its member bands in implementing off-reservation treaty seasons and in the protection of treaty rights and natural resources. GLIFWC provides natural resource management expertise, conservation enforcement, legal and policy analysis, and public information services. All member tribes retained hunting, fishing and gathering rights in treaties with the U.S. government, including the 1836, 1837, 1842, and 1854 Treaties.

This management document supports sustainable practices to protect, maintain and improve the native aquatic plant community, the fishery, water quality, and the recreational and aesthetic values of the lakes. This document also incorporates a plan to prevent the introduction of new aquatic invasive species (AIS) like Eurasian watermilfoil (EWM) not currently known to be in either of the lakes, and lays out a monitoring program to aid in early detection of any new AIS.

3.0 Aquatic Plant and Comprehensive Lake Management Actions

When this project started, its main focus was creating an Aquatic Plant Management Plan for the Clam Lakes that would provide the avenue for continued management of curly-leaf pondweed, purple loosestrife and nuisance levels of native aquatic plant growth. In addition, certain aspects of water quality were to be evaluated and general recommendations made for improving water quality. To the extent possible this was completed.

4.0 Public Participation and Input

Since this project began in 2009, public participation and input has been sought by various stakeholders including the CLPRD, SCTES, WDNR, and several consultants. When this project first began, public input was centered on the current aquatic plant management program in the Clam Lakes. Soon after this project began, the focus shifted to the fishery, specifically the explosion in the carp population found in the lake. The carp population had significant impacts on water quality, native and non-native aquatic plants, lake use, and expenditures of time and resources, and continues those impacts to date. Through it all, the CLPRD has attempted to keep its constituency informed and involved. The following are some examples of how that was done.

4.1 Lake Use Survey

In 2009, a Lake User Survey was developed in cooperation with the CLPRD and the WDNR. The purpose of the survey was to seek a better understanding of the many feelings and attitudes of lake residents and users related to management actions that had been carried out for many years and possible alternatives, lake use, water quality, knowledge of aquatic invasive species, wild rice, and best management practices for lake protection.

The completed survey consisted of 12 pages, including a cover letter. Section headings included: residency, lake stewardship, lake use and lake issues, aquatic plant growth, aquatic invasive species, aquatic plant management alternatives, and community support (Appendix A). The cover letter promoted the completion of this survey as an opportunity for land owners and lake users to voice their concerns and opinions related to how the two lakes are and should be managed. Respondents to the survey could remain anonymous if they chose too, and all completed surveys were sent to a third party for evaluation. Members of the CLPRD Board were not given access to the survey responses until all results had been tabulated.

The survey was distributed to over 400 people through direct mailings, the CLPRD webpage, and placement at local businesses. In addition, several of the resorts on the lakes distributed the survey to their guests. More than 260 surveys were completed for a return rate around 65%. It is felt that property owners and lake users on both lakes and in the river are well represented. It is believed that the responses received accurately reflect the feelings, attitudes, and opinions of all lake users as well as their general level of knowledge and understanding of the issues facing the Clam Lakes.

Survey results are referred to throughout this document. A full report of Survey Results is included in Appendix B.

4.2 CLPRD Meetings

In August of each year the CLPRD holds an annual meeting where its members are updated on actions taken in the previous year, and management plans for the coming year. Presentation related to the aquatic plant survey work and the public use survey was delivered in 2009 and 2010. From 2011-2013 additional presentations were delivered by SCTR updating carp and wild rice management actions.

4.3 CLPRD Webpage

Most of the data collected for this project and the projects implemented by SCTES have been posted on the CLPRD webpage http://www.clamlakeprd.com/index.html last accessed on February 21, 2014.

4.4 Public Review of This Document

Public review of this document was completed in early 2014.

5.0 Documentation of Problems and Need for Management

Issues impacting the Clam Lakes are wide ranging. First and foremost is managing the carp population so that management of wild rice, aquatic plants (native and non-native), fisheries, and the watershed can actually make a difference. EWM has not been identified in either lake to date and a plan needs to be in place as to how to prevent it from being introduced. Reducing nutrient loading to the system through shoreland restoration planning, septic system maintenance, and watershed improvements will help maintain or improve the current water quality status. As the carp population is brought under control, there will be a great opportunity to restore native aquatic plants before non-natives like CLP can get well-established again. Implementing aquatic plant management strategies that will also support the recovery of the panfish population will also help keep future carp populations under control. Being aware of how different lake uses, particularly large boats in shallow waters, impact water quality and making changes to reduce these impacts will also help maintain or improve water quality and aquatic plants.

6.0 Lake Information

Identifying appropriate aquatic plant and water quality management recommendations for the Clam Lakes requires a basic understanding of its physical characteristics, including its morphology (size, structure, and depth), critical habitat, and the fishery, as well as factors influencing water quality, such as soils and land use. All of these factors have the potential to influence aquatic plant growth. Aquatic plant management activities can impact the lakes water quality, fish and wildlife habitat, and both target and non-target aquatic plants. Plant survey data and water quality data were collected within the lakes during the development of this plan. These data along with data collected in the past and future will provide the information necessary to evaluate the effects of aquatic plant management and other management activities on the lakes and their ecosystem.

6.1 Physical Characteristics

Lower and Upper Clam Lakes are natural flowages of the Clam River in Burnett County, Wisconsin. Lower Clam Lake is the smaller of the two with a surface area of 366 acres, a maximum depth of 14 feet and mean depth of 7 feet (Table 1). Upstream and to the south is Upper Clam Lake with a surface area of 1,338 acres, maximum depth of 11 feet and mean depth of 5 feet (Table 2). The water level of both lakes is maintained by a water control structure on Lower Clam Lake (2).

Table 1 – Lower Clam Lake Information

Characteristic	Data
Waterbody Identification Code	2655300
Surface area	366 acres
Volume	2,254.3 acre-ft
Maximum depth	14 ft
Mean depth	7 ft
Bottom Composition – muck	10%
Bottom Composition – sand	75%
Bottom Composition – gravel	10%
Bottom Composition – rock	5%
Waterbody Type	Flowage
Hydrologic Lake Type	Drainage
Sub-basin	Upper St. Croix River
Watershed	Clam River
Sub-watershed	Clam Lake
Shoreline Distance	3.8 miles
Boat Landings	1

Table 2 – Upper Clam Lake Information

Characteristic	Data
Waterbody Identification Code	2656200
Surface area	1,338 acres
Volume	6,282 acre-ft
Maximum depth	11 ft
Mean depth	5 ft
Bottom Composition – muck	30%
Bottom Composition – sand	70%
Waterbody Type	Flowage
Hydrologic Lake Type	Drainage
Sub-basin	Upper St. Croix River
Watershed	Clam River
Sub-watershed	Clam Lake
Shoreline Distance	12.5 miles
Boat Landings	2

6.1.1 Upper Clam Lake

Depth soundings at Upper Clam's 668 survey points (Figure 1) revealed the deepest areas in the lake occur on the west side of the central basin. This 7-9 ft are follows the river channel to the lake outlet on the north side. The southwest bay is a gently sloping flat that angles uniformly from 2 to 7ft towards the main basin. The southeast bay where the Clam River enters the lake is also a flat that slowly slopes from 2 to 5ft before dropping off more rapidly into the main basin around the islands. The 7-9ft main basin has steeper shorelines midlake and is generally bowl shaped with the exception of a sand bar on the eastern shore just north of where the lake narrows. The many north bays are mostly in the 2-6ft range with the exception of the main channel (Figure 1).

Bottom sediments in the southwest, south and both southeast bays are dominated by thick organic muck while the main basin is primarily sandy muck. Pure sugar sand was found along the big island's shoreline, at the Clam River Inlet, on the midlake bar, and on the margins of the main basin. Of the lake's 668 points, 597 (89.4%) were categorized as being muck or sandy muck, 70 (10.4%) as being pure sand, and 1 (0.2%) as rock (Figure 1). The littoral or plant growing zone extended to 8.0ft in 2012, although the majority of plants were found in water <4ft deep as both the mean and median depths of plants were 2.7ft and 3.0ft. These values all showed decline from 2009 when plants were found to 9ft with mean and median depth of 3.3ft and 3.5ft respectively.

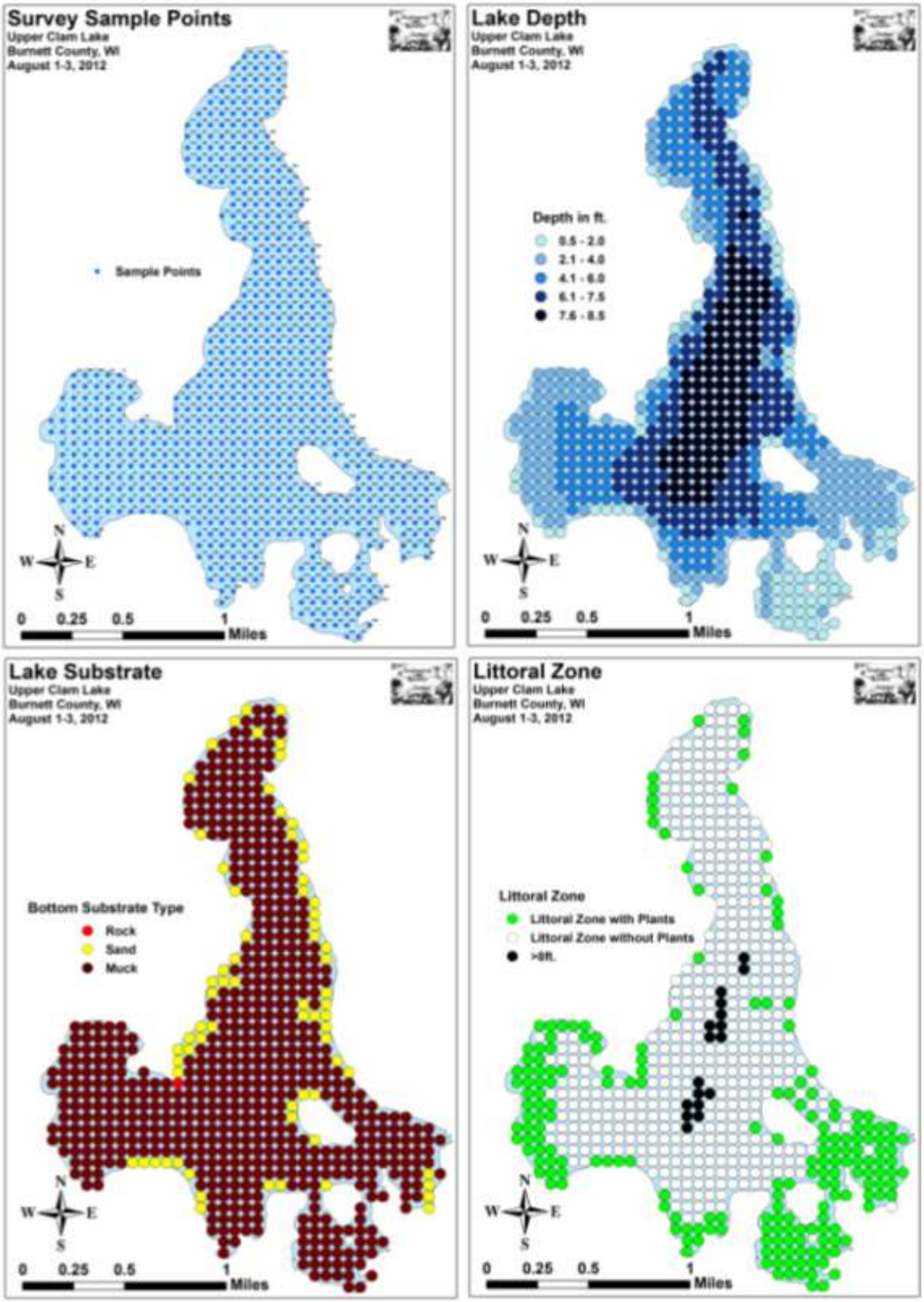


Figure 1 – 2012 Point-Intercept Survey Points, Lake Depth, Bottom Substrate, and Littoral Zone for Upper Clam Lake

6.1.2 Lower Clam Lake

Depth soundings at Lower Clam's 350 survey points revealed the deepest areas in the lake occur on the west side where the channel from Upper Clam cuts a 9-13ft furrow along the shoreline before turning to the northeast approximately 400 yards north of the Hwy 70 bridge. The central basin is a generally uniform 6-9ft bowl that gets gradually shallower moving west to east. The far south end of the eastern bay is a shallow 2-5ft flat that slopes towards the 6ft river channel that exits the lake in the northeast corner (Figure 2).

Sand dominated the majority of the nearshore lake bottom on Lower Clam on the north, west and south sides. This quickly transitioned to nutrient poor sandy muck at most depths beyond 4ft. Further to the east, this muck gradually thickened and became more nutrient rich; especially in the south end of the east bay. Of the lake's 350 points, 313 (89.4%) were categorized as being muck or sandy muck, and the remaining 37 (10.6%) as being pure sand (Figure 2).

The littoral or plant growing zone extended to 5.5ft in 2012 and showed a highly significant decline in area from 2009 when scattered plants extended to 8.0ft. Additionally, the vast majority of plants in 2012 were found in water <4ft deep as both the mean and median depths of plants were 2.9ft and 3.0ft. These values also showed a decline from 2009 when mean and median depths were 3.9ft and 3.5ft respectively.

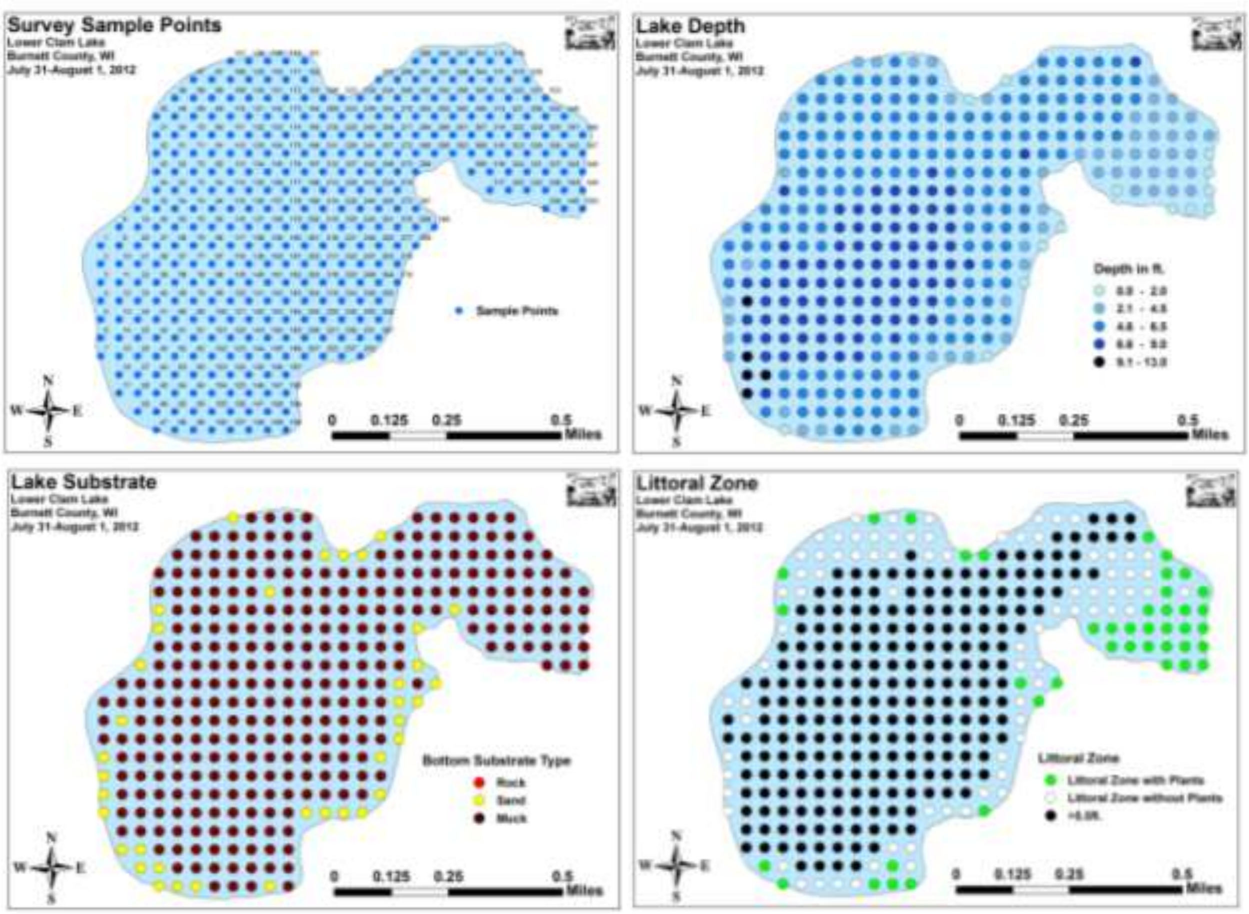


Figure 2 – 2012 Point-Intercept Survey Points, Lake Depth, Bottom Substrate, and Littoral Zone for Lower Clam Lake

6.2 Clam Lakes Watershed

A drainage basin or watershed is an area of land where surface water from rain and melting snow or ice converges to a single point at a lower elevation where those waters join another waterbody, such as a river, lake, reservoir, estuary, wetland, sea, or ocean. Defined more fully, a watershed describes an area of land that contains a common set of streams and rivers that all drain into a single larger body of water, such as a larger river, a lake or an ocean. A watershed can cover a small or large land area. Small watersheds are usually part of larger watersheds. All the streams flowing into small rivers, larger rivers, and eventually into the ocean, form an interconnecting network of waterways.

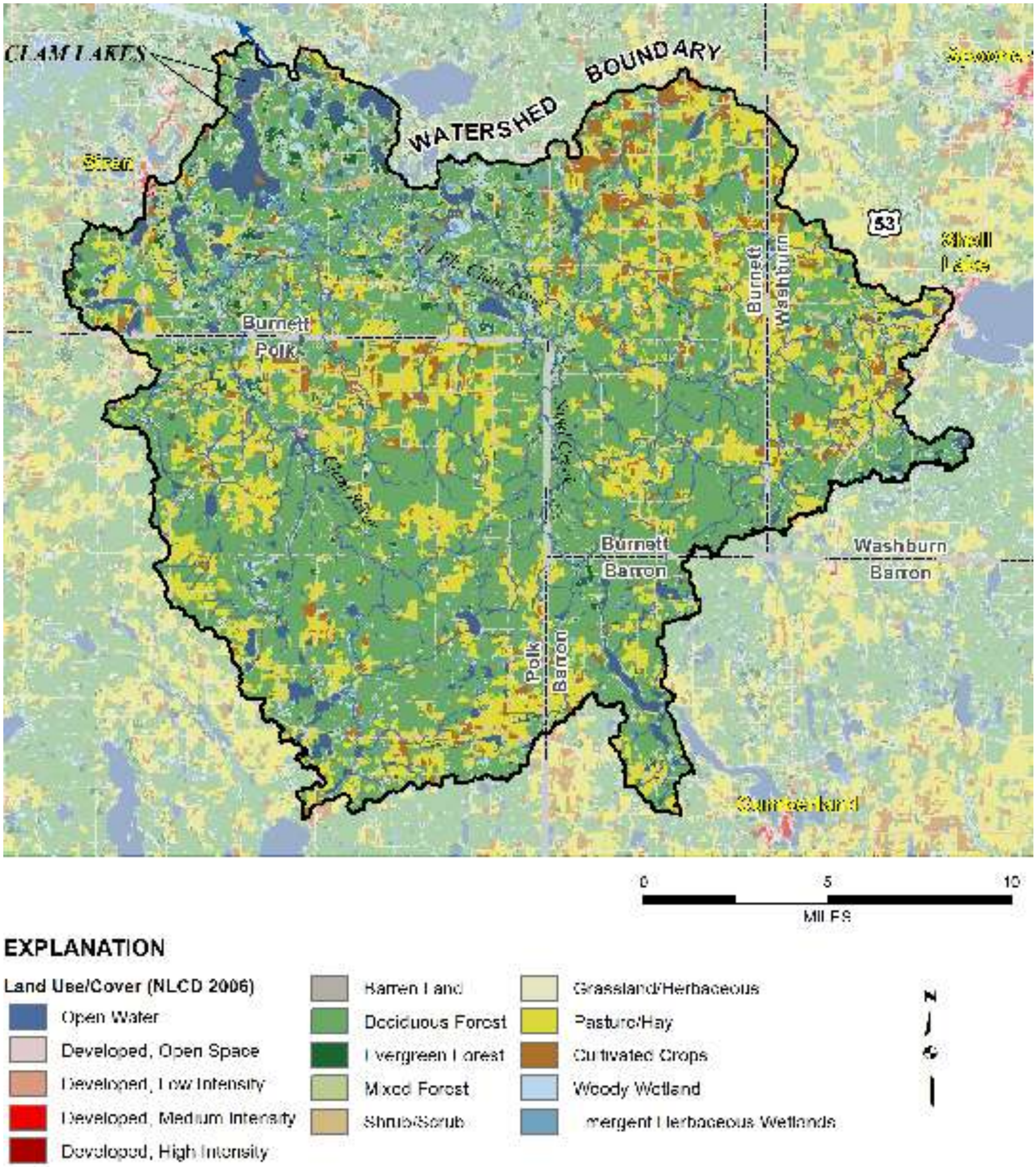
Homes, farms, ranches, forests, small towns, big cities and more can make up watersheds. Some cross county, state, and even international borders. Watersheds come in all shapes and sizes. Some are millions of square miles and others are just a few acres. As water drains from these areas, it picks up many different types of pollution including soils eroded from farm lands, and deposits it in streams and rivers, and eventually lakes and other larger bodies of water. Water that filters through the soil can also become contaminated with pollution that is left over from agricultural, industrial, commercial, and other types of human activity.

The Clam Lakes have a nearly 200,000 acre watershed in parts of four different counties. There are many different land uses within this watershed (Table 3, Figure 3). Fortunately, it remains largely undeveloped with nearly 70 % of it undeveloped. Approximately 25% is agricultural land, but most of this is pasture or hay, not row crops like corn and soybeans that often contribute large amount of eroded soil. Three main tributaries drain the Clam Lakes Watershed: Sand Creek, Clam River, and the North Fork of the Clam River.

Table 3
Land Use in the Clam Lakes Watershed

Land Use/Cover	Acres
Developed, Open Space	8,601.9
Developed, Low Intensity	335.2
Developed, Medium Intensity	31.0
Developed, High Intensity	14.0
Deciduous Forest	104,194.8
Evergreen Forest	3,238.4
Mixed Forest	9,574.1
Pasture/Hay	40,767.2
Cultivated Crops	9,593.4
Shrub/Scrub	620.3
Grassland/Herbaceous	1,545.1
Open Water	8,829.9
Woody Wetlands	4,650.4
Emergent Wetlands	5,526.9
TOTAL	**197,522.7**

Source: NLCD, 2006



CLAM LAKES
WATERSHED BOUNDARY
Siren
Burnett
Polk
Burnett
Washburn
53
Burnett
Barron
Washburn
Barron
Polk
Barron
Cumberland
0
5
10
MILES
EXPLANATION
Land Use/Cover (NLCD 2006)
Open Water
Developed, Open Space
Developed, Low Intensity
Developed, Medium Intensity
Developed, High Intensity
Barren Land
Deciduous Forest
Evergreen Forest
Mixed Forest
Shrub/Scrub
Grassland/Herbaceous
Pasture/Hay
Cultivated Crops
Woody Wetland
Emergent Herbaceous Wetlands
N

Figure 3 – Land Use in the Clam Lakes Watershed (3)

7.0 Aquatic Ecosystems

Many components make up the aquatic ecosystem that is a given body of water. An evaluation of some of these components is necessary to understand how management actions could impact the overall ecosystem. In the following sections aquatic plants, wetlands, critical habitat, rare and endangered species habitat, waterfowl, fishery, and coarse woody structure are discussed in more detail.

7.1 Aquatic Plants

Aquatic plants, also known as macrophytes, are a natural part of most lake communities and provide many benefits to fish, wildlife, and people. Native macrophytes have many important functions and values to a lake ecosystem. They are the primary producers in the aquatic food chain, converting the basic chemical nutrients in the water and soil into plant matter, which becomes food for all other life.

Aquatic plants provide valuable fish and wildlife habitat. More food for fish is produced in areas of aquatic vegetation than in areas where there are no plants. Insect larvae, snails, and freshwater shrimp thrive in plant beds. Panfish eat aquatic plants in addition to aquatic insects and crustaceans. Plants also provide shelter for young fish. Northern pike spawn in marshy and flooded areas in early spring and bass, sunfish, and yellow perch usually nest in areas where vegetation is growing.

Many submerged plants produce seeds and tubers (roots) which are eaten by waterfowl. Bulrushes, sago pondweed, wild celery, and wild rice are especially important duck foods. Submerged plants also provide habitat to a number of insect species and other invertebrates that are, in turn, important foods for brooding hens and migrating waterfowl.

The lake aesthetic valued by so many is enhanced by the aquatic plant community. The visual appeal of a lakeshore often includes aquatic plants, which are a natural, critical part of a lake community. Plants such as water lilies, arrowhead, and pickerelweed have flowers or leaves that many people enjoy.

Aquatic plants improve water clarity and water quality. Certain plants, like bulrushes, can absorb and break down polluting chemicals. Nutrients used by aquatic plants for growth are not available to algae, thus reducing algae abundance and improving water clarity. Algae, which thrive on dissolved nutrients, can become a nuisance when too many submerged water plants are destroyed. Aquatic plants also maintain water clarity by preventing the re-suspension of bottom sediments. Aquatic plants, especially rushes and cattails, dampen the force of waves and help prevent shoreline erosion. Submerged aquatic plants also weaken wave action and help stabilize bottom sediment.

Native aquatic plant communities also offer protection from non-native aquatic invasive species. Current scientific literature generally accepts the concept that invasions of exotic plants are encouraged, and in some cases induced, by the disruption of natural plant communities. Curly-leaf pondweed, which is present in both lakes, is an opportunistic plant. Much like lawn and agricultural weeds that germinate in newly disturbed soil, curly-leaf pondweed is more likely to invade areas in which the native plant community has been disturbed or removed. Removing the natural competition from native plants may also open up the door to new invasive species and less desirable plant communities.

As a natural component of lakes, aquatic plants support the economic value of all lake activities. Wisconsin's $13 billion tourism industry is anchored by 15,081 lakes and 12,600 rivers and streams which draw residents and tourists to hunt, fish, camp, and watch wildlife on and around lakes. According to the WDNR, the world class fishery lures more than 1.4 million licensed anglers each year, supports more than 30,000 jobs, generates a $2.75 billion annual economic impact, and $200 million in tax revenues for state and local governments.

7.2 Wetlands

In Wisconsin, a wetland is defined as an area where water is at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation, and which has soils indicative of wet conditions (Wisconsin Statue 23.32(1)). Wetlands contain a unique combination of terrestrial and aquatic life and physical and chemical processes. Wetlands are protected under the Clean Water Act and state law and in some places by local regulations or ordinances. Landowners and developers are required to avoid wetlands with their projects whenever possible; if the wetlands can't be avoided, they must seek the appropriate permits to allow them to impact wetlands (for example, fill, drain or disturb soils).

According to the National Wetland Inventory, emergent, forested/shrub and freshwater, emergent wetlands are present in the Clam Lakes watershed. The majority of the wetland borders the lakes and tributary streams and have a direct hydrologic connection to the lakes (Figure 4). Emergent wetlands (light green) are wetlands with saturated soil and are dominated by grasses such as redtop and reed canary grass, and by forbs such as giant goldenrod. Forested/shrub wetlands (darker green) are wetlands dominated by mature conifers and lowland hardwood trees. Forested/shrub wetlands are the dominant form of wetlands in the watershed and are important for stormwater and floodwater retention and provide habitat for various wildlife.

Figure 4 – Clam Lakes Wetlands (4)

Wetlands serve many functions that benefit the ecosystem surrounding the Clam Lakes. Wetlands support a great variety of native plants and are more likely to support regionally scarce plants and plant communities. Wetlands provide fish and wildlife habitat for feeding, breeding, resting, nesting, escape cover, travel corridors, spawning grounds for fish, and nurseries for mammals and waterfowl. Contrary to popular belief, healthy wetlands reduce mosquito populations; natural enemies of mosquitoes (dragonflies, damselflies, backswimmers, and predacious diving beetles) need proper habitat (that is, healthy wetlands) to survive.

Wetlands provide flood protection within the landscape by retaining stormwater from rain and melting snow and capturing floodwater from rising streams. This flood protection minimizes impacts to downstream areas. Wetlands provide groundwater recharge and discharge by allowing the surface water to move into and out of the groundwater system. The filtering capacity of wetland plants and substrates help protect groundwater quality. Wetlands can also stabilize and maintain stream flows, especially during dry months.

Wetland plants and soils provide water quality protection by storing and filtering pollutants ranging from pesticides to animal wastes. Wetlands also provide shoreline protection by acting as buffers between the land and water. Wetland plants protect against erosion by absorbing the force of waves and currents and by anchoring sediments. This is important in waterways where high boat traffic, water currents, and wave action may cause substantial damage to the shore.

Although some small (two acres or less) wetlands may not appear to provide significant functional values when assessed individually, they may be very important components of a larger natural system. Not only do small wetlands provide habitat functions, they also store phosphorus and nitrogen and trap pollutants such as heavy metals and pesticides. Draining these small wetlands, which often do not appear on maps, not only requires the proper permits, but can also release the once-stored pollutants and nutrients into lakes and streams.

7.3 Critical Habitat

Every body of water has areas of aquatic vegetation or other features that offer critical or unique aquatic plant, fish and wildlife habitat. Such areas can be mapped by the WDNR and designated as Critical Habitat. Critical Habitat areas include important fish and wildlife habitat, natural shorelines, physical features important for water quality (for example, springs) and navigation thoroughfares. These areas, which can be located within or adjacent to the lake, are selected because they are particularly valuable to the ecosystem or would be significantly and negatively impacted by most human induced disturbances or development. Critical Habitat areas include both Sensitive Areas and Public Rights Features. Sensitive Areas offer critical or unique fish and wildlife habitat, are important for seasonal or life-stage requirements of various animals, or offer water quality or erosion control benefits.

The WDNR mapped sensitive areas on the Clam Lakes in 1997 (Figure 5). The full report is included in Appendix C. The Sensitive Area survey identified three areas on Upper Clam Lake and one area on Lower Clam Lake. These areas of aquatic vegetation on Clam and Lower Clam Lake offer critical or unique fish and wildlife habitat. These habitats provide the necessary seasonal or life stage requirements of the associated fisheries, and the aquatic vegetation offers water quality or erosion control benefits to the body of water.

The data and recommendations from the Sensitive Area Report were reviewed and incorporated into this management plan. In addition to site-specific recommendations, the report recommends that aquatic vegetation should be protected and any removal or control should be minimized. In sensitive areas, it is important to maintain vegetated shoreland buffers. Stumps and woody habitat, which provide fish cover, should not be removed from sensitive areas.

Although restrictions are in place to protect these areas during plant management operations, in some cases, short-term disruptions to habitat during the removal of monotypic stands of aquatic invasive species may lead to positive long-term improvements to the habitat of the lake. Disruptions to the sensitive areas may be warranted when responding to the discovery of a new invasive species.

Figure 5 – Sensitive Areas (dark blue) in Upper and Lower Clam Lakes (5)

7.3.1 Shoreland Buffers

Any buffer that does not extend back from the waters' edge at least 35' is not providing adequate protection for water quality and should be expanded to at least 35'. Local zoning ordinances and lakes classification systems have tried to provide better guidelines pertaining to buffer widths and setbacks based on lake type. Landowners are encouraged to go beyond the minimum requirements laid out by zoning and consider extending buffer widths to beyond 35' and integrating other innovative ways to capture and reduce the runoff flowing off from their property while improving critical shoreline habitat. Berms and low head retention areas can greatly increase the effective capture rate from developed portions in addition to that portion captured within the buffer.

The Burnett County Land and Water Conservation Department provides incentives to encourage restoring or preserving waterfront as natural shoreline. Over 600 parcels have been enrolled in the Burnett County Shoreline Incentives Program since it began in 2000. Owners of these parcels receive and annual property tax credit in return for ensuring permanent protection for the shoreline zone. Incentives provided for each parcel enrolled in the Shoreline Incentives Program are as follows:

- An annual property tax credit of $50
- An enrollment payment of $250
- A free visit with a natural landscape expert
- Planting plans to restore a natural shoreline
- Payments that cover 70% of the cost of plants and materials
- An exclusive shirt or cap that identifies you as a Shoreline Incentives participant
- An optional sign to post at the water's edge

There are currently 15 parcels on the Clam Lakes already enrolled in the Burnett County Program, and another 14 parcels along the Clam River (Burnett County, personal communication, Feb. 2014). New property owners interested in being a part of this program can find more information at http://www.burnettcounty.com/index.aspx?NID=526 (last accessed on January 2, 2014).

7.4 Rare and Endangered Species and Habitat

The Wisconsin Natural Heritage Inventory (NHI) program is part of an international network of programs that focus on rare plants and animals, natural communities, and other rare elements of nature. Each species has a state status including Special Concern, Threatened, or Endangered. Species are listed by township: Lower Clam Lake is situated in T39, R16W and Upper Clam Lake is in T38, R16W. It is important for lake managers to consider impacts to these valuable species, nearly all of which can be directly affected by aquatic plant management. Choosing the proper management techniques and the proper timing of management activities can greatly reduce or prevent negative impacts.

Two Threatened (Blanding's turtle, and pugnose shiner) and five Special Concern species are listed for T39, R 16W (bald eagle, lake sturgeon, Karner blue butterfly, Torrey's bulrush, and a riffle beetle). One Threatened species (pugnose shiner), one Endangered species (sand violet), and four Species of Special Concern are listed for T38, R16W (bald eagle, trumpeter swan, the sylvan hygrotus diving beetle, and Torrey's bulrush). Descriptions of these species can be found at http://dnr.wi.gov/topic/EndangeredResources/biodiversity.html/ (last accessed 2014-1-2).

The Natural Heritage Inventory Program tracks examples of all types of Wisconsin's natural communities that are deemed significant because of their undisturbed condition, size, what occurs around them, or for other reasons. Natural communities listed for the T39, R16W include the northern sedge meadow. Natural communities listed for T38, R16W include: alder thicket, lake—hard bog, and lake—shallow hard seepage. Full descriptions of these communities including current threats can be found on the WDNR website at: http://dnr.wi.gov/topic/endangeredresources/communities.asp (last accessed 2014-1-2).

The Natural Heritage Inventory Program also tracks other natural features that provide important habitat for certain plants and animals and are places where a catastrophic event could have an impact on a large number of common and/or rare species. Potential range for the Karner Blue Butterfly, a federally endangered species, is one such natural feature listed for T38, R16W and T39, R16W. A full description of a potential range for the Karner blue

can be found on the WDNR website at:
http://dnr.wi.gov/topic/endangeredresources/OtherElements.asp (last accessed 2014-1-2).

7.4.1 Clam Lake Wildlife Area

The Clam Lake Wildlife Area is 285 acres on the south side of Upper Clam Lake. The wildlife area consists of a 20-acre peninsula on the west side of the lake, two large sedge/brush islands, 10 acres on the eastern shore, and over 200 acres on the southern shore including a mile of the Clam River. A map is included in Appendix D. The area includes wetlands, old fields, northern hardwoods, and riparian areas of lake shore and river. The WDNR manages the area for waterfowl nesting and the wild rice beds at the mouth of the Clam River. Recreational opportunities include birding, canoeing, cross country skiing, fishing, hiking, hunting, snowmobiling, trapping, foraging, and wildlife viewing.

7.5 Waterfowl

The Clam Lakes have traditionally been an important stopping point for waterfowl during their normal migration patterns. In 2010-2011 waterfowl surveys on Clam and Long Lakes identified a total of 10 waterfowl species and 3,416 individual ducks were counted (6). In addition, observations of 6 other species were recorded. Species recorded include Canada goose, trumpeter swan, wood duck, gadwall, mallard, ring-neck, blue-winged teal, bufflehead, hooded merganser, common merganser, great blue heron, scaup, common loon, double-crested cormorant, American white pelican, and bald eagle.

The American white pelican is listed as a species of moderate conservation concern under the Upper Mississippi Valley/Great Lakes Waterbird Conservation Plan. Wood duck, mallard, and blue winged teal are all focal species of the Upper Mississippi Great Lakes Joint Venture. Scaup are the only species showing a decreasing trend according to the 1998 update to the North American Waterfowl Management Plan (NAWMP). They are currently 45% below goal with habitat degradation and loss identified as one of the major reasons for achieving desired recruitment rates. An objective under the NAWMP is to maintain or exceed recent rates of annual increase in populations of trumpeter swans to achieve an autumn index of 2,500. The blue winged teal, lesser scaup and trumpeter swan are all listed as a species of greatest conservation need under the Wisconsin Wildlife Action Plan.

7.6 Fishery

Lower and Upper Clam Lakes support a diverse fish community including walleye, largemouth bass, smallmouth bass, northern pike, channel catfish, lake sturgeon, bluegill, black crappie, yellow perch, pumpkinseed, rock bass, bowfin, redhorse, common carp, and white sucker (7).

Northern Pike are abundant while panfish and largemouth bass are common. Common carp have become very abundant in recent years and have had dramatic impacts on native fish and aquatic plants in the lakes (7). Fish stocking in Upper Clam Lake included walleye fingerlings in 1989 and northern pike fry in 1981 and 1984 (Table 4).

Table 4 - Fish Stocking in Upper Clam Lake

Year	Species	Age Class	Number Stocked	Average Fish Length (in)
1989	Walleye	Fingerling	12,134	3.00
1984	Northern Pike	Fry	152,047	1.00
1981	Northern Pike	Fry	80,095	-

7.6.1 Carp in the Clam Lakes

Anecdotal reports from local residents and natural resources managers suggested that the carp population in Upper Clam Lake increased noticeably between 2000 and 2010 while the panfish population had declined over the same period. In June 2009, staff from the WDNR (Spooner, WI) and SCTES conducted electro-fishing in shallow near-shore areas of Upper Clam Lake. During this survey, they captured and measured approximately 300 carp, with subsequent age determination (spinal annuli) for 140 of these captured carp. Results indicated that over 40% of the carp were from a single year-class that had hatched in 2005 (Figure 6). This suggests that conditions in the spring and summer of 2005 favored carp recruitment. Furthermore, by 2009, carp in this abundant year-class had grown large, generally ranging from 20 to 25 in long, suggesting that the population would experience little or no loss due to predation in subsequent years.

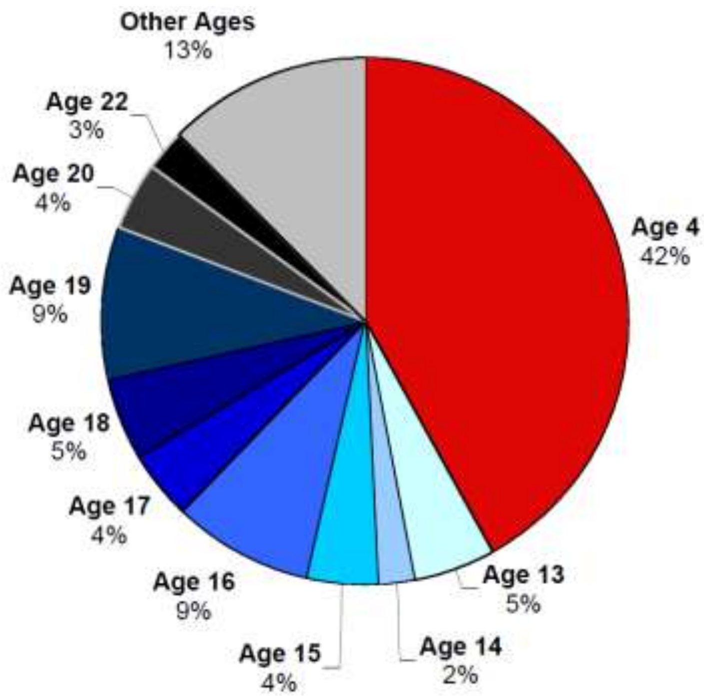


Figure 6 – 2009 Carp Population Age Structure in Upper Clam Lake (WDNR and St. Croix Tribal Environmental Department (SCTED), 2009)

7.6.1.1 Carp Management in the Clam Lakes

SCTES in cooperation with the WDNR and the CLPRD have developed and are implementing a carp management program in the Clam Lakes. In 2013, 33,056 lbs of carp were removed, and remaining population estimates made. Of the three population estimates made, the most reliable one suggests about 48,500 carp in the lake. This results in a biomass estimate of about 370 lbs of carp/acre, well over the 100 lbs of carp per acre that is the target threshold (Anthony Havranek, personal communication, Feb. 2014). Additional carp harvest is planned for 2014

As this program moves forward and has success, aquatic plants will once again become a major management issue. At the present time, managing aquatic plants both non-native and native are secondary to getting the carp population under control.

7.7 Coarse Woody Structure

Coarse woody structure (CWS) is a type of structural habitat found in the littoral zone, or near-shore region, of lakes and is contributed as trees fall from shore into lakes. Natural addition of CWS to lakes can be a very slow process. For example, the mean germination date of eastern white pine sampled from the littoral zone of a lake in Ontario was 600 years ago (8). Therefore, most of the CWS in the littoral zone took 600 years to grow and eventually fall into the lake. Many studies suggest that CWS is an important component of habitat in littoral zones. Wood provides a surface for insect larvae and provides shelter for small fish from predation.

Complex interactions among fish are at play with abundant structural habitat as discussed above. Predator and prey dynamics among varying macrophyte densities may be comparable to those occurring among CWS (9), especially if most of the branches and twigs are intact. Compared to macrophytes, however, CWS as structural habitat in littoral zones is scarce. For example, a survey of 13,657 square meter quadrats in 12 lakes revealed that only 6% of quadrats had CWS within one meter (10).

One reason for scarce CWS in the littoral zone is shoreline development. As shoreline development increases, CWS abundance decreases (11) (12) mainly due to riparian tree removal. Despite its rarity, CWS has very little protection in Wisconsin statutes related to lakes and lake habitat. Furthermore, an official method for measuring CWS in lakes has not yet been adopted by the state.

Since the decline of aquatic plants, correlating with a decline of panfish in the lakes, more attention is being paid to CWS in the Clam Lakes. In 2013, twelve “Fishsticks” structures at four different sites were installed by SCTES, the WDNR, and the CLPRD. These entities should continue focusing on protecting existing CWS in the lakes and adding it through Fishsticks and similar projects. Individual property owners should be encouraged to leave CWS in the lakes, unless it is causing hardship.

8.0 Primary Human Use Areas

Based on results from the 2010 Lake Use Survey, rest and relaxation, fishing, and pontoon boating are the top three activities on both lakes. Surprisingly, water-skiing and tubing came in as the 6th and 7th most participated in activity on Lower and Upper Clam Lake respectively. Swimming, wildlife viewing, and canoe/kayaking filled in the spaces. Boating seems to be a favorite lake use as 86% of respondents use watercraft on the water 1-2 times per month or more. Swimming is not as favorable as only 62% swim or wade in the lake during the same time frame. Almost 22% do not swim in the lakes at all.

8.1 Motorized Watercraft

Motorized watercraft includes powerboats, fishing boats, pontoon boats, and “jet skis” or personal watercraft (PWC). They are propelled by some sort of motor: outboard, inboard, inboard/outboard, or jet propulsion. Most of these propulsion systems make use of a propeller (13).

There are a number of reasons why boats and boat activity are an important issue. Numbers of registered boats in Wisconsin have increased by 87% since the late 1960’s (567,000 in 1997-98 compared to 303,000 in 1968-69). Size of boats has also increased: over 40% of the registered boats were between 16 and 39 feet long in 1997-98 compared to just 18% in 1968-69. Along with the bigger boats have come bigger engines. The Duluth News-Tribune reports that horsepower has doubled on new boats registered in MN between 1981 and 1999. There has also been an explosion in recent years in new types of watercraft, especially personal watercraft. PWCs in WI increased from 6500 in 1991 to 28,900 in 1998, representing 5.1% of all registered watercraft. These smaller, more powerful craft have unique issues, due to their maneuverability and accessibility to shallow and remote areas. Finally, increased development of lakes and rivers leads to increased boat activity, especially in areas that have traditionally not been used for recreation (13).

Boats may interact with the aquatic environment by a variety of mechanisms, including emissions and exhaust, propeller contact, turbulence from the propulsion system, waves produced by movement, noise, and movement itself. In turn, each of these impacting mechanisms may have multiple effects on the aquatic ecosystem. Sediment re-suspension, water pollution, disturbance of fish and wildlife, destruction of aquatic plants, and shoreline erosion are the major areas of concern (13).

8.1.1 Motorized Watercraft and Water Clarity

Algal growth, runoff, shoreline erosion, wind mixing of the lake or river bottom, and tannic and humic acids from wetlands can all affect the clarity of the water. Water clarity often fluctuates seasonally and can be affected by storms, wind, normal cycles in food webs, and rough fish (e.g. carp, suckers, and bullheads) (13).

Propellers may disturb the lake or river bottom directly, or indirectly through the wash or turbulence they produce, especially in shallow water. This may affect water clarity by increasing the amount of sediment particles in the water or may cause nutrients that are stored in the sediments, such as phosphorus, to become available for algal growth. Waves created by watercraft may contribute to shoreline erosion, which can cloud the water (13).

In his study, Apslund concludes that boats have been shown to affect water clarity and can be a source of nutrients and algal growth in aquatic ecosystems. Shallow lakes, shallow parts of lakes and rivers, and channels connecting lakes are the most susceptible to impacts. Depth of impact varies depending upon many factors including boat size, engine size, speed, and substrate type. Few impacts have been noted at depths greater than 10 feet (13).

Creating no-wake zones in shallow areas of lakes and rivers could help to reduce impacts on water clarity, both by reducing the overall amount of boat activity in these areas and by limiting impacts from high-speed boats. In certain cases it may be beneficial to restrict boat activity altogether, such as in extremely shallow waters (13).

8.1.2 Motorized Watercraft and Shoreline Erosion

Shoreline erosion is a term that refers to the process by which soil particles located along riverbanks or lakeshores become detached and transported by water currents or wave energy. Shoreline erosion is affected by two main factors: 1) the intensity or energy of the erosive agent, i.e. water movement; and 2) the characteristics of the bank material itself. Water currents, waves, and water levels are the primary agents that cause shoreline erosion, although overland runoff can also erode shorelines. The erosive characteristics of shoreline soils can also affect erosion rates – less cohesive materials such as sand erode more quickly than clay. The amount of vegetative cover, slope, and human disturbance also affect shoreline erosion rates at a given site. A certain amount of natural erosion may occur with storm or flood events, but usually erosion is minimal on natural shorelines. Shoreline development can affect erosion rates significantly by removal of vegetative cover or compaction of bank material (13).

Boats produce a wake, which may in turn create waves that propagate outward until dissipated at the shoreline. Wave height and other wave characteristics vary with speed, type of watercraft, size of engine, hull displacement, and distance from shore. Propeller turbulence from boats operating in near shore areas may also erode shorelines by destabilizing the bottom (13).

Apslund concludes that waves or wake produced by boats is the primary factor by which boats can influence shoreline erosion. Wave heights depend upon speed, size and draft of boat, but can reach heights of 40-50 cm (15-20 in.) equivalent to storm-induced waves. However, wave heights dissipate rapidly as they move away from the boat, while wind waves increase with larger distances. Therefore, river systems, channels connecting lakes, and small lakes are likely to be most influenced by boat-induced waves, as boats may operate relatively close to shore and wind-induced waves are reduced. Shoreline erosion has been documented in river systems and has been attributed to frequency and proximity of boat traffic. Loosely consolidated, steep, un-vegetated banks are more susceptible to shoreline erosion.

Again creating no-wake zones that are designed to minimize boat wake are an obvious solution to limit shoreline erosion, particularly in channels or small sheltered lakes. Currently in WI, boats are restricted from operating at speeds greater than no-wake within 100 feet from fixed structures such as boat docks and swimming platforms. Many lake communities have established no-wake ordinances at 100 feet from shore or more. Seawalls and riprap have been used extensively in lakes and rivers to prevent shoreline erosion; however, these engineering approaches have little wildlife value and are expensive. Maintaining and restoring natural shorelines would help reduce the impacts of all types of waves on shoreline erosion (13).

8.1.3 Motorized Watercraft and Aquatic Plants

Boats may impact macrophytes either directly, through contact with the propeller and boat hull, or indirectly through turbidity and wave damage. Propellers can chop off plant shoots and uproot whole plants if operated in shallow water. Increased turbidity from boat activity may limit the light available for plants and limit where plants can grow. Increased waves may limit growth of emergent species. Finally, boats may transport non-native species, such as Eurasian water milfoil, from one body of water to another (13).

Several researchers have documented a negative relationship between boat traffic and submerged aquatic plant biomass in a variety of situations. The primary mechanism appears to be direct cutting of plants, as many have noted floating plants in the water following heavy boat use. Other researchers have determined that scouring of the sediment, uprooting of plants, and increased wave activity may also be factors. Where frequent boat use has created channels or tracks, it was noted that these scoured areas persist for several years (13).

Again creating no-wake zones and restricted motor areas can effectively reduce the impact of boats on aquatic plants. Limiting boat traffic in areas with sensitive species or where a large proportion of the plant material is floating or emergent may be a good way to guide boat activity to more appropriate parts of a waterbody. While no-wake zones do not prevent all impacts, they do serve to reduce the overall amount of boat activity in a given area. Basing no-wake zones on water depth or the maximum depth of plant growth may be more useful than those based upon fixed distances from shore (13).

8.1.4 Motorized Watercraft and Fisheries

Climate, food availability and quality, suitability of shelter, and the presence of predators (including humans) affect individual fish, as well as fish populations. Water quality, turbidity, and the presence of pollutants can also affect fish reproductive success, which affects fish populations. Species composition is usually determined by a number of factors including water quality, water temperature, and pH. Angling also has a large impact on fish populations and community structure and is usually closely regulated to try to maintain a balanced fishery. In sum, any human activity that affects water quality and habitat has the potential to affect fish populations and overall community structure (13).

Direct contact of boats or propellers may be a source of mortality for certain fish species, such as carp. Pollution from exhaust or spills may be toxic to some fish species. Boat movement can affect individual fish directly by disturbing normal activities such as nesting, spawning, or feeding. Increased turbidity from boats may interfere with sight-based feeding or success of eggs or fish spawning. On a population level, boats may affect fish through habitat alteration caused by waves or propeller damage (13).

Keeping boats out of known fish spawning areas may help to improve overall fish success; however, it would be detrimental to anglers. Most boat activity usually occurs after peak fish spawning times, but extending protection of critical areas through early June may help to protect certain species. A more useful approach would be to protect shallow waters and plant beds from boat activity through the use of no-wake zones. No-wake zones in prime fishing areas may also help to reduce user conflicts by creating a separation between anglers and high-speed boaters (13).

9.0 Water Quality

Water quality information was retrieved from the WDNR Surface Water Integrated Monitoring System (SWIMS, 2014). Data of interest was dissolved oxygen, temperature, water clarity or Secchi depth, total phosphorus, and chlorophyll *a*. Information was also retrieved from a report compiled by the U.S. Geological Survey in cooperation with the St. Croix Chippewa Indians of Wisconsin (2). The purpose of the report was to provide a summary of water resource information in the vicinity of St. Croix Reservation land and identify factors that impact water resources. The study area was 707 square miles (Appendix E), including Upper Clam Lake as a lake of special interest. Although Lower Clam Lake is not included in the study area, it is presumed water quality averages in Saad & Robertson (2000) apply to both lake basins.

Additional water quality information was collected by SCTES through 2013.

9.1 Monitoring Stations

The WDNR establishes and manages stations in lakes for the purpose of collecting data from the same site year after year. Through this data, changes in lakes over time can be tracked and comparison of lakes can be made. Lower and Upper Clam Lakes each have one monitoring station and three access points total (Table 5, Figure 7). Monitoring stations information and data are retrievable from the WDNR Surface Water Integrated Monitoring System (SWIMS) online database.

Table 5 - Monitoring Stations for Lower & Upper Clam Lakes

Monitoring Station Number	Monitoring Station Name	First Field Work Event Date	Last Field Work Event Date
10029236	Lower Clam Lake at Center	4/27/2009	8/8/2011
073158	Hwy 70 Public Access	8/26/2007	8/17/2013
10029237	Upper Clam Lake at Center Main Basin	4/27/2009	4/29/2011
10020278	Ramp	5/27/2007	6/23/2013
10018160	Access	8/19/2007	6/1/2012

Figure 7 – Monitoring Stations Map for Lower & Upper Clam Lakes

9.2 Dissolved Oxygen and Temperature

Both Lower Clam and Upper Clam Lakes are shallow systems, which allow the water column to continually mix during ice-free periods. Both lakes are therefore classified as cold polymictic lakes, meaning they are ice-covered part of the year but during ice-free periods they do not thermally stratify, or, if they do, any thermal stratification is weak. Saad & Robertson (2000) reported weak summer stratification in Upper Clam Lake. Temperature data were collected by volunteers from Lower Clam Lake monitoring station 10029236 from April through August in 2009. Temperature data were recorded in Upper Clam Lake at monitoring station 10029237 from April through August in 2009 and 2010. The maximum depth of volunteer monitoring for temperature in both lakes was 6 feet.

Dissolved oxygen in Lower Clam was measured in April, June, and July of 2009 with values ranging from 7 mg/L to 9 mg/L. Upper Clam Lake dissolved oxygen levels were monitored from April to July in 2009 with values ranging from 6.2 mg/L to 10 mg/L. Monitoring also occurred from June to August in 2010 with a range of 3.4 mg/L to 8.1 mg/L. Dissolved oxygen data from both lakes do not suggest low or limiting oxygen levels and are adequate to sustain fish and other aquatic organisms. Similarly, Saad & Robertson (2000) reported relatively high DO concentrations from the surface to the bottom of Upper Clam Lake.

Water quality monitoring by SCTES from 2001-2013 also indicates a lake that is does not regularly stratify. DO concentration range from 1.745mg/L (Feb. 2011) to a max of 15.72mg/L. Average DO concentration over the 13 years is 9.42 mg/L.

9.3 Water Clarity

Water clarity is a measurement of how deep sunlight can penetrate into the waters of a lake. It can be measured in a number of ways, the most common being an 8" disk divided into four sections, two black and two white, lowered into the lake water from the surface by a rope marked in measurable increments (Figure 8). The water clarity reading is the point at which the Secchi disk (named for its inventor) when lowered into the water can no longer be seen from the surface of the lake. Water color (like dark water stained by tannins from nearby bogs and wetlands), particles suspended in the water column (like sediment or algae), and weather conditions (cloudy, windy, or sunlight) can impact how deep a Secchi disk can be seen down in the water. Some lakes have water clarity readings of just a few inches, while other lakes have conditions that allow the Secchi disk to be seen for dozens of feet before it disappears from view.

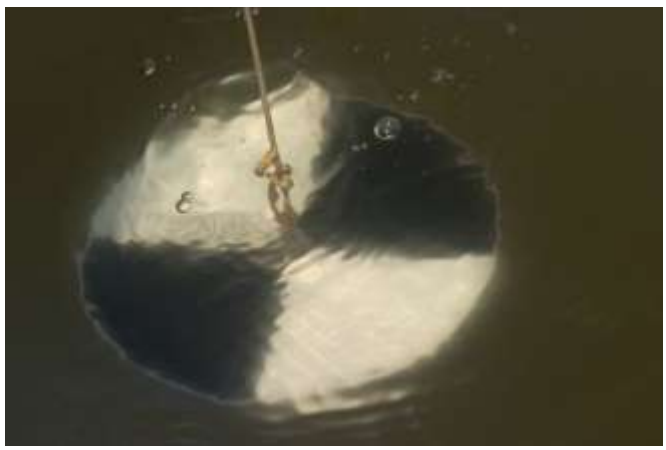


Figure 8 – Black and White Secchi Disk for measuring Water Clarity

Secchi depths vary throughout the year, generally with shallower readings in summer when algae become dense and limit light penetration and deeper readings in spring and late fall when algae growth is limited.

Only limited SWIMS Secchi data is available for Lower and Upper Clam Lakes at one monitoring station per basin. Lower Clam Lake was monitored in 2009 at station 10029236 with a mean summer (June-August) Secchi depth of 3.3 feet (Figure 9). Upper Clam Lake was monitored in 2009 and 2010 at station 10029237 with a mean summer Secchi depth of 2.6 feet and 2.1 feet respectively with an overall mean of 2.4 feet for both years (Figure 9). The overall mean summer Secchi depths for each lake classify Lower and Upper Clam Lakes as eutrophic systems.

Secchi depth values for the St. Croix Reservation vicinity compiled by Saad & Robertson (2000) range from 2.0 to 14.1 feet with an average of 7.3 feet, therefore classifying the "average" lake in the region as mesotrophic. Hence, the Clam Lakes have water clarity that is lower than average for waters in the region.

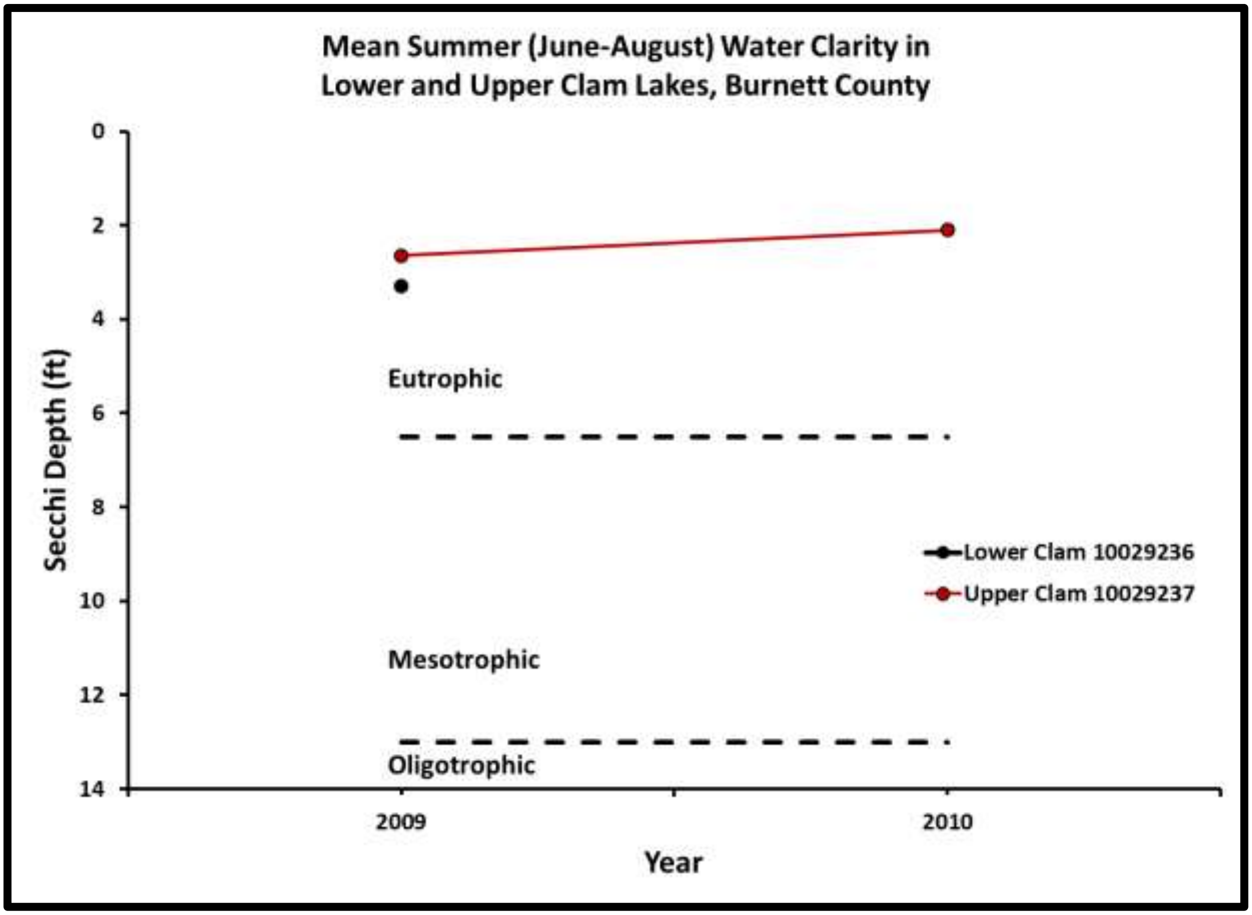


Figure 9 – Secchi Depth in Lower and Upper Clam Lakes

The average summer (June - August) Secchi reading on Upper Clam Lake collected by SCTES from 2001-2013 is 2.74 ft.

9.4 Phosphorus

Phosphorus is an important nutrient for plant growth and is commonly the nutrient limiting plant production in Wisconsin lakes. When phosphorus is limiting production, small additions of the nutrient to a lake can cause dramatic increases in plant and algae growth.

Total phosphorus data for Lower Clam Lake was collected from 2009 through 2011 from monitoring station 10029236. Mean summer (June-August) near-surface (0-6 feet) total phosphorus values range from 64.5µg/L to 114.3µg/L, with an overall mean of 91.9µg/L (Figure 10). Upper Clam Lake was monitored in 2009 and 2010 at station 10029237 with mean summer near-surface values ranging from 69µg/L to 122µg/L and an overall mean of 95.5µg/L. Although both lakes exhibit some phosphorus values in the hyper-eutrophic range, the overall means classify both lakes as eutrophic.

Phosphorus values for the St. Croix Reservation vicinity range from 10µg/L to 150µg/L with an average of 29µg/L (2). The "average" lake in the region is eutrophic. The Clam Lakes have higher than average phosphorus concentrations when compared to waters in the region.

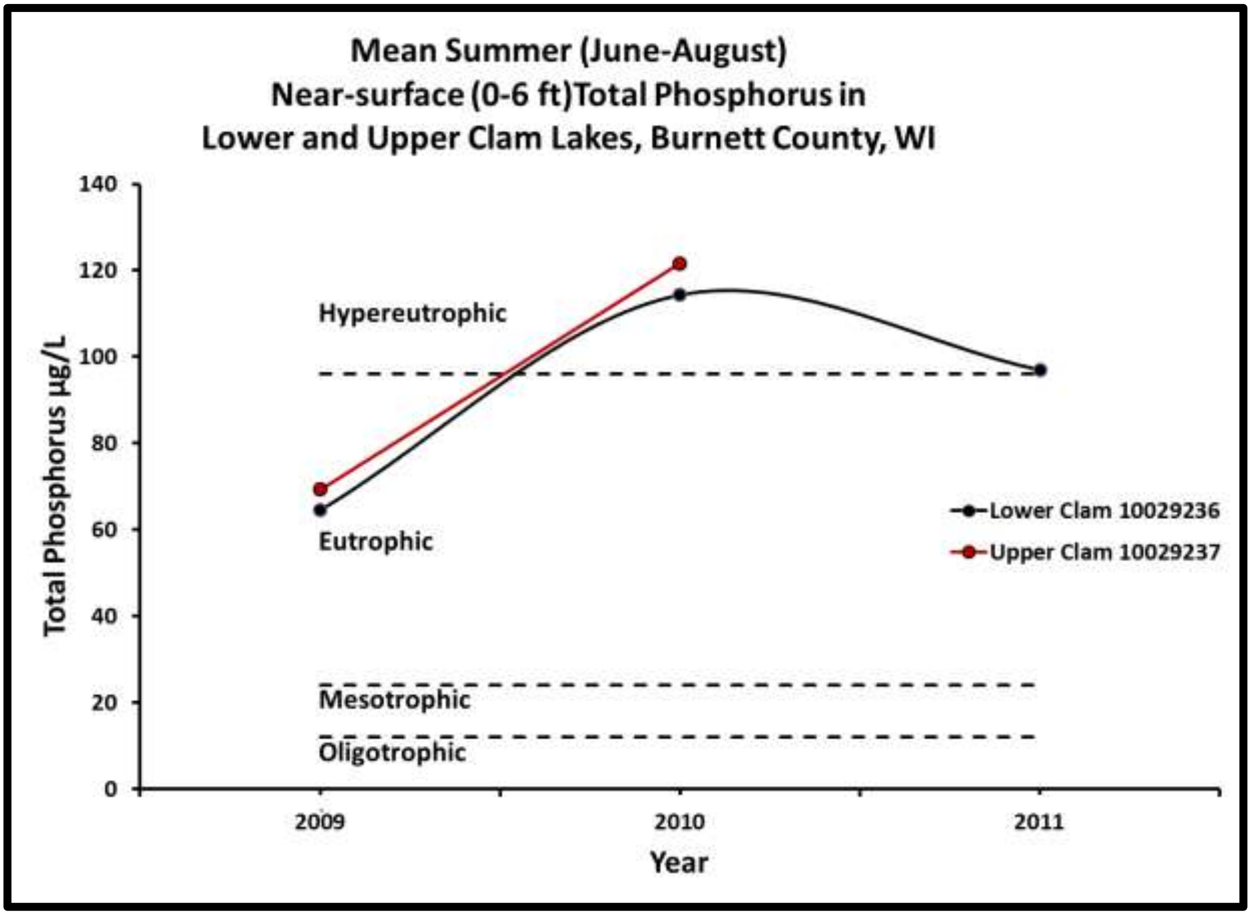


Figure 10 – Total Phosphorus in Lower and Upper Clam Lakes

SCTES data for total phosphorus collected between 2001 and 2013 ranged from 58µg/L to 158µg/L with a mean of 101µg/L supporting the CLMN records indicating that the Clam Lakes are eutrophic, bordering on hyper-eutrophic.

9.5 Chlorophyll-*a*

Chlorophyll *a* is a measurement of algae in the water. The concentration varies throughout the year, generally peaking in late summer. Chlorophyll-*a* is the preferred parameter for measuring trophic state index (TSI) in lakes because it is directly associated with algal blooms. Therefore, values are expressed as TSI in Figure 11. Chlorophyll-*a* values for Lower Clam Lake were measured from 2009 through 2011 at monitoring station 10029236 with a mean summer (June-August) near-surface (0-6 feet) TSI_{CHL} ranging from 63 (28.6µg/L) to 72 (71.0µg/L) with an overall mean of 68 (53.6µg/L) (Figure 11). Chlorophyll-*a* values for Upper Clam Lake were measured in 2009 and 2010 at monitoring station 10029237 with a mean summer near-surface TSI_{CHL} ranging from 64 (29µg/L) to 66 (37.8µg/L) with an overall mean of 65 (33.7µg/L). These mean values classify both lakes as eutrophic

TSI values for Chlorophyll-*a* in the St. Croix Reservation vicinity ranges from 36 (1.7µg/L) to 65 (32µg/L) with an average of 53 (9.8µg/L) (2). The "average" lake in the region is eutrophic. The Clam Lakes have higher than average chlorophyll-*a* concentrations when compared to waters in the region.

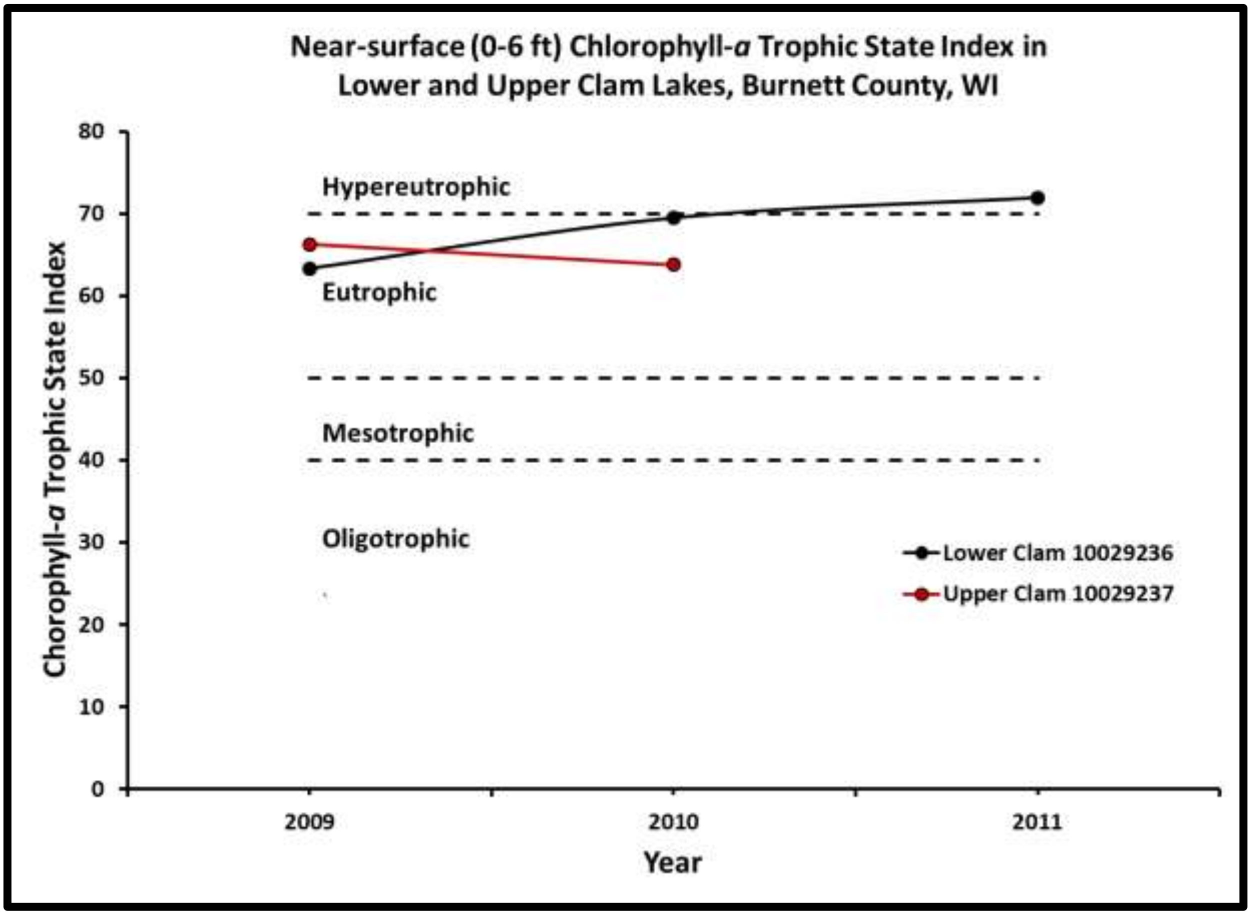


Figure 11 – Chlorophyll-*a* TSI Values in Lower and Upper Clam Lakes

SCTES data for Chlorophyll-a data collected between 2001 and 2013 ranges from 14.2µg/L to 60.37µg/L with a mean of 62.85µg/L supporting the CLMN records indicating that the Clam Lakes are eutrophic, bordering on hyper-eutrophic.

9.6 Water Quality Discussion

Volunteer monitoring on Lower and Upper Clam Lakes revealed water clarity, total phosphorus, chlorophyll-*a* TSI values that classify the lakes as eutrophic, borderline hyper-eutrophic. For trophic state classification, preference is given to the TSI_{CHL} because it is the most accurate at predicting algal biomass. TSI_{CHL} for Lower and Upper Clam Lakes are 68 and 65 respectively. Lakes with these TSI values are often dominated by blue-green algae with algae scum and nuisance aquatic plant growth possible (Figure 12). Since there are only three seasons of data available, it cannot be inferred whether water quality is improving, deteriorating, or remaining the same.

TSI	Trophic State	Description of Associated Conditions
<30	Oligotrophic	Classical oligotrophy: clear water, many algal species, oxygen throughout the year in bottom water, cold water, oxygen-sensitive fish species in deep lakes. Excellent water quality.
30 - 40		Deeper lakes still oligotrophic, but bottom water of some shallower lakes will become oxygen-depleted during the summer.
40 - 50	Mesotrophic	Water moderately clear, but increasing chance of low dissolved oxygen in deep water during the summer.
50 - 60	Eutrophic	Lakes becoming eutrophic: decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident, warm-water fisheries (pike, perch, bass, etc.) only.
60 - 70		Blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible.
70 - 80		Becoming very eutrophic. Heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae block sunlight).
>80		Algal scums, summer fishkills, few plants, rough fish dominant. Very poor water quality.

U. Clam 65
L. Clam 68

Figure 12 – Trophic States and Associated Conditions (Adapted from SEH, Inc.)

10.0 Nearshore and Watershed Phosphorus Loading Assessment

Phosphorus promotes excessive aquatic plant and algal growth in lakes. In more than 80% of Wisconsin's lakes, phosphorus is the key nutrient affecting the amount of algae and weed growth that occurs.

Phosphorus cycling in a lake is a complex process. In addition to plant and algae utilization of available phosphorus, a major component of cycling is the exchange of phosphorus between bottom sediments and the overlying water. Generally speaking, the amount of new phosphorus deposited into the lake sediments is greater than the amount of existing phosphorus in the sediment that is released back into the water. Deposition and build-up of phosphorus in the lake sediment occurs by four methods:

1. phosphorus from the watershed that settles rapidly to the bottom,
2. phosphorus in various forms that is chemically bound and transported to the sediment,
3. sedimentation of phosphorus associated with decay of organic matter, and
4. uptake of available phosphorus by aquatic biota (plant and algae growth) that is eventually transported back to the sediment.

The chemical make-up of the sediment is an important to the build-up of phosphorus in it. Inorganic forms of phosphorus chemically bind with iron, aluminum, manganese, and carbonates (fundamental elements found in sediment). When more of these compounds are present in the sediment, more phosphorus can be stored there, in some cases permanently.

Under certain conditions, phosphorus bound in the sediment can be released back into the overlying waters. The presence of oxygen (oxic conditions) in the area where the water and the sediment meet will prevent most of the bound phosphorus from being released back into the overlying water. When oxygen is not present (anoxic conditions) in the water adjacent to the sediment, a chemical reaction occurs that releases previously bound phosphorus back into the overlying waters. Additional phosphorus may be released under high pH conditions. The rate of phosphorus release from lake sediments in shallow water increases (about doubles) markedly if the sediments are disturbed by agitation from turbulence cause by natural wind and waves, carp, and by human use of the water (for example, motor boat prop-wash) (14).

Phosphorus enters the lake water from many different sources, both from within the lake and from the surrounding environment. External sources include the watershed, atmospheric deposition, and the movement of groundwater into the lake. Internal sources include phosphorus present in the lake sediments and the cycling of phosphorus in the lake by plants, animals, and chemical processes. Not all of the potential sources of phosphorus were evaluated during this project. Those that were are explained more in the following sections.

10.1 Internal Phosphorus Sources

10.1.1 Sediment Release

Sediment release rates were not calculated as a part of this project, but due to the shallow nature of the lakes and increased turbidity as a result of natural occurrences like wind and waves, carp activities, and human actions it is likely that this is a major source of phosphorus in the lakes. By increasing the amount of emergent vegetation in the nearshore area to help stabilize sediment, controlling the carp population, and minimizing sediments stirred up by boat motors in shallow water, this source of phosphorus can be reduced.

10.1.2 Aquatic Plant Decay

Plants require about twenty elements for growth, but the growth of aquatic life is often limited by the availability of phosphorus. Emergent, rooted, floating-leaved and submersed aquatic plants take up most of their phosphorus from the lake sediment. As foliage matures, a gradual, partial senescence of leaves often occurs, particularly among submersed aquatic plants, from which nutrients including phosphorus leach. Some of these leaves are sloughed off the living plants and collect as detritus on the sediment. Phosphorus release from decaying plant tissue in the water appears to be very rapid, with 20-50% of total phosphorus leaching out in the first few hours and 65-85% over longer periods (14). When sediment is present, as much as 60% of the phosphorus released may be absorbed back into the sediment (15).

Under normal conditions, aquatic plants continue to grow and both use up and deposit phosphorus through the growing season. In the fall, when water temperatures cool down, most aquatic plants die, fall back to the bottom of the lake, and decay. At this time, some of the phosphorus released from these senescing plants may be absorbed back into the sediment. Water temperatures at this time are generally too cold to allow for immediate use of the released phosphorus to grow algae.

Large infestations of CLP in a body of water can be a significant internal source of phosphorus in a lake when the plant senesces (dies and decays) mid-summer releasing a large amount of phosphorus in a short period at the height of the algae growing season. Prior to 2010, when the Clam Lakes were severely impacted by dense growth CLP, this source of phosphorus may be been significant. Large scale harvesting of CLP completed by the CLPRD removed much of this phosphorus source in the past. Since the distribution and density of CLP in the lake has decreased due to carp activity in the last few years, this source of phosphorus has already been reduced. Management efforts should strive to keep the density and distribution of CLP in both lakes at very low levels.

10.2 External Phosphorus Sources

10.2.1 Atmospheric Deposition

Atmospheric deposition of phosphorous comes from the phosphorous found in the dust and other particulate matter that is blown over and settles into the lake or is cleansed from the air when it rains. This particulate matter could be carried to the lake from a great distance away by a weather system or be blown off the land immediately adjacent to the lake. Atmospheric contributions of phosphorus in rain and dry deposition range from approximately 0.01-0.65 grams/meter2/year with most values in the lower range (14). Atmospheric deposition for the Clam Lakes estimated through the Lake Modeling Suite (WiLMS) (16) is approximately 450 lbs/year. Methods to reduce this source of loading include incorporating best management practices aimed at fixing the particulate matter to the ground. Grass cover on crop land and dampening of exposed sediment, sand, and gravel areas to prevent wind erosion are examples of best management practices that should be implemented in the area adjacent to the Clam Lakes.

10.2.2 Groundwater Flow

Groundwater flow into the lake also contributes phosphorous. The type of substrate groundwater flows through, the areas of inflow and outflow, and the volume of groundwater that is moving influences the amount of phosphorous it carries into the lake. The phosphorous content of groundwater is generally low; average concentrations are about

20µg/L, even in areas where soils contain relatively large quantities of phosphorus. The low phosphorus content is the results of the relatively insoluble nature of phosphorus-containing minerals and the scavenging of surface phosphate by biota and soil particles (14).

Groundwater contributions were not calculated as a part of this project.

10.2.3 Tributary Loading

The Clam Lakes are impounds on the Clam River. Many smaller tributaries that drain areas of the watershed carry sediment, phosphorus, and other pollutants to the Clam River. As long as the flow in the tributaries remains strong enough, these pollutants are carried downstream to the Clam Lakes where water flow significantly slows allowing pollutants carried in the stream water to settle out and remain in the Clam Lakes long enough to impact water quality, aquatic plants, and many others aspects of the ecosystem. The nutrient load carried into the Clam Lakes from the watershed can be calculated if appropriate stream monitoring and water quality sampling is completed. This was not done for this project, so phosphorus loading from this source was not calculated. It is however, safe to say that this phosphorus is likely one of the largest sources impacting the water quality of the lakes.

10.2.4 Nearshore and Septic System Contribution

The nearshore area of the Clam Lakes was evaluated during phase three of this project. Data collected during the 2010 Lake Use Survey made it possible to estimate phosphorus contributions from septic systems. Phosphorus contributions from both these sources are explored further in the next several sections.

10.3 Shoreline Inventory

In the summer of 2010, a shoreline inventory survey was completed on the Clam Lakes. During the survey the entire shoreline was patrolled with a small craft, placing GPS points at the beginning and end of several designated shoreline uses. Disturbed shoreline was divided into lawn and impervious surface sub categories; natural shoreline was divided into forest, prairie, shrub, wetland, and open water subcategories. In addition, the existence of buffer strips and rip rap; the presence of emergent aquatic vegetation, and sites with substantial erosion were all documented. GIS mapping was then used to place these points on a map of the lakes. Shoreline status was determined for Upper, Lower, and the two miles of river outlet.

Table 6 shows the breakdown of this shoreline survey. More than 35% (7.25 miles out of nearly 21 miles) of the shoreline of the entire system is mowed lawn or impervious surface right to the water's edge. Approximately 6% (1.2 miles) of the shoreline has rip rap in place. More than 60% of the property around Lower Clam is mowed to the water's edge, much higher than the 28% and 30% on Upper Clam and in the river respectively. Emergent vegetation was identified as being present around 61% of the entire shoreline.

A little more than 71% of the shoreland on Upper Clam Lake is natural; 68% of the river outlet is natural; and only 38% of the shoreland on Lower Clam Lake is in a natural state. Wetlands make up the largest piece of the natural shoreline on Upper Clam; shrubs are the largest part of the natural shoreline on Lower Clam, and forests make up the largest piece of the natural river shoreline.

Table 6
Shoreline status categories: % coverage and miles of shoreline on the Clam Lakes. Note: The *Other* category overlaps with the *Disturbed* and *Natural* categories (e.g. a shoreline segment may have *Lawn* and *Riprap*).

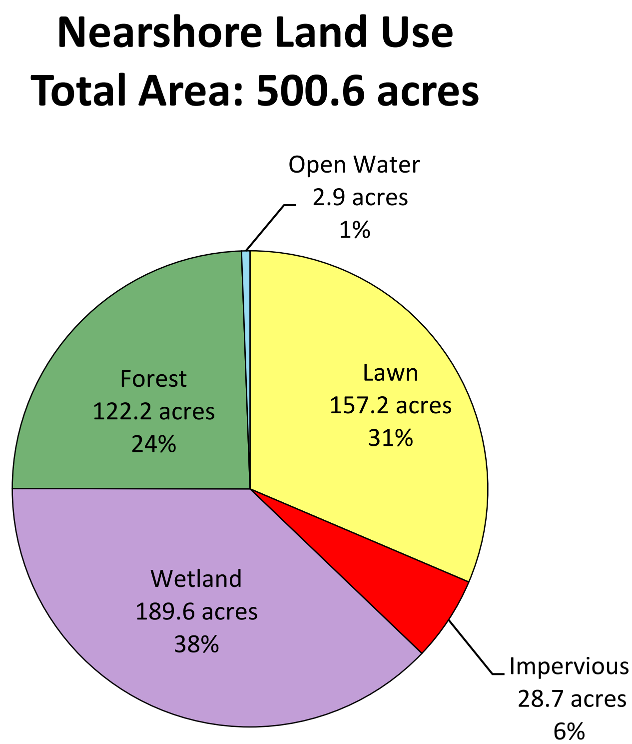
Land Use		Upper (%)	Miles	Lower (%)	Miles	River (%)	Miles
Disturbed	Impervious	0.4%	0.05	0.7%	0.03	1.6%	0.06
	Lawn	28.2%	3.68	60.3%	2.43	29.5%	1.10
Natural	Forest	12.1%	1.58	10.7%	0.43	45.6%	1.71
	Prairie	0.1%	0.01	0.0%	0.00	0.0%	0.00
	Shrub	24.0%	3.13	14.3%	0.58	17.8%	0.67
	Wetland	35.1%	4.59	13.0%	0.52	4.6%	0.17
	Open Water	0.3%	0.03	1.1%	0.04	0.8%	0.03
Other	Buffer	8.6%	1.13	10.7%	0.43	6.4%	0.24
	EAV	69.1%	9.04	45.6%	1.84	50.7%	1.89
	Erosion	1.3%	0.16	3.2%	0.13	13.9%	0.52
	Rip rap	4.2%	0.55	15.1%	0.61	1.2%	0.05
EAV: Emergent Aquatic Vegetation							

Source:2010 Shoreline Survey, SEH

10.4 Nearshore Area Land Cover

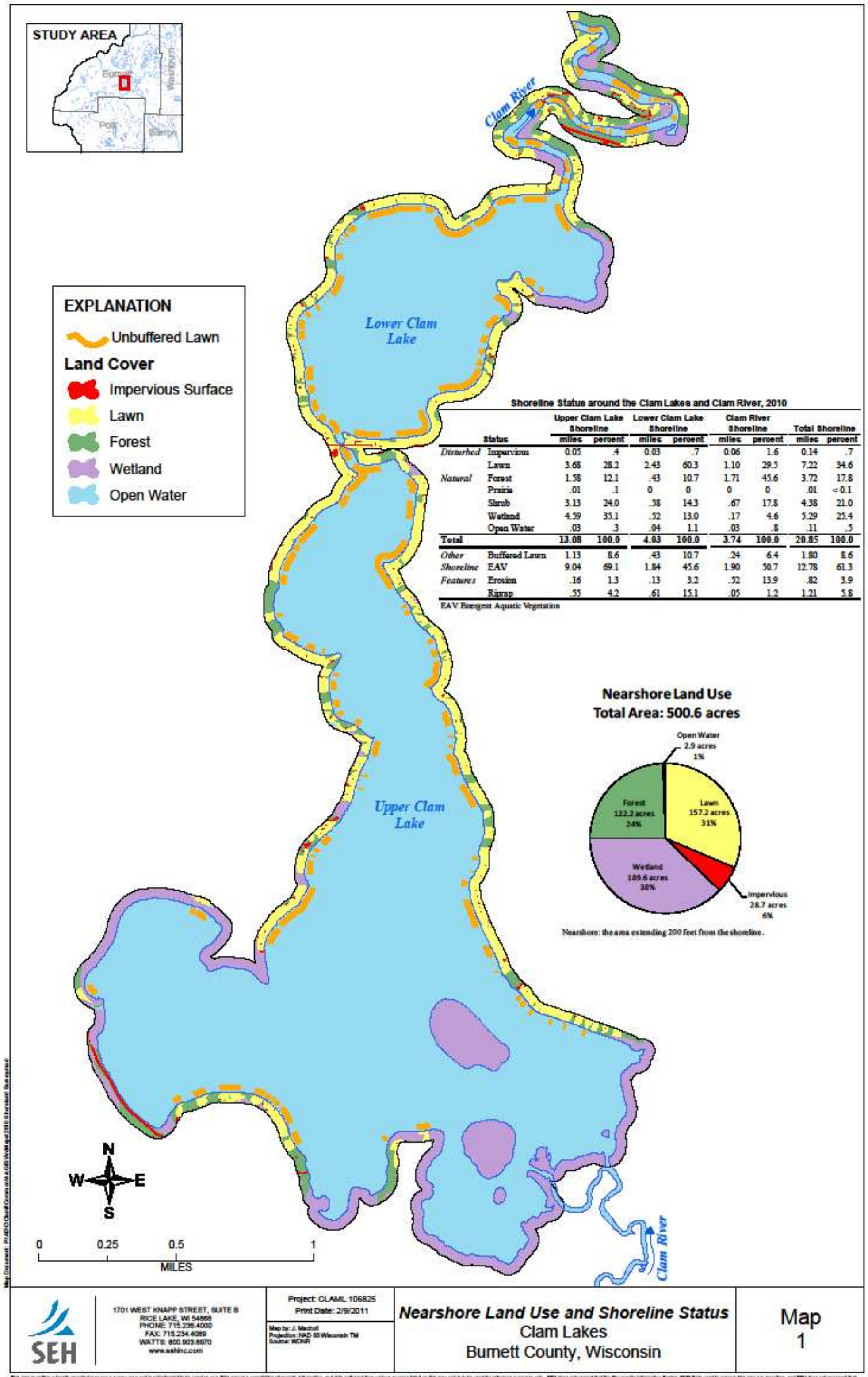
In addition to the shoreline survey, a band of the nearshore area from the water's edge inland 200-ft was evaluated for land use. The land use was assessed using recent high resolution (6-inch) ortho-photos and GIS. Land use was classified as disturbed (lawn, impervious surface) or natural (forest, wetland). More than 500 acres was evaluated around Upper and Lower Clam Lakes and the river outlet. Figure 13 shows the total percent of land use within that 200-ft nearshore band around the lakes and river.

Wetlands make up the largest piece of the nearshore area at 38%, most of which is located on the southern third of Upper Clam Lake. Mowed lawn makes up the second largest piece at 31%. When combined with impervious surfaces including roads, rooftops and driveways 37% of the nearshore area is in a disturbed state. Natural forest cover and open water make up the remaining 25% of the total land use in the nearshore area. Figure 14 shows the distribution of land use in the 200-ft nearshore area. The majority of mowed lawn is on the east and west shores of Upper Clam, and essentially all the way around Lower Clam.



Nearshore: the area extending 200 feet from the shoreline.

Figure 13 – Land Use in the Nearshore Area of the Clam Lakes



Shoreline Status around the Clam Lakes and Clam River, 2010

	Status	Upper Clam Lake Shoreline		Lower Clam Lake Shoreline		Clam River Shoreline		Total Shoreline	
		miles	percent	miles	percent	miles	percent	miles	percent
Disturbed	Impervious	0.05	.4	0.03	.7	0.06	1.6	0.14	.7
	Lawn	3.68	28.2	2.43	60.3	1.10	29.5	7.22	34.6
Natural	Forest	1.58	12.1	.43	10.7	1.71	45.6	3.72	17.8
	Prairie	.01	.1	0	0	0	0	.01	<0.1
	Shrub	3.13	24.0	.58	14.3	.67	17.8	4.38	21.0
	Wetland	4.59	35.1	.52	13.0	.17	4.6	5.29	25.4
	Open Water	.03	.3	.04	1.1	.03	.8	.11	.5
Total		**13.08**	**100.0**	**4.03**	**100.0**	**3.74**	**100.0**	**20.85**	**100.0**
Other	Buffered Lawn	1.13	8.6	.43	10.7	.24	6.4	1.80	8.6
Shoreline	EAV	9.04	69.1	1.84	45.6	1.90	50.7	12.78	61.3
Features	Erosion	.16	1.3	.13	3.2	.52	13.9	.82	3.9
	Riprap	.55	4.2	.61	15.1	.05	1.2	1.21	5.8

EAV: Emergent Aquatic Vegetation

Figure 14 – Nearshore and Shoreline Status of the Clam Lakes

10.4.1 Impervious Surfaces

The impacts of impervious surfaces on water quality are well known. Different land uses have different levels of impervious surface (Figure 15) (17). The total coverage by impervious surfaces in an area (for example, a watershed, or within a municipality) is usually expressed as a percentage of the total land area. The coverage increases with rising urbanization. In rural areas, impervious cover may be only one or two percent. In residential areas, coverage increases from about 10 percent in low-density subdivisions to over 50 percent in multi-family communities. In industrial and commercial areas, coverage rises above 70 percent, and in regional shopping centers and dense urban areas, it is over 90 percent.

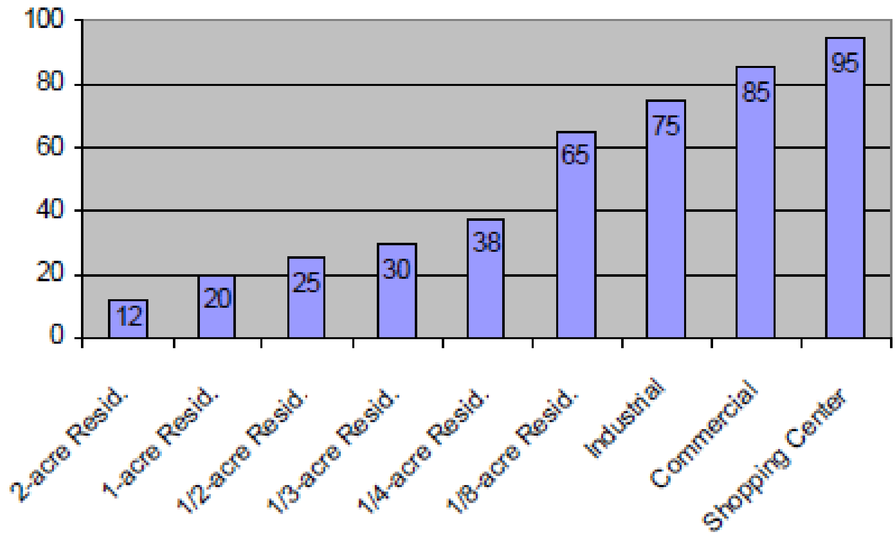


Chart adapted from Ferguson, B. K. 1998. *Introduction to Stormwater: Concept, Purpose, Design*. New York: John Wiley & Sons.

Figure 15 – Average Percentage of Impervious Cover by Land Use

Impervious surfaces closer to the water have a greater negative impact on water quality because there is less opportunity for the runoff from these areas to soak into the ground or be filtered before reaching the lake or stream. The findings from a study of 47 watersheds in southeastern Wisconsin indicated that 1 acre of impervious surface within 100 meters (~330 feet) of the stream had a negative effect on fish populations and diversity equivalent to 10 acres of impervious surface more than 100 meters from the stream (17).

Lawns often comprise the largest fraction of land area within low-density residential development and often have similarities with impervious surfaces. Although lawns are pervious, they have sharply different properties than the forests and farmlands they replace. Compared to forests and farmlands, residential lawns generally have more compacted soils, greater runoff and much higher input of fertilizers and pesticides (17). A pound of soil in a lawn has 24% less volume than forest soil and 15% less volume than pasture soils (Figure 16). The decreased volume of the lawn soil reflects decreased pore space and ability to infiltrate water, resulting in increasing runoff. Cultivated soils and lawn soils are similar to each other due to disturbance and compaction. The soil cover also affects water quality. For example, blades of turf grass are flat and easily flattened during a runoff event whereas native grasses and forbs typically have round, square or triangular stems that stay upright to slow runoff velocity and filter it during a storm (17).

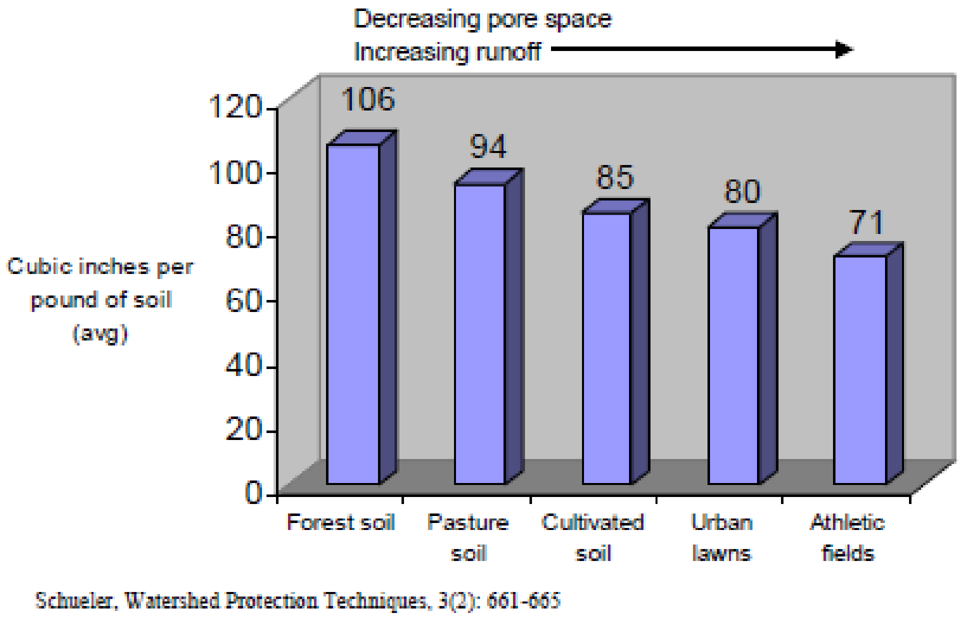


Figure 16 – Soil Compaction with Different Land Uses

Identifying and protecting the remaining natural shoreline, restoring disturbed shoreline with shoreland improvement best management practices, and reducing the amount of impervious surface and turf grass in the nearshore areas of the Clam Lakes would reduce the amount of runoff that carries suspended solids, phosphorus, and other pollutants into the lakes. In addition, fish and wildlife habitat would be improved.

Property owners should be encouraged to participate in the Burnett County Shoreland Incentive Program and/or a Lakeshore Education Specialist could be employed by the CLPRD to identify and work with shoreline property owners interested in shoreland improvement planning and possible implementation of restoration plans on their properties. Planning and implementation could be expedited if money was made available to hire a shoreland consultant to complete planning for these landowners and if there were incentives to implement the projects once the planning was complete. This service should be made available to any property included in the boundaries of the CLPRD.

10.5 Septic System Contribution

Loading from septic systems in the nearshore area was estimated using results from the lake use survey. Septic system usage data was determined for permanent, seasonal, and "other" dwellings adjacent to the lake via the sociological survey.

Septic tank output was estimated through the Lake Modeling Suite (WiLMS) (16) using 0.50 kg of phosphorus per capita-year and 405.25 total capita-years. The percent of total phosphorus retained by the nearshore soils (well-drained sandy loams) was estimated at 80% generating an estimated annual phosphorus load from septic systems of approximately 90 lbs annually.

It is generally understood that septic system contributions are a small percentage of the overall total phosphorus loading to a lake system, however it is one area where there are obvious techniques to minimize this source. Regular septic system inspections and repair of faulty or failing systems are easy, though not always inexpensive fixes to reduce loading from this source. It is also important to note that even properly functioning systems do not remove all nutrients and chemicals from the water. Water soluble pollutants such as pharmaceuticals, solvents, drain cleaners, and many household chemicals are not removed or treated in septic systems, so reducing the use of these substances and proper disposal of unwanted pharmaceuticals is important.

10.6 Agricultural Best Management Practices

Agriculture (row crops) only makes up about 5% of the entire Clam Lakes watershed, and there is no agriculture in the immediate nearshore area of either lake. None the less, encouraging agricultural producers in the watershed to incorporate agricultural best management practices like no till, field buffers, cover crops, and nutrient management planning will provide benefit to the lakes. The Burnett County Soil and Water Conservation Department has been and will continue to work with farmers in Burnett County to ensure their practices have minimal or no impact on area lakes.

11.0 Aquatic Plant Community

Aquatic plants play an important role in lakes. They anchor sediments, buffer wave action, oxygenate water, and provide valuable habitat for aquatic animals. The amount and type of plants in a lake can greatly affect nutrient cycling, water clarity, and food web interactions. Furthermore, plants are very important for fish reproduction, survival, and growth, and can greatly impact the type and size of fish in a lake.

Unfortunately, healthy aquatic plant communities are often degraded by poor water clarity, excessive plant control activities, and the invasion on non-native nuisance plants (18). These disruptive forces alter the diversity and abundance of aquatic plants in lakes and can lead to undesirable changes in many other aspects of a lake's ecology. Consequently, it is very important that lake managers find a balance between controlling nuisance plant growth and maintaining a healthy, diverse plant community.

11.1 Point-Intercept Plant Surveys

Using a standard formula that takes into account the shoreline shape and distance, water clarity, depth, islands and total lake acres, a 668 point sampling grid for Upper Clam Lake and a 350 point grid for Lower Clam Lake were generated by the WDNR. Early-season cold water and mid-season warm water whole lake point-intercept plant surveys were completed on both lakes during the 2009 season by Endangered Resources Services (ERS), LLC. The early season surveys concentrated on identifying and mapping CLP and the mid-season survey focused on all plants. The WDNR and the CLPRD have both received copies of the CLP and whole lake plant survey reports. The reports are summarized in the following sections.

At the request SCTES and the CLRPD, another mid-season point-intercept survey was done in 2012 so that plant communities from 2009 and 2012 could be compared. Between 2009 and 2012, the population of carp in the lakes increased to alarming numbers, having a devastating impact on aquatic vegetation. Management efforts throughout this time frame have focused on controlling the carp population as an absolute necessity before considering any aquatic plant or water quality management.

11.2 Curly-leaf Pondweed

CLP density surveys were carried out on May 14, 2009 on Lower Clam and May 19-20, 2009 on Upper Clam. CLP bed mapping surveys were conducted on both lakes on June 6. CLP was found to be dominant throughout the littoral zone of Lower Clam Lake, but only scattered in the northern 1/4 of Upper Clam Lake. While CLP in Lower Clam was generally monotypic and highly invasive, Upper Clam's plants tended to be found in lower densities, were generally not bed forming, and had native species mixed in.

On October 16th, 2009 CLP turion sampling at 42 on Lower Clam and at 77 sites on Upper Clam was completed. As expected, a large number of turions were found in Lower Clam Lake. The locations of heaviest deposition correlated well with the dense beds of CLP identified during the spring bed-mapping survey. What was a little unexpected was the lack of turions found in Upper Clam Lake. Only a few locations had turions at all. In the past, the harvesting program for CLP was fairly extensive on both lakes. In recent years, Lower Clam Lake seems to have the largest issue with CLP.

11.2.1 2009 Lower Clam Lake Results

All 350 WDNR established point-intercept locations on Lower Clam were checked for the presence of CLP. CLP was present at 231 locations or 66% of the area surveyed. Of these, 160 points had a rakefull rating of 3 and another 44 were rated as a 2 indicating approximately 58% of the lake had a significant infestation (Figure 17). The only areas on the lake not dominated by CLP were the deepest areas along the old river channel that were beyond the littoral zone, the lake's sandy shorelines, and the far eastern bay. At the time of the early-season survey, the far eastern bay was the only place on the lake that had any native vegetation growing. The densest areas of CLP were in approximately 4-6 ft of water, but plants were found from 1-8 ft.

During the turion survey on Lower Clam Lake, a turion sample was taken at 42 sites. Turion density reached a high of 933turions/m^2 with a mean of 126turions/m^2.

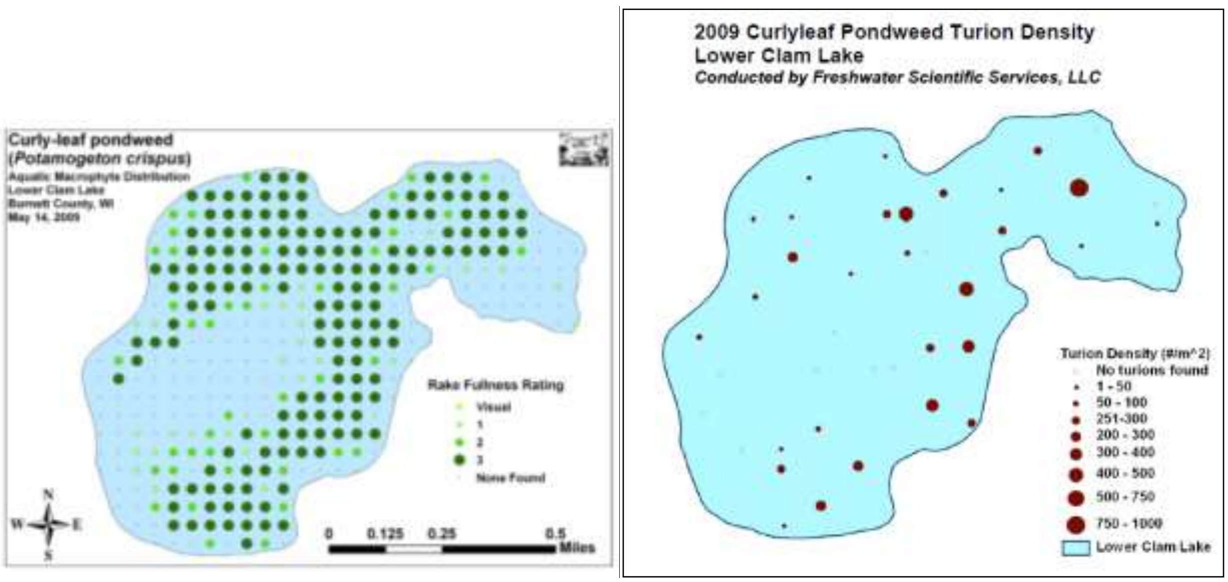


Figure 17 – CLP Presence and Density Lower Clam Lake (plants and turions)

A single expansive bed of CLP that dominated the littoral zone of the lake was located and mapped. It covered a total of 220.2 acres or 65.3% of the lake's 337 acres (Figure 18). This giant bed extended almost unbroken from the north to south shores of the lake with the exception of the previously mentioned areas. Plants were canopied throughout, prop trails were everywhere, and it was obvious that the beds were impeding boat traffic and general lake use. Also of note were the huge piles of uprooted plants that had accumulated along the shore forcing residents to spend significant time and effort to clean up their property.

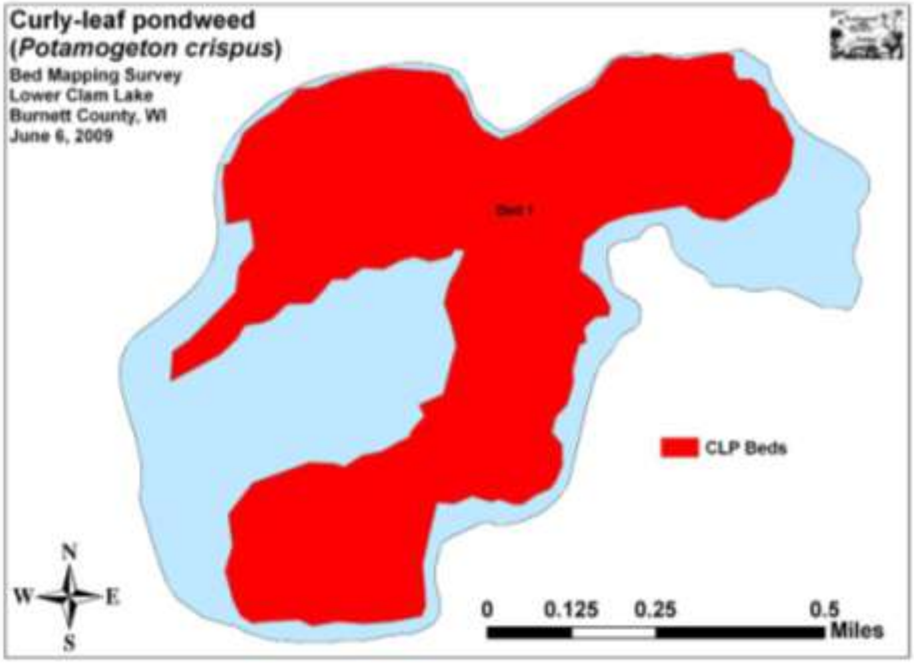


Figure 18 – CLP Bed Mapping Lower Clam Lake

11.2.2 2012 Lower Clam Lake Results

In 2012, an early season CLP point-intercept and bed-mapping survey was not completed. By the time the mid-season point-intercept survey was completed, most of the Curly-leaf pondweed in the lake had senesced as the only evidence of CLP that was seen was a single turion in the rake, and a few scattered plants near shore inter point. Despite this, by comparing the summer results from 2009 to 2012, the data shows a significant decline in both the detection of living CLP plants as well as evidence of CLP presence such as detritus from dead plants and turions that will overwinter and grow into new plants the following spring (Figure 19).

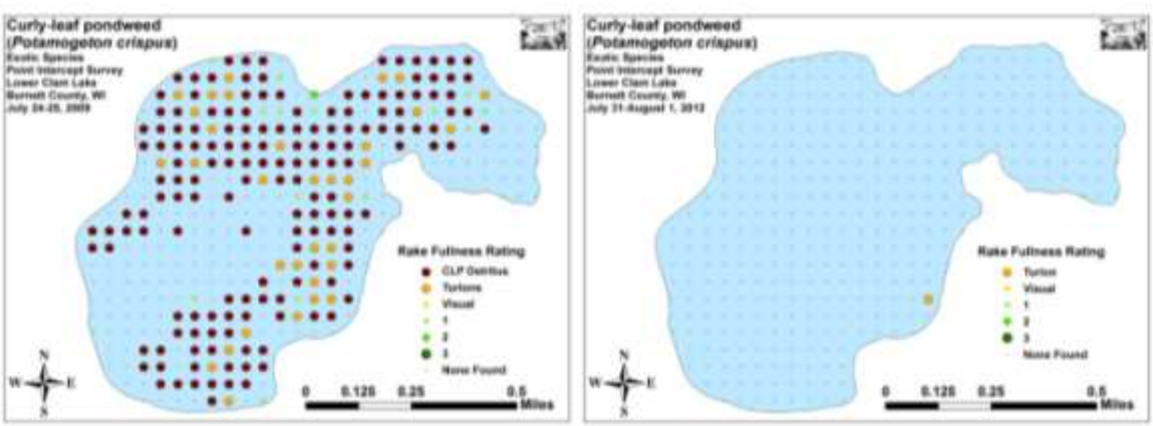


Figure 19 – CLP Density and Distribution Summer 2009 and 2012 in Lower Clam Lake

11.2.3 2009 Upper Clam Lake Results

All 668 WDNR established point-intercept locations on Upper Clam were checked for the presence of CLP as all could have fallen in the littoral zone. CLP was present at 33 locations or 4.9% of the points surveyed. Of these, 3 had a rakefull rating of 3 and another 10 a 2 indicating <2% of the lake had a significant infestation (Figure 20). CLP was essentially absent from the bottom ¾ of the lake. The only CLP found here were single stems, and repeated rakings at the locations turned up no further individuals. In the northwest bay where the majority of the lake's CLP was found, the plants were not canopied, and were beginning to form turions indicating the vegetative growth phase was essentially over. Two small beds in the northeast bay near the river outlet were located and mapped. They covered a total of 2.6 acres or 0.2% of the lake's 1207 acres (Figure 21).

During the turion survey on Upper Clam Lake, a turion sample was taken at 77 sites. Turion density reached a high of 133turions/m^2 with a mean of 6turions/m^2 (Figure 22).

The 2009 distribution and density of CLP turions in Upper and Lower Clam Lake generally reflected the CLP growth densities reported in the 2009 from Endangered Resource Services, LLC. These data provide a baseline for evaluating future changes in the density and extent of the CLP infestation in the Clam Lakes. Based upon the results presented here, turion densities greater than 250/m$_2$ are likely to result in dense CLP growth (19).

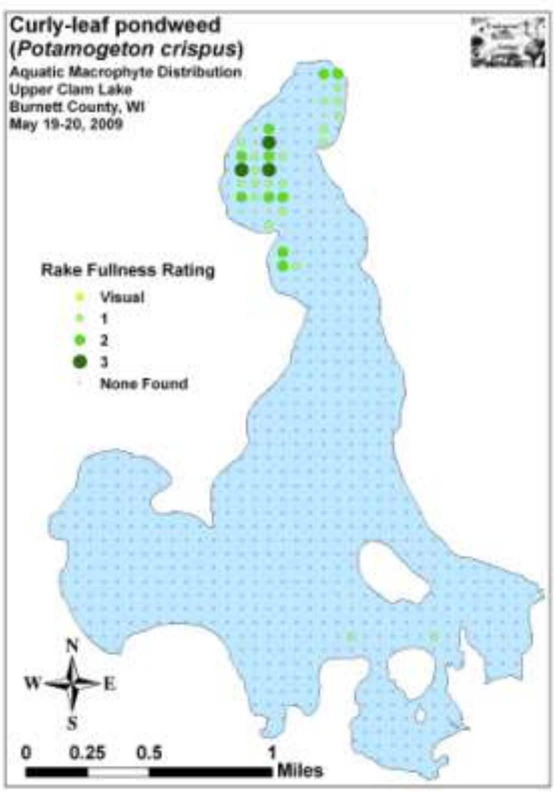


Figure 20 – CLP Presence and Density Upper Clam Lake

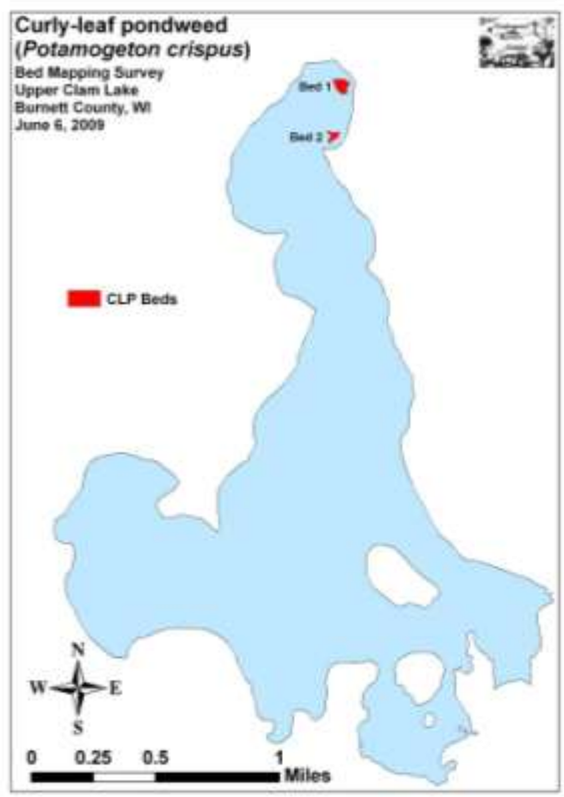


Figure 21 – CLP Bed Mapping Upper Clam Lake

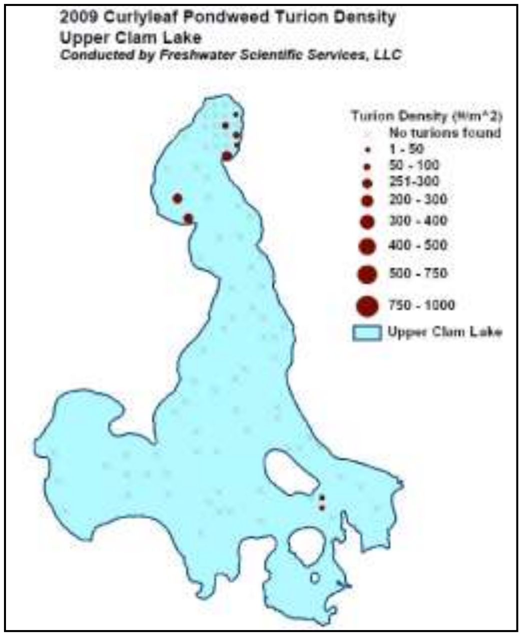


Figure 22 – CLP Turion Density in Upper Clam Lake in 2009

11.2.4 2012 Upper Clam Lake Results

Most of the Curly-leaf pondweed in the lake had senesced by the time of the survey as the only CLP that was seen was a single plant in the rake, and a few scattered individuals we recorded at visuals at two additional points (Figure 23). These results are similar to what was observed in 2009.

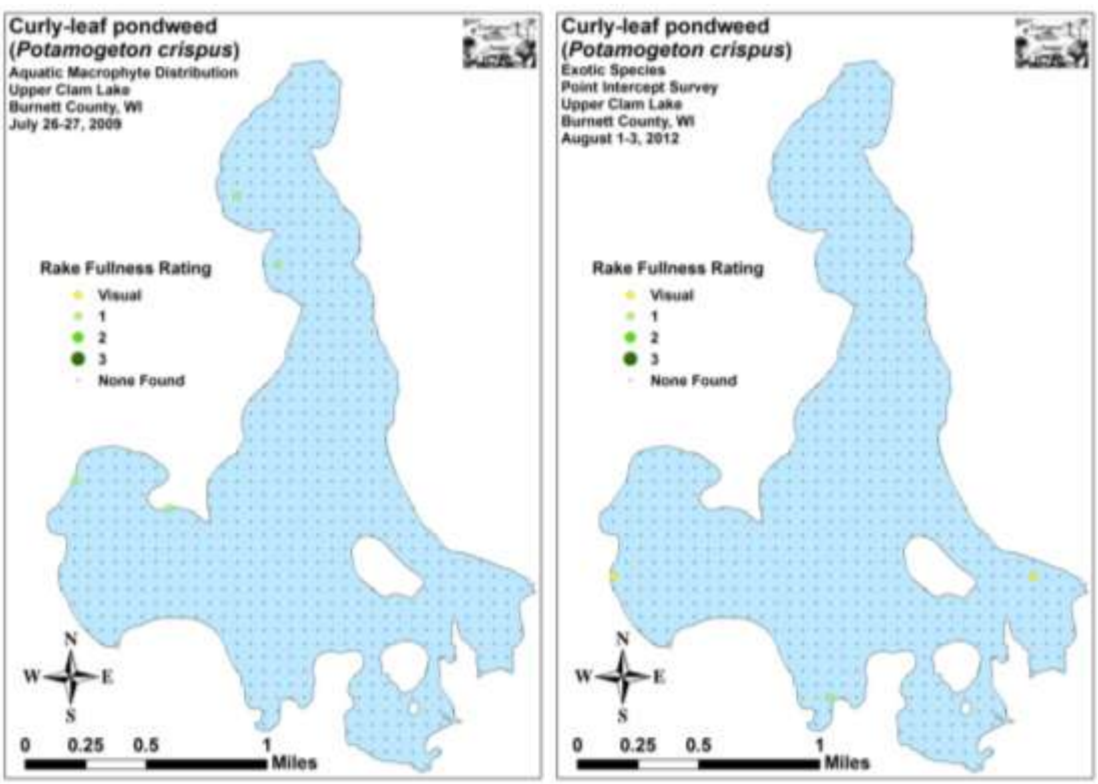


Figure 23 – CLP Density and Distribution Summer 2009 and 2012 in Upper Clam Lake

11.3 Mid-season Aquatic Plant Survey

ERS completed a warm water point/intercept survey of all aquatic macrophytes from July 24-27, 2009. The survey used the WDNR statewide guidelines for conducting systematic point intercept macrophyte sampling. The guidelines ensure that all sampling in the state is conducted in the same manner, thus allowing data to be compared across time and space. The immediate goals of the project were to determine if EWM had invaded the lakes and to gather data on the diversity, abundance and distribution of native aquatic plant populations. These data provide a baseline for long-term monitoring of each lake's macrophyte community.

Another warm water point-intercept survey was completed at the end of August in 2012.

11.3.1 2009 Lower Clam Lakes Results

The Lower Clam Lake survey grid contained 350 points. As with Upper Clam, almost the entire lake was within the littoral zone so every point was surveyed. Lower Clam's substrate was 88.9% muck and 11.1% sand. The main basin was ringed in sugar sand with deeper sites having a uniform sandy muck bottom. The east bay offered the only thick organic muck habitat in the whole lake. Plants were found growing in just 20.0% of the entire lake bottom, and in 20.7% of the littoral zone. Summary statistics are included in Table 7.

Table 7
Aquatic Macrophyte P/I Survey Summary Statistics, Lower Clam Lake, Burnett County (July 24-25, 2009)

Total number of points sampled	350
Total number of sites with vegetation	70
Total number of sites shallower than the maximum depth of plants	338
Frequency of occurrence at sites shallower than maximum depth of plants	20.71
Simpson Diversity Index	0.92
Maximum depth of plants (ft)	8.00
Number of sites sampled using rope rake (R)	0
Number of sites sampled using pole rake (P)	350
Average number of all species per site (shallower than max depth)	0.48
Average number of all species per site (veg. sites only)	2.31
Average number of native species per site (shallower than max depth)	0.43
Average number of native species per site (veg. sites only)	2.41
Species Richness	26
Species Richness (including visuals)	28
Species Richness (including visuals and boat survey)	30
Mean depth of plants (ft)	3.96
Median depth of plants (ft)	3.50

Lower Clam Lake's overall diversity was slightly higher than Upper Clam's with a Simpson Diversity Index value of 0.92. However, species richness was much lower with 30 total species found growing in and immediately adjacent to the lake. The western 80% of the lake that had been so completely dominated by dense curly-leaf pondweed beds in the spring was almost totally barren of plants in during this survey. Even the boat survey produced little more than a few scattered patches of sago pondweed, bushy pondweed, and mud plantain in this part of the lake. Common bur-reed and river bulrush were again common along shore in undeveloped areas.

Lower Clam's east bay contained most of the lake's diversity. The bay was dominated by coontail, white water lily and spatterdock. Closer to the channel, these beds were widely scattered, but they became progressively denser and richer as the lake grew shallower to the southeast. The highest species richness was noted on the far eastern transect where the lake was <1 ft deep and bordered a diverse sedge marsh.

Coontail, bushy pondweed, muskgrass and curly-leaf pondweed were the most common macrophyte species in Lower Clam Lake. A total of 24 native plants were identified to species during the point intercept survey. They produced a mean Coefficient of Conservatism of 5.4 and a Floristic Quality Index of 26.3. This mean C was again well below average for this part of the state while the FQI was slightly above average. Vasey's pondweed, a state species of special concern with a C value of 10, was the lake's most notable sensitive plant.

11.3.2 2012 Lower Clam Lake Results

At the time of the survey, Secchi disc readings were in the 2ft range. This very poor water clarity produced a littoral zone that extended to 5.5ft and showed a highly significant decline in area from 2009 when scattered plants extended to 8.0ft. Additionally, the vast majority of plants in 2012 were found in water <4ft deep as both the mean and median depths of plants were 2.9ft and 3.0ft (Table 8). These values also showed a decline from 2009 when mean and median depths were 3.9ft and 3.5ft respectively. Plants were patchy in distribution with only 12.0% of the lake bottom being colonized. This was also down significantly from 19.7% in 2009. Diversity was moderately high and unchanged with a Simpson Index value of 0.91in both 2009 and 2012. Richness was down from 25 species found in the rake in 2009 to 19 in 2012.

Table 8 –
Aquatic Macrophyte P/I Survey Summary Statistics
Lower Clam Lake, Burnett County
July 24-25, 2009 and July 31-August 1, 2012

Summary Statistics:	2009	2012	p Lake
Total number of points sampled	350	350	n.s.
Total number of sites with vegetation	69	42	-**
Total number of sites shallower than the maximum depth of plants	338	122	-***
Frequency of occurrence at sites shallower than maximum depth of plants	20.41	34.43	+**
Simpson Diversity Index	0.91	0.91	n.s.
Maximum depth of plants (ft)	8.0	5.5	n.s.
Mean depth of plants (ft)	3.9	2.9	n.s.
Median depth of plants (ft)	3.5	3.0	n.s.
Average number of all species per site (shallower than max depth)	0.45	0.88	n.s.
Average number of all species per site (veg. sites only)	2.22	2.55	n.s.
Average number of native species per site (shallower than max depth)	0.41	0.88	n.s.
Average number of native species per site (veg. sites only)	2.34	2.55	n.s.
Species richness	25	19	n.s.
Species richness (including visuals)	27	22	n.s.

Species richness (including visuals and boat survey)	29	33	n.s.
Mean total rake fullness (veg. sites only)	1.71	1.86	n.s.

n.s. = Not Significant - Significant differences = * p <. 05, ** p <. 01, *** p <. 005

Lakewide, only 7 of the 42 sites with vegetation had more than 4 native species present in the rake, and the average at sites with vegetation was 2.55 native species. Overall plant density was low/moderate with a mean rake fullness of 1.86 at sites with vegetation.

When considering the lake as a whole, white water lily, slender naiad, coontail, spatterdock, and small pondweed were the most common species. They were found at 45.24%, 28.57%, 26.19%, 21.43%, and 21.43% of survey points with vegetation respectively. Collectively, they accounted for 47.66% of the total relative frequency. Muskgrass (7.48) and Floating-leaf pondweed (4.67) were the only other species that had relative frequencies over 4%.

A total of 19 native index species were identified in the rake during the point intercept survey. They produced a mean Coefficient of Conservatism of 5.1 and a Floristic Quality Index of 22.3. Nichols (1999) reported an average mean C for the Northern Lakes and Forest Region of 6.7 putting Lower Clam Lake well below average for this part of the state. The FQI was also below the median FQI of 24.3 for the Northern Lakes and Forest Region (20). All of these values were lower than what was found in 2009.

Comparing the two surveys found a significant decrease in coontail, wild celery, sago pondweed, and river bulrush. It also showed a highly significant decrease in curly-leaf pondweed (Figure 24).

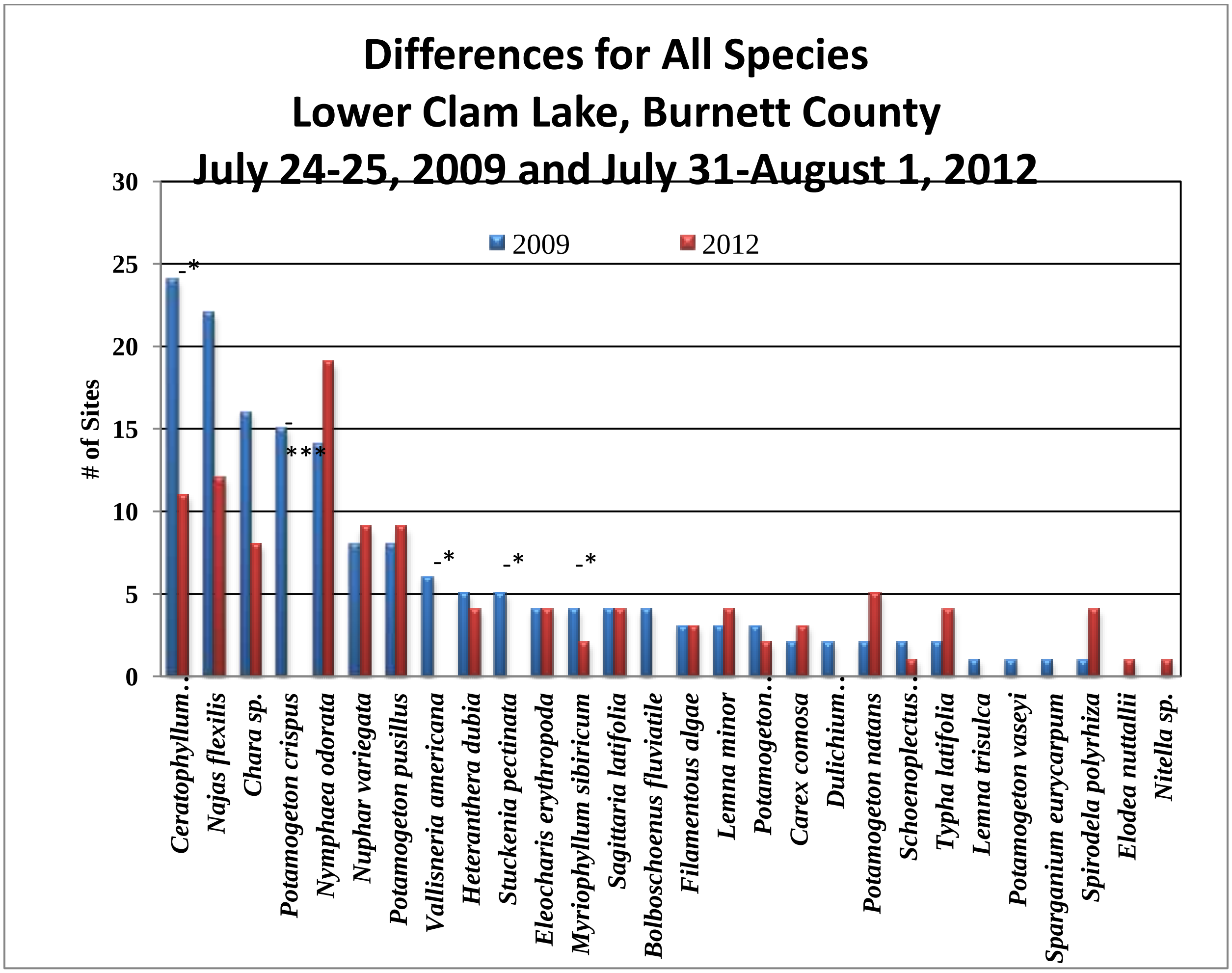


Figure 24 – 2009 – 2012 Macrophyte Changes on Lower Clam Lake

11.3.3 2009 Upper Clam Lake Results

The Upper Clam Lake survey grid contained 668 points. Because almost the entire lake fell within a foot of the littoral zone, every point was sampled. Upper Clam's substrate was categorized as 89.7% muck and 10.3% sand. The southwest, south and both southeast bays had thicker organic muck while the main basin was primarily sandy muck. Pure sugar sand was found along the big island's shorelines, at the Clam River Inlet, on the mid-lake bar, and on the margins of the main basin. Plants were found growing on 32.8% of the entire lake bottom, and in 33.1% of the littoral zone. Summary statistics are provided in Table 9.

Table 9 -
Aquatic Macrophyte P/I Survey Summary Statistics, Upper Clam Lake, Burnett County (July 26-27, 2009)

Total number of points sampled	668
Total number of sites with vegetation	219
Total number of sites shallower than the maximum depth of plants	661
Frequency of occurrence at sites shallower than maximum depth of plants	33.13
Simpson Diversity Index	0.90
Maximum depth of plants (ft)	9.00
Number of sites sampled using rope rake (R)	0
Number of sites sampled using pole rake (P)	668
Average number of all species per site (shallower than max depth)	0.89
Average number of all species per site (veg. sites only)	2.68
Average number of native species per site (shallower than max depth)	0.88
Average number of native species per site (veg. sites only)	2.68
Species Richness	38
Species Richness (including visuals)	40
Species Richness (including visuals and boat survey)	44
Mean depth of plants (ft)	3.33
Median depth of plants (ft)	3.50

Upper Clam Lake’s overall diversity was high with a Simpson Diversity Index value of 0.9. Species richness was also very high with 44 total species found growing in and immediately adjacent to the lake. The majority of aquatic macrophytes were found growing in relatively shallow water with a mean depth of 3.3 ft and a median depth of 3.5 ft. Total lake plant biomass was incredibly low. Plants were widely scattered throughout the littoral zone with depth seeming to be less important than in most other lakes. With almost no exceptions, high density, richness and total rake biomass sites were near shore in water <3 ft. Specifically, Upper Clam’s four southern bays provided most of the lake’s diversity. These shallow bays supported expansive floating, and emergent plant beds. However, with the exception of the southern ends of the two south-central bays, almost no submergent plants were found.

Detritus in the bays gave evidence of expansive submergent plant communities of flat-stem pondweed and potentially other species in the past so this loss of plant density and diversity appears to be relatively recent. Surviving submergent species tended to have bristly, hard, or thin leaves like coontail and floating-leaf pondweed. Plants with broad, soft leaves like common waterweed, clasping-leaf pondweed, and ribbon-leaf pondweed, showed evidence of being grazed on by carp, and were almost entirely absent from the lake.

The sandy/sandy muck bottom areas of the central basin were almost totally devoid of plants with the exception of a few dense emergent beds immediately adjacent to the shore. In general, these areas supported not only much lower densities, but also many fewer species albeit ones unique to these habitats. Bushy pondweed, muskgrass, and sago pondweed were the most widely distributed submergent in this habitat type while common bur-reed, river bulrush, hardstem bulrush, and threesquare were the most common emergent species.

Bushy pondweed, coontail, muskgrass, and small pondweed were the most common macrophyte species in Upper Clam Lake. A total of 36 native plants were identified to species. They produced a mean Coefficient of Conservatism of 5.6 and a Floristic Quality

Index of 33.7 putting Upper Clam Lake well below average for the coefficient of conservatism in this part of the state. The FQI was, however, well above the mean FQI of 24.3 for the Northern Lakes and Forest Region (20). High quality plants like northern wild rice and ribbon-leaf pondweed were notable contributors to this value.

11.3.4 2012 Upper Clam Lake Results

At the time of the survey, Secchi disc readings were in the 2ft range. This very poor water clarity produced a littoral zone that extended to 8.0ft although the majority of plants were found in water <4ft deep as both the mean and median depths of plants were 2.7ft and 3.0ft (Table 10). These values all showed a decline from 2009 when we found plants to 9ft with mean and median depths of 3.3ft and 3.5ft respectively. Plants were patchy in distribution with 29.5% of the lake bottom being colonized. This was down slightly from 32.6% in 2009. Diversity was high with a Simpson Index value of 0.92 in 2012 which was up from 0.90 in 2009. Richness was down from 37 species found in the rake in 2009 to 34 in 2012.

Table 10 –
Aquatic Macrophyte P/I Survey Summary Statistics
Upper Clam Lake, Burnett County
July 26-27, 2009 and August 1-3, 2012

Summary Statistics:	2009	2012	p Lake	p SE Bay
Total number of points sampled	668	668	n.s.	n.s.
Total number of sites with vegetation	218	197	n.s.	**+***
Total number of sites shallower than the maximum depth of plants	661	650	**-***	n.s.
Frequency at sites shallower than maximum depth of plants	32.98	30.31	n.s.	**+***
Simpson Diversity Index	0.90	0.92	n.s.	n.s.
Maximum depth of plants (ft)	9.0	8.0	n.s.	n.s.
Mean depth of plants (ft)	3.3	2.7	n.s.	n.s.
Median depth of plants (ft)	3.5	3.1	n.s.	n.s.
Average number of all species per site (shallower than max depth)	0.88	0.93	n.s.	**+*****
Average number of all species per site (veg. sites only)	2.68	3.08	n.s.	**+*****
Average number of native species per site (shallower than max depth)	0.88	0.93	n.s.	**+*****
Average number of native species per site (veg. sites only)	2.69	3.08	n.s.	**+*****
Species richness	37	34	n.s.	n.s.
Species richness (including visuals)	39	35	n.s.	n.s.
Species richness (including visuals and boat survey)	43	39	n.s.	n.s.
Mean total rake fullness (veg. sites only)	1.76	2.09	n.s.	**+*****

n.s = Not Significant - Significant differences = * p <. 05, ** p <. 01, *** p <. 005

Lakewide, the average number of native species per site with vegetation increased from 2.69 in 2009 to 3.08 in 2012. Overall plant density (mean rake fullness) also increased from a low/moderate value of 1.76 to a moderate 2.09 at sites with vegetation.

When considering the lake as a whole, slender naiad, coontail, muskgrass, and slender waterweed were the most common species. They were found at 43.65%, 41.12%, 34.52%, and 28.93% of survey points with vegetation respectively. Collectively, they accounted for 48.11% of the total relative frequency. Small pondweed (8.07), white water lily (7.91), water star-grass (5.60), and northern wild rice (5.60) were the only other species that had relative frequencies over 4%.

A total of 32 native index species were identified in the rake during the point intercept survey. They produced a mean Coefficient of Conservatism of 5.3 and a Floristic Quality Index of 30.2. Nichols (1999) reported an average mean C for the Northern Lakes and Forest Region of 6.7 putting Upper Clam Lake well below average for this part of the state. The FQI was, however, above the median FQI of 24.3 for the Northern Lakes and Forest Region (20). All of these values were lower than what was found in 2009.

Comparing the two surveys found a highly significant increase in common waterweed, slender waterweed, filamentous algae, white water lily, and northern wild rice; moderately significant increases in water star-grass, and significant increases in water marigold. The survey also showed moderately significant declines in sessile-fruited arrowhead and sago pondweed, and significant declines in muskgrass, softstem bulrush, and common watermeal (Figure 25).

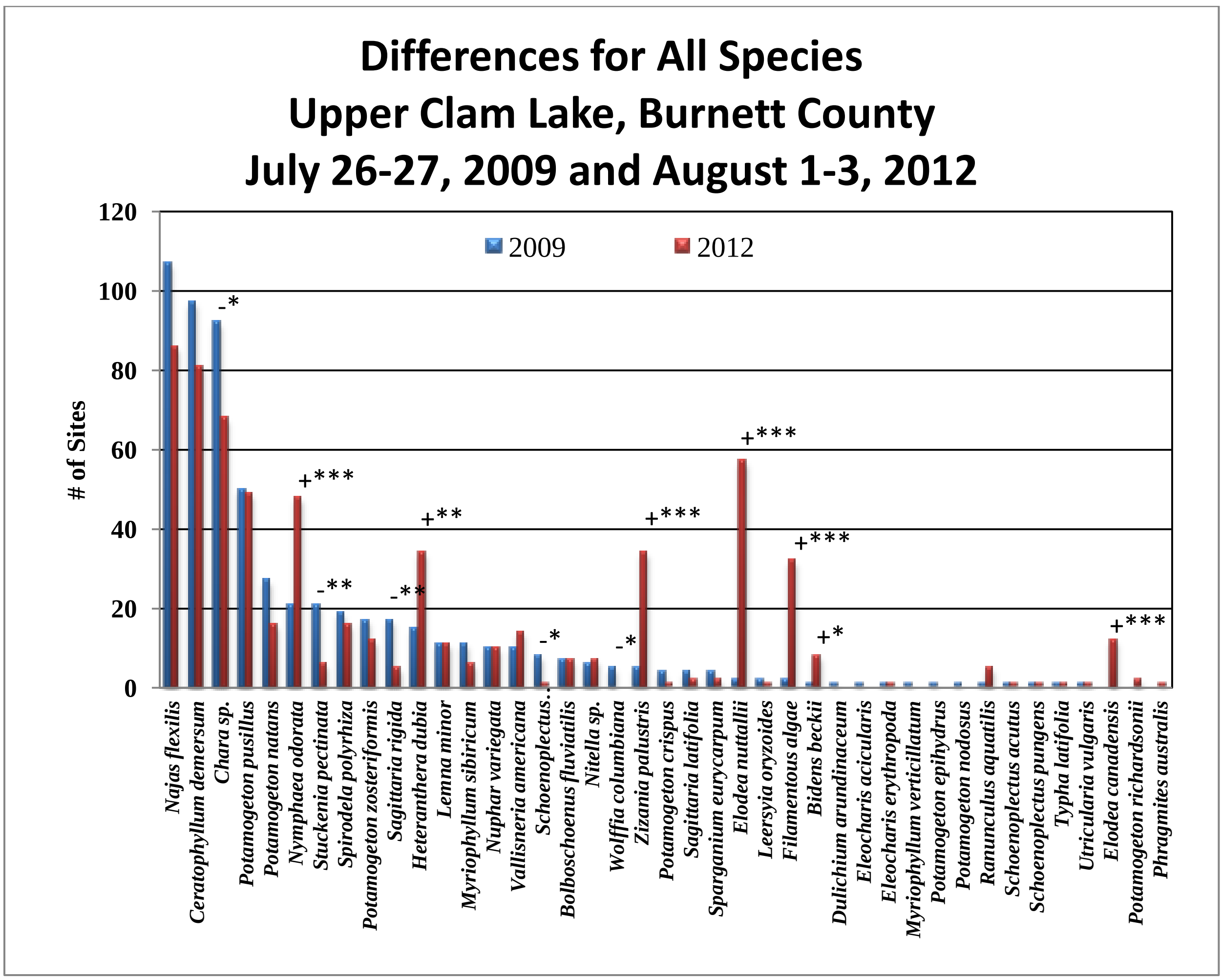


Figure 25 – 2009 – 2012 Macrophyte Changes on Upper Clam Lake

In both the 2009 and 2012 Surveys, no evidence of Eurasian watermilfoil was found in either of the Clam Lakes.

12.0 Wild Rice

Wild rice is an annual aquatic grass that produces seed that is a nutritious source of food for wildlife and people (Figure 26). As a native food crop, it has a tremendous amount of cultural significance to the Wisconsin and Minnesota Native American Nations. Wild rice pulls large amounts of nutrients from the sediment in a single year and the stalks provide a place for filamentous algae and other small macrophytes to attach and grow. These small macrophytes pull phosphorous in its dissolved state directly from the water. Wild rice can benefit water quality, provide habitat for wildlife, and help minimize substrate re-suspension and shoreland erosion.

In Wisconsin, wild rice has historically ranged throughout the state. Declines in historic wild rice beds have occurred statewide due to many factors, including dams, pollution, large boat wakes, and invasive plant species. Renewed interest in the wild rice community has led to large-scale restoration efforts to reintroduce wild rice in Wisconsin’s landscape. Extensive information is available on wild rice from GLIFWC and the WDNR.

Figure 26 – Wild Rice

12.1 Historic Wild Rice in Lower Clam Lake

Although Upper Clam Lake is well known for its expansive rice beds, the smaller beds on Lower Clam tend to be overlooked. The rice on Lower Clam is largely limited to the bay east of the outlet which is visible at the upper right in the photo in Figure 27. There are anecdotal reports that these beds were seeded by local residents fairly recently. They are located in an area with little lakeshore development. It remains to be seen if these beds are facing the same decline that has been witnessed on the Upper Clam beds, whose most recent appreciable crop was in 2006. The Tribal Watch Status for Lower Clam is high due to decline concerns.

Figure 27 – Wild Rice in the Bay East of the Outlet on Lower Clam Lake in 2008 (GLIFWC, 2010)

12.2 Historic Wild Rice in Upper Clam Lake

Upper Clam Lake has been one of the most significant rice waters in Wisconsin, with expansive rice beds occurring primarily on the large lobes on the southern half of the lake. Through the 20 years prior to 2008, Upper Clam Lake consistently supported large areas (250 to 300 acres) of northern wild rice. The photos in Figure 28 give a sense of the kind of beds Upper Clam Lake is capable of supporting. Unfortunately, in the years since the photos in Figure 28 were taken, the rice beds on Upper Clam have experienced an unusually sudden and drastic decline.

However, only very small beds have been observed in the 6-8 years since these photos were taken. Wild rice harvest records (Figure 29) show that Upper Clam Lake was a consistent high-quality source of wild rice from 1992 through 2006, with anecdotal accounts that this was also typical of most years prior to 1992. The lake has experienced a dramatic decline in the extent and density of wild rice growth in subsequent years. This decline is also evident in the harvesting records, with no reported harvest of rice from the lake between 2007 and 2009 (Figure 29).

Through 2010, after four years of documented decline, only a few sparse remnant stands of wild rice remained in the isolated shallow bays of Upper Clam Lake, less than 80 acres of very sparse rice. Due to this decline, very little new wild rice seed was produced in Upper Clam Lake from 2007 to 2010. Consequently, the bank of seeds remaining from previous years of rice growth is likely severely reduced, possibly limiting a natural recovery of rice beds (21).

Wild rice beds may experience periodic natural declines, and high variability in seed production. However, even after substantial declines, rice beds are typically able to reestablish from seeds remaining in lake sediments. The decline of rice beds in Upper Clam Lake coincided with a documented increase in common carp, suggesting that carp feeding and spawning activities reduced the survival and growth of wild rice in the lake. Furthermore, carp may have reduced the abundance of wild rice seeds by directly consuming them or by uprooting young rice plants before new seeds could be produced (21).

This lake has tremendous significance to the St. Croix Tribe, whose reservation includes frontage on the lake. The tribe harvests, monitors, and helps manage this water. It is critically important that the extensive rice beds on this body of water be preserved. The Tribal Watch Status for Upper Clam Lake is extremely high and much has been done since 2010 to protect, preserve, and enhance the remaining wild rice beds.

Figure 28 – Wild Rice in the SW Bay in 2006 and 2007 (top) and in the SE Bay in 2007 (bottom) on Upper Clam Lake (GLIFWC, 2010)

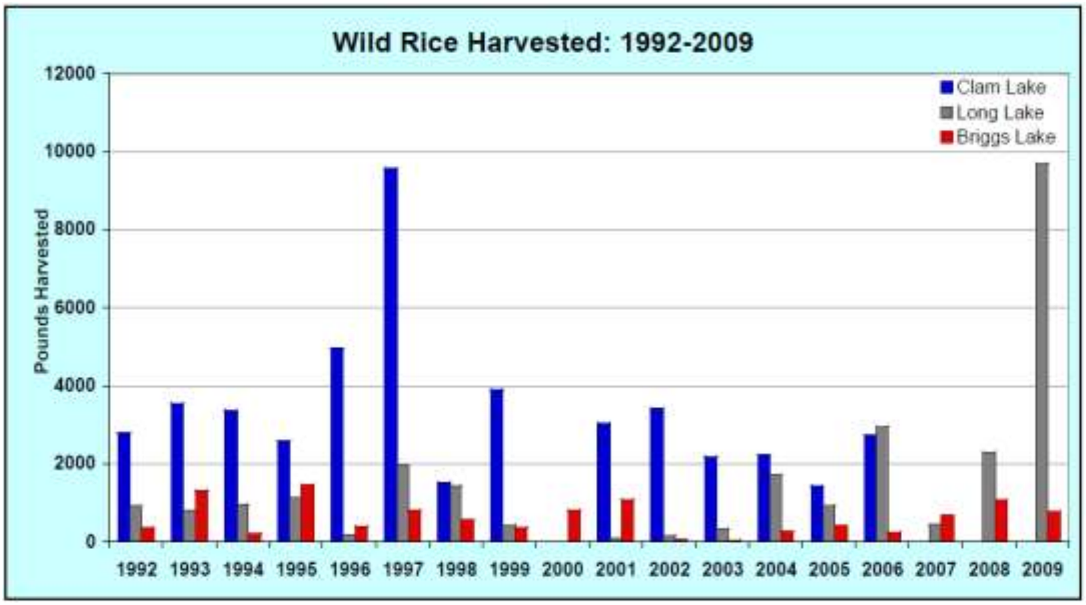


Figure 29 – Wild Rice Harvest on Upper Clam, Long, and Briggs Lakes from 1992-2009 (GLIFWC, 2010)

12.3 Efforts to Protect, Preserve, and Enhance Remaining Wild Rice Beds in Upper Clam Lake

The documented abundance and survival of large carp in Upper Clam Lake suggested that there was a high potential for impacts on aquatic plants, particularly during spring spawning when the carp concentrated in shallow areas. A 2 year-old gravid female carp was captured during the 2009 survey, suggesting that the large group of carp born in 2005 may have begun spawning in shallow areas as early as 2007, when they reached 2 years of age. This timing coincides with the first year of major wild rice decline in the lake.

A meeting was held on January 19, 2010 at the Tribal Resources Office in Hertel, WI to discuss 2009 findings on the Clam Lakes and what to do in 2010. The local WDNR Fish Manager, SCTES biologists, GLIFWC Biologists, Clam CLPRD representatives, SEH, and others were in attendance. Additional carp studies were completed in 2010 by both the WDNR and Tribal Resources. SCTES also completed a more comprehensive wild rice survey of the system in 2010. In another study completed in 2010 (22), a system of carp exclusion cages were set up by SCTES and WDNR resources in Upper Clam Lake in an attempt to determine what impact the carp may be having in the system. Several of the cages were seeded with rice (Figures 30 & 31).

Figure 30 – Seeded and Fenced (left) and Unseeded and Fenced (right) Wild Rice Exclosures installed in 2010

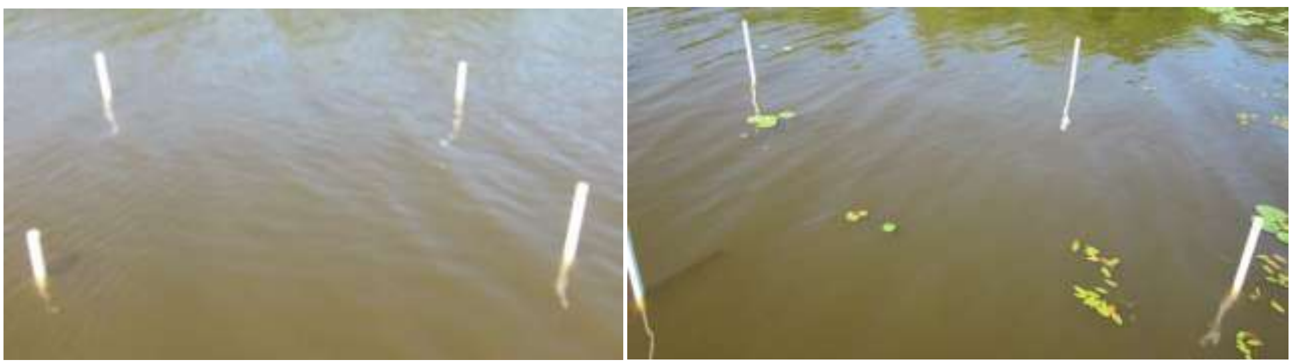


Figure 31 – Seeded and Unfenced (left) and Unseeded and Unfenced (right) Wild Rice Exclosures installed in 2010

The study clearly showed that direct carp effects severely limited wild rice survival, growth, and reproduction in Upper Clam Lake. The high survival and growth of rice inside the fenced plots with seeding, which were subject to the same water conditions as the other plots that were not seeded, suggested that indirect carp effects (increased turbidity and nutrients) did not substantially impact wild rice (22). Previous studies have shown that abundant carp can severely reduce submersed aquatic vegetation in shallow areas through direct uprooting or herbivory. Findings in this study strongly suggest that these direct carp effects can also impact wild rice, despite being an emergent plant.

Although wild rice survival and growth can also be reduced by high water levels in June and July, study results clearly show that water level did not substantially affect wild rice survival or growth, as evidenced by the lush rice growth in seeded plots. Water elevation in Upper Clam Lake fluctuated somewhat during the period from April through July 2010, but there was no evidence of "drowning" rice (22).

The study found that direct carp effects severely reduced wild rice during its early stages of growth, as indicated by the near complete lack of young wild rice shoots in open plots during the May survey. However, the study could not determine whether carp had eaten the seeds, eaten young shoots, or merely uprooted new shoots before the end of May. Regardless of whether carp eat wild rice seeds and shoots or merely uproot young plants, carp damage to rice during its early-season growth period likely represents a bottleneck that limits the amount of rice that reaches the emergent growth stage (22).

In addition to showing the strong impact of direct carp effects on wild rice, the study clearly showed that the abundance of wild rice seeds remaining in sediments of Upper Clam Lake from past years was not sufficient to produce substantial rice growth in the absence of carp. The abundance of rice growth in non-seeded, fenced plots was very low throughout the study, and was not significantly greater than what was observed in any of the open plots. Based upon the 4-year duration and longer of the current rice decline in Upper Clam Lake; the low number of seeds found during the 2009–2010 seed enumeration study, and the lack of rice growth in non-seeded fenced plots during this study, the failure of rice in Upper Clam Lake does not appear to be a typical natural decline.

12.3.1 Installation and Effectiveness of Carp Barriers

In an effort to protect and preserve the remaining wild rice beds in the southern most bay of Upper Clam Lake, in April 2011 staff from SCTES installed carp barriers that consisted of two nets with surface floats and bottom weights stretched across the two narrow channels that connect the southern bay of Upper Clam Lake to the main basin of the Lake (Figure 32). These barriers were in place before carp moved into shallow areas to spawn, but carp were not removed from behind the barrier.

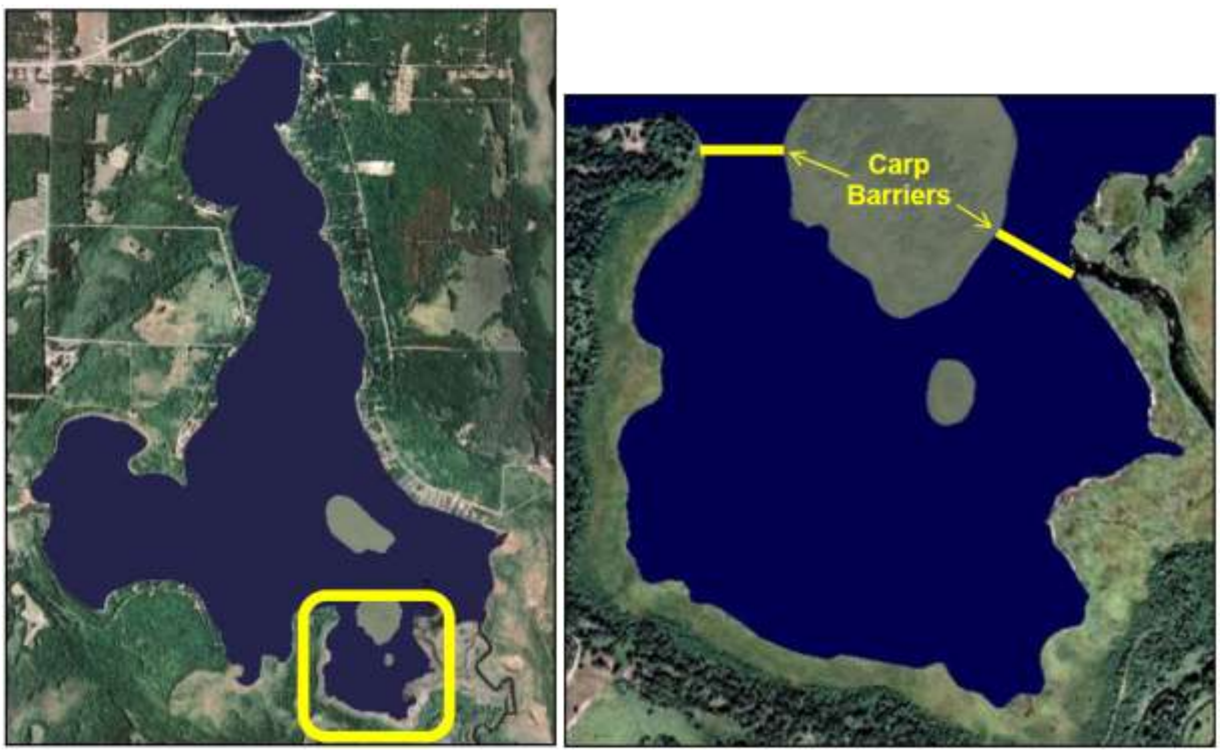


Figure 32 – Wild Rice Protection Barriers on the SE Bay of Upper Clam Lake

Despite the installation of the carp barrier, the density of wild rice in the southern bay did not increase in 2011. However, increased native aquatic plant growth in the bay suggested that the nets successfully reduced carp activity in the bay in 2011. The abundance and diversity of aquatic plants generally appeared to be greater than in previous years, and were dramatically greater in the enclosed bay than in the areas immediately outside of the carp barrier. In 2011, dense growth of native aquatic plants covered roughly 80% of the bay, with many areas supporting a fairly diverse assemblage of plant species. These dramatic differences were very similar to what was observed during the carp exclosure plot experiment conducted in 2010 (22).

12.3.2 Wild Rice Management Implications

The 2010 carp exclosure plot experiment clearly indicated that exclusion of carp alone did not result in rice growth; seeding of rice was also necessary (23). In that study, it appeared that the wild rice seed bank in lake sediments had been severely depleted by carp. This suggests that similar seed depletion may have occurred in the southern bay over the past 10 years, and likely explains why we did not see a recovery of dense rice growth in the bay after only one season of carp exclusion.

The dramatic recovery of dense rice growth in the southern bay after 2 to 3 years of carp exclusion without supplemental manual seeding strongly suggests that rice beds may naturally recover in the rest of the lake if carp abundance can be reduced. In fact, a few areas in the open portion of the lake (particularly the shallow southeastern portion of the lake) clearly supported low to moderate density rice growth in 2013 after several years of carp removal. This suggests that the carp population may have been suppressed sufficiently by recent nettings to allow natural recovery of rice in the lake. However, the abundance of rice seeds in most of the lake is likely extremely low (23). Consequently, in the first few years of recovery, rice growth will likely be sparse and very susceptible to grazing by the remaining carp. Accordingly, the recovery of dense rice beds in the open lake would almost certainly be enhanced by manual seeding with seed collected from the fully recovered southern bay. Furthermore, the carp-barrier nets should continue to be installed at the same locations each spring to maintain the current “nursery stock” of rice seed in the southern bay until large-scale rice bed recovery is achieved in the rest of the lake (24).

12.3.2.1 Positive Impacts of the Carp Barriers Maintained Through 2013

The recommendation to keep the carp barrier across the southeast bay of Upper Clam Lake was heeded and in each of the last two years they have been reinstalled in the spring of the year before carp have a chance to move into the area. Survey work done in 2012 and again in 2103 show that by keeping carp out of the SE Bay, the wild rice has rebounded nicely (Figure 33). Further consideration should be given to fencing carp out of other areas of both lakes to help restore wild rice and other native plants.

Figure 33 – Wild Rice in the SE Bay of Upper Clam Lake in 2012 (left, ERS) and 2013 (right, GLIFWC)

13.0 Non-native Aquatic Invasive Plant Species Present in the Lakes

Volunteer monitoring for aquatic invasive species (AIS) in Lower and Upper Clam Lakes occurred in 2009 for several species. The zebra mussel was the only AIS for which monitoring occurred several years (Table 11). CLP was found in both lakes in 2009 during an aquatic plant survey and a voucher specimen was sent to the Wisconsin State Herbarium. Field notes accompanying the specimen indicate CLP to be abundant and monotypic in Lower Clam and widely scattered in Upper Clam. According to the WDNR Online Lakes Page for Upper Clam Lake, CLP was first documented in 2004.

Purple loosestrife was also collected during the aquatic plant survey in 2009 and a voucher specimen sent to the Wisconsin State Herbarium. Matthew Berg collected the plant on July 24th from Lower Clam Lake and noted purple loosestrife was rare with about 10-15 plants in the eastern bay along its western shore.

During the 2009 survey CLP was limited in Upper Clam Lake. Since that time, neither lake has much CLP in it. Purple loosestrife is present in both lakes; however, physical removal and biological control efforts made by Burnett County are effectively managing it in the lakes.

Table 11 - Volunteer Monitoring Results for AIS in Lower & Upper Clam Lakes

Aquatic Invasive Species	Lower Clam Lake		Upper Clam Lake	
	Year(s) monitored	AIS Found? Year(s)	Year(s) monitored	AIS Found? Year(s)
Hydrilla	2009	No	2009	No
Curly-leaf pondweed	2009	Yes, 2009	2009	Yes, 2004, 2009
Purple Loosestrife	2009	Yes, 2009	2009	Yes, 2009
Eurasian water-milfoil	2009	No	2009	No
Zebra mussels	2009, 2011, 2013	No	2004, 2009, 2011, 2013	No
Spiny water flea	-	-	2009	No
Fishhook water flea	-	-	2009	No
Banded mystery snail	2009	No	2009	No
Chinese mystery snail	2009	Yes, 2009	2009	Yes, 2009
Rusty Crayfish	2009	No	2009	No

13.1.1 Curly-leaf Pondweed

Curly-leaf pondweed is a submerged aquatic perennial that is native to Eurasia, Africa, and Australia. It was introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant and was planted in Michigan lakes as a food source for ducks. Curly-leaf pondweed has been documented throughout the U.S. In some lakes, curly-leaf pondweed coexists with native plants and does not cause significant problems; in other lakes, it becomes the dominant plant and causes significant problems (25). Dense growth can interfere with late spring and early summer recreation and the release of nutrients into the water column from the decaying curly-leaf during the height of the growing season can fuel algal blooms. Phosphorus release rates from the senescence of monotypic curly-leaf beds have been reported as high as nearly 10 pounds per acre and averages about 5 pounds per acre (26) (27) (28).

The leaves of curly-leaf pondweed are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed (Figure 34). The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. Curly-leaf is commonly found in alkaline and high nutrient waters, preferring soft substrate and shallow water depths. It tolerates low light and low water temperatures.

Figure 34 – Curly-leaf Pondweed

Curly-leaf pondweed spreads through burr-like winter buds called turions (Figure 35). These plants can also reproduce by seed, but this plays a relatively small role compared to the vegetative reproduction through turions. New plants form under the ice in winter, making curly-leaf one of the first nuisance aquatic plants to emerge in the spring, often starting to grow late in the fall and staying green under the ice. Growth is accelerated in spring when light and temperature conditions are best suited for growth. Turions begin to grow in June and by late June and early July, the warm water conditions cause curl-leaf to senesce, dropping turions to the sediment while the rest of the plant decays (Figure 35).

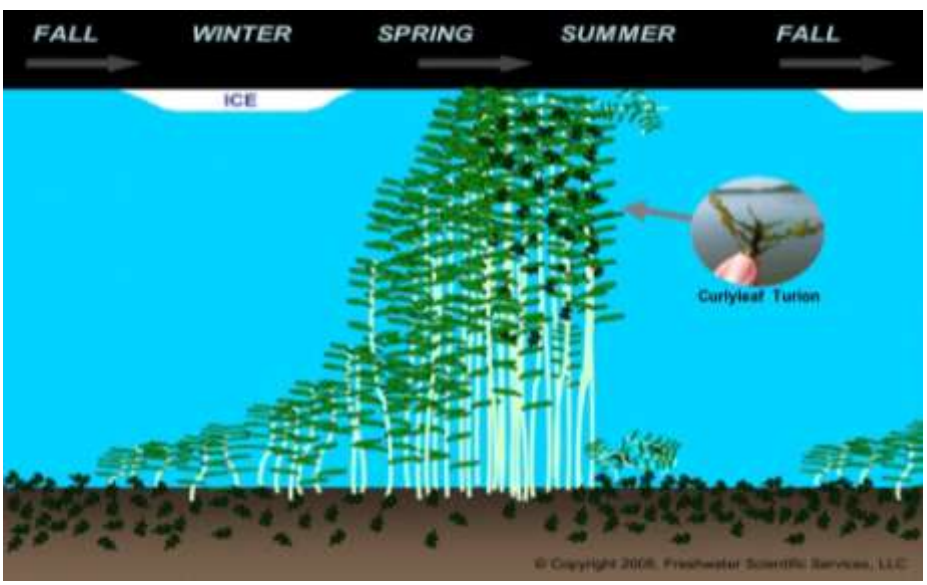


Figure 35 – Curly-leaf Life Cycle

13.1.2 Purple Loosestrife

Purple loosestrife is a perennial herb 3 to 7 feet tall with a dense bushy growth of 1 to 50 stems. The stems, which range from green to purple, die back each year. Showy flowers vary from purple to magenta; possess 5 to 6 petals aggregated into numerous long spikes, and bloom from July to September. It is easiest to distinguish in late July and August as it has a very distinctive flowering head. Leaves are opposite, nearly linear, and attached to four-sided stems without stalks. It has a large, woody taproot with fibrous rhizomes that form a dense mat (Figure 36).

Figure 36 – Purple Loosestrife

The reproductive success of purple loosestrife across North America can be attributed to its wide tolerance of physical and chemical conditions characteristic of disturbed habitats, and its ability to reproduce prolifically by both seed dispersal and vegetative propagation. The absence of natural predators, like European species of herbivorous beetles that feed on the plant's roots and leaves, also contributes to its proliferation in North America. This plant's optimal habitat includes marshes, stream margins, alluvial flood plains, sedge meadows, and wet prairies. It is tolerant of moist soil and shallow water sites such as pastures and meadows, although established plants can tolerate drier conditions.

Purple loosestrife has also been planted in lawns and gardens, which is often how it has been introduced to many wetlands, lakes, and rivers. By law, purple loosestrife is a nuisance species in Wisconsin. It is illegal to sell, distribute, or cultivate the plants or seeds, including any of its cultivars.

14.0 Non-Native Aquatic Invasive Species Threats

Introduction of new aquatic invasive species is a constant threat to lakes and rivers. The non-native species of most concern are Eurasian watermilfoil, zebra and quagga mussels, spiny water flea, giant reed grass, New Zealand mudsnails, and hydrilla. Aquatic invasive species monitoring recommended in this Aquatic Plant/Lake Management Plan and supported by the CLPRD will be watching for the introduction of these and other aquatic invasive species in hopes of early detection.

14.1 Eurasian Watermilfoil (EWM)

EWM is a submerged aquatic plant native to Europe, Asia, and northern Africa (Figure 37). Although EWM was not found in the Clam Lakes during extensive surveying in 2009 and 2012, its introduction remains a concern. As a popular destination in northwestern Wisconsin, the Clams Lakes are a prime candidate for the introduction of EWM via boat traffic. And due to the impacts on native plants caused by the carp population, there is little native vegetation to help keep EWM at bay if it were to get introduced.

Figure 37 – Eurasian Watermilfoil

EWM first arrived in Wisconsin during the 1960s and is the only non-native milfoil in the state. During the 1980s it began to move from several counties in southern Wisconsin to lakes and waterways in the northern half of the state. EWM grows best in alkaline systems with a high concentration of dissolved inorganic carbon and fertile, fine-textured, inorganic sediments. In less productive lakes EWM is restricted to areas of nutrient-rich sediments. It has a history of becoming dominant in eutrophic, nutrient-rich lakes, although this pattern is not universal. It is an opportunistic species that prefers highly disturbed lake beds, lakes receiving nutrient-laden runoff, and heavy-use lakes.

Unlike many other plants, EWM is not dependant on seed for reproduction. In fact, its seeds germinate poorly under natural conditions. EWM reproduces by fragmentation, allowing it to disperse over long distances by currents and inadvertently by boats, motors, and trailers. The fragments, which are produced after the plant fruits once or twice during the summer and by destruction of the plant (for example by propellers), can stay alive for weeks if kept moist.

Once established in an aquatic community, EWM reproduces from shoot fragments and stolons (runners that creep along the lake bed). Stolons, lower stems, and roots persist over winter and store the carbohydrates that help the plant claim the water column early in spring. The rapid growth can form a dense leaf canopy that shades out native aquatic plants. Its ability to spread rapidly by fragmentation and effectively block the sunlight needed for native plant growth often results in monotypic stands.

Monotypic stands of EWM provide only a single habitat, and threaten the integrity of aquatic communities in a number of ways. For example, dense stands disrupt predator-prey relationships by fencing out larger fish and reduce the number of nutrient-rich native plants available for waterfowl. Dense stands of EWM also inhibit recreational uses like swimming, boating, and fishing. Some stands have been dense enough to obstruct industrial and power generation water intakes. The visual impact that greets the lake user on EWM-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". The cycling of nutrients from sediments to the water column by Eurasian watermilfoil may lead to deteriorating water quality and algae blooms in infested lakes.

EWM would likely thrive in the Clam Lakes, but probably not to a large extent; northern watermilfoil, a native macrophyte and close relative to EWM, and Illinois pondweed, a common associate of EWM, were located throughout the lakes, but their occurrences were relatively low. Research has shown that the abundance of EWM in a lake is inversely related to cumulative native plant cover (29). For this reason it is important to maintain healthy and diverse native stands of vegetation (30).

A EWM Monitoring and Rapid Response Plan has been developed for the Clam Lakes and is in Appendix F.

15.0 Need for Aquatic Plant Management

15.1 Curly-leaf pondweed Management in Lower Clam Lake

Lower Clam Lake continues to have a very limited plant community with high diversity, but relatively few species, low total acreage, and little biomass when considering the lake's entire surface area and littoral zone. Historically, Curly-leaf pondweed dominated this community, but it now seems to have been nearly eliminated from the lake – likely due to the recent spike in the carp population. At this time, there doesn't seem to be a need for CLP management, but a CLP survey done in May/June 2013 could clarify if, in fact, CLP levels are as low as they appeared this July/August. If levels have actually declined as much as they appear to have, it may offer a unique opportunity to restore more favorable native pondweeds to the lake using exclosures in a similar way to what was done with the wild rice in Upper Clam Lake.

15.2 Curly-leaf pondweed Management in Upper Clam Lake

Upper Clam Lake's plant community appears on the road to recovery. Historically, Curly-leaf pondweed dominated this community, but it now seems to have been nearly eliminated from the lake – likely due to the recent spike in the carp population. At this time, there doesn't seem to be a need for CLP management, but a CLP survey done in May/June 2014 could clarify if, in fact, CLP levels are as low as they appeared this July/August. If levels have actually declined as much as they appear to have, it may offer a unique opportunity to restore more favorable native pondweeds to the lake using exclosures in a similar way to what was done with the wild rice in the southwest bay.

15.3 Carp and Wild Rice Management in Lower Clam Lake

Currently, there is little wild rice left in Lower Clam Lake, and it may be there wasn't much there to begin with. Regardless of the lake's rice growing potential, the large numbers of carp in the lake's east bay suggest that without constructing a large exclosure like the one in Upper Clam Lake, it is unlikely that reseeding rice in this area would be successful at this time. Carp were extremely numerous among the lilypads and rice of the east bay with bubble trails and fish jumping clear of the water throughout the survey area. Because of this, it would be beneficial to continue carp netting/removal in the winter.

15.4 Carp and Wild Rice Management in Upper Clam Lake

Currently, there is little wild rice outside the exclosures in Upper Clam Lake and carp continue to be extremely numerous among the lilypads throughout the lake. Because of this, it would be beneficial to continue winter carp netting/removal. And, based on the success of the exclosure in the southeast bay, similar results could be achieved in the south and southwest bays along undeveloped shoreline areas if more exclosures were installed. This may not be an option due to funding, but the success of the current project certainly justifies the efforts made to this point.

15.5 Native Aquatic Macrophytes, Algae and Water Clarity in Lower Clam Lake

Lower Clam Lake is currently suffering from a lack of rooted plants. Without these plants to absorb nutrients out of the water column, algae tend to proliferate leading to declines in both water clarity and quality. Although the lake's high carp population is certainly responsible for some, and perhaps the majority of this loss of clarity, it was noted during the mid-season survey, that many residents along the lake have no native plant buffer strip along the shoreline which is leading to soil erosion and nutrient runoff. If residents would not mow down to the lakeshore, bag their grass and leaf clippings, dispose of fire pit ash and pet waste away from the lake, and eliminate fertilizer applications, they could significantly cut the nutrients going into the lake. Working to develop a lakewide action plan that sets concrete goals to limit nutrient input along the lakeshore along with continuing the carp reduction program could result in fewer algal blooms and better clarity throughout the summer.

15.6 Native Aquatic Macrophytes, Algae and Water Clarity in Upper Clam Lake

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16.0 Aquatic Plant Management Alternatives

Nuisance aquatic plants can be managed a variety of ways in Wisconsin. The best management strategy will be different for each lake and depends on which nuisance species needs to be controlled, how widespread the problem is and the other plants and wildlife in the lake. In many cases, an integrated approach to aquatic plant management that utilizes a number of control methods is necessary.

At the present time, aquatic plant management in the Clam Lakes should be focused on protecting what remains of the aquatic plant communities, including the early season CLP growth. At such a time when the carp population is brought under control, efforts should emphasize restoration of native plants, while non-native plants are further managed out of the system.

When and if aquatic plant management on the Clam Lakes again becomes necessary, the following management alternatives are available. Not all of these alternatives are appropriate for the Clam Lakes. The most appropriate management alternatives are listed first. Other management alternatives are provided for informational purposes only.

Control methods for nuisance aquatic plants can be grouped into four broad categories:

- manual and mechanical control, which include harvesting, hand-pulling, and raking plants;
- biological control, which includes the use of organisms such as herbivorous insects, parasitic organisms, and planting aquatic plants;
- physical habitat alteration, which includes dredging, drawdown, lake bottom covers, and non-point source nutrient controls; and
- chemical control, which involves the use of herbicides.

Each of the above control categories are regulated by the WDNR and most activities require a permit from the State. Most control methods are regulated under Chapter NR 109 except for chemical control which is regulated under Chapter NR 107. Installing lake bottom covers, which is not a commonly accepted practice, also requires a Chapter 30 permit.

Regardless of the target plant species, native or non-native, sometimes no active management of the aquatic plant community is the best option. Plant management activities can be disruptive to native plant species their ecological functions, and may open up areas for new invasive species to colonize. Other benefits of no management include no financial cost, no system disturbance, and no unintended effects of chemicals. Not managing aquatic invasive species, however, may allow small populations of a plant to become larger and more difficult to control.

The benefits and limitations of a number of management techniques are described below. Although many of the available control methods are currently not applicable for the Clam Lakes, informed decision-making on aquatic plant management options requires an understanding of plant management alternatives and how appropriate and acceptable each alternative is for a given lake.

16.1 No Manipulation

No manipulation of the aquatic plant community is often the easiest, cheapest, and in some cases most effective aquatic plant management alternative, even for non-native invasive species like curly-leaf pondweed. Until such a time as the carp population in the Clam Lakes is brought under control, this may be the best management option for the Clam Lakes. Allowing native plants the time to recover on their own is important in both the short and long term. However, allowing for unassisted recovery may not be enough. Wild rice research since the negative impacts of the carp population were witnessed strongly supports natural recovery and assisted recovery. Aquatic plant surveying of the entire system should be completed often enough to track the recovery of native plants, and track the expansion of non-native aquatic plants like CLP and purple loosestrife.

16.2 Manual and Mechanical Controls

Except for wild rice, manual removal of aquatic plants by means of a hand-held rake or by pulling the plants from the lake bottom by hand is allowed within a 30-foot-wide corridor along a 100-foot length of shoreline without a permit, provided the plant material is removed from the Lake (Figure 38) and not in an area formally identified by the WDNR as sensitive or critical habitat.

Although up to 30 feet of shoreland vegetation can be removed, removal should only be done to the extent necessary. Clearing large swaths of aquatic plants not only disrupts lake habits, it also creates open areas for non-native species to establish. If an aquatic invasive species such as curly-leaf pondweed is the target species, then removal by this means is unrestricted as long as native plants are not damaged or eliminated.

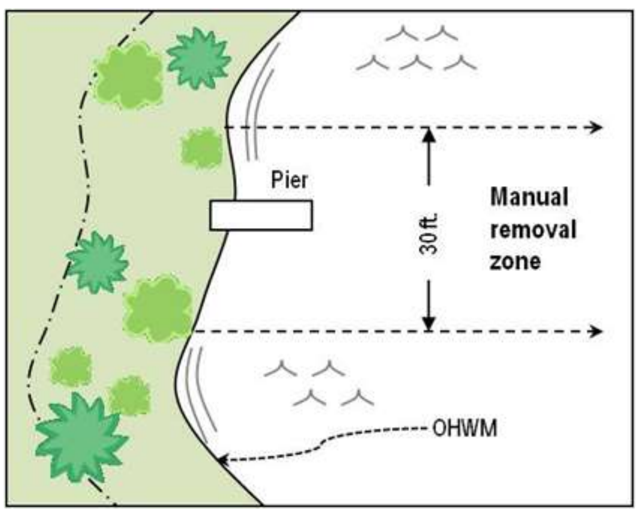


Figure 38 – Aquatic Vegetation Manual Removal Zone

Manual removal can be effective at controlling individual plants or small areas of plant growth. It limits disturbance to the lake bottom, is inexpensive, and can be practiced by many lake residents. Manual removal is most effective in shallow, hard bottom areas of a lake. It is appropriate for areas important for fish spawning. Pulling aquatic invasive species while snorkeling or scuba diving in deeper water can be done without a permit and can be effective at slowing the spread of a new aquatic invasive species infestation within a lake when done properly. When harvesting curly-leaf pondweed it is important that all material is removed as free-floating curly-leaf fragments can remain viable and produce turions for up to two weeks.

Only very selective physical removal of aquatic plants is recommended on the Clam Lakes. Native vegetation is somewhat limited due to carp and water quality issues, and great care should be taken to only remove that which really is creating hardship. In order to prevent CLP from again becoming the issue it was prior to the carp population explosion, CLP plants should be identified and removed from the lake, at least in areas immediately adjacent to the shoreline, and prior to the plant producing turions.

16.2.1 Large-scale Manual Removal

Hand-pulling or diver removal is typically used when an aquatic invasive species exists as single plants or isolated beds, as in new infestations. Large-scale hand or diver removal projects have successfully reduced or controlled established aquatic invasive species populations (31). One such effort which involved the removal of Eurasian watermilfoil using diver hand harvesting of the entire littoral zone of the lake at least twice each summer for three years followed by three years of maintenance management successfully reduced the overall distribution of Eurasian watermilfoil in the lake from 16% of the littoral zone to 3%. Overall costs ranged from a high of $796 per hectare of Eurasian watermilfoil removed during the three years of intensive management effort, to about $300 per hectare during the three year maintenance period (31).

Several local lake groups have and continue to use large-scale manual removal to manage Eurasian watermilfoil. Horseshoe Lake in Barron County uses diver removal on small or isolated areas of Eurasian watermilfoil, and uses chemical herbicides on larger, more expansive sites. Early in the management phase, Sand Lake in Barron County participated in diver removal, but stopped using divers as the Eurasian watermilfoil expanded too rapidly for the divers to keep up with. For several years the St Croix Flowage in Douglas County attempted to control the spread of Eurasian watermilfoil by diver removal. While successful in the first couple of years, the use of small-scale herbicide application has been added to the control regime.

In 2011, the Red Cedar Lakes Association performed diver removal on a dense, isolated one acre bed of curly-leaf pondweed in Red Cedar Lake. This large-scale effort was conducted by a group of local high school students (members of the Conservation Club) and a Red Cedar Lake Association representative. Water depths and inexperience made removal difficult; however, the effort was fairly successful and the divers were able to remove a large boat load of curly-leaf pondweed. In 2012 during early summer curly-leaf bed mapping, a determination was made on whether a bed could be hand harvested based on the previous years experience. In mid-summer, volunteers re-visited sites and removed on average 83% of the curly-leaf in 14 different beds.

Due to the formally widespread nature of the CLP population, particularly in Lower Clam Lake, large-scale physical removal in the open water may be difficult, but it should be considered if conditions make it possible.

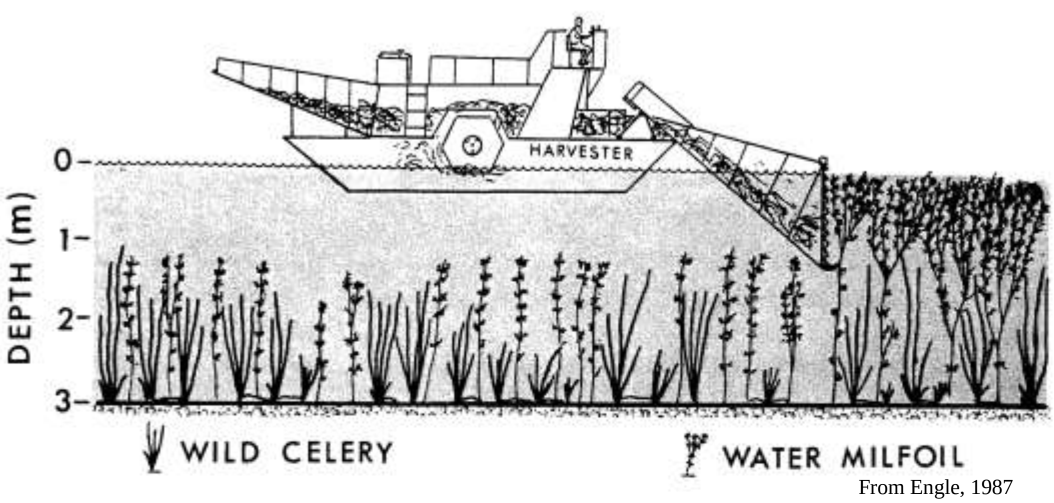
16.2.2 Mechanical Control

Mechanical control methods use motorized accessories to assist in vegetation removal. Mechanical control can be used for both small- and large-scale control efforts and require WDNR permits regardless of the size of the area to be managed. As with manual control, plant fragments must be removed from the water to the extent practical.

The most common form of mechanical control is the use of large-scale mechanical harvesters on the lake. The harvesters are generally driven by modified paddle wheels and include a cutter that can be raised and lowered to different depths, a conveyor system to capture and store the cuttings, and the ability to off-load the cuttings. Harvesters operate a depths ranging from skimming the surface to remove floating plant fragments to as much as five feet deep.

Harvesters can remove thousands of pounds of vegetation in a relatively short period of time. By removing the plant biomass, harvesting also removes nutrients form a lake. Everything in the path of the harvester will be removed including the target species, other plants, macro-invertebrates, semi-aquatic vertebrates, forage fishes, young-of-the-year fishes, and even adult game fish found in the littoral zone (32). An advantage of mechanical aquatic plant harvesting is that the harvester typically leaves enough plant material in the lake to provide shelter for fish and other aquatic organisms, and to stabilize the lake bottom sediments (33).

Large-scale plant harvesting in a lake is similar to mowing the lawn. Plants are cut at a designated depth, but the root of the plant is often not disturbed. Plant composition can be modified by cutting away dense cover which may increase sunlight penetration enough to stimulate growth of underlying species (Figure 39) (33). Cut plants will usually grow back after time, just like the lawn grass. Re-cutting during the growing season is often required to provide adequate annual control (34). Harvesting activities in shallow water can re-suspend bottom sediments into the water column releasing nutrients and other accumulated compounds (34). Some research indicates that after cutting, reduction in available plant cover causes declines in fish growth and zooplankton densities. Other research finds that creating deep lake channels by harvesting increases the growth rates of some age classes of bluegill and largemouth bass (35).



From Engle, 1987

Figure 39 – Harvesting Surface Foliage to Maintain Habitat and Stimulate Basal Plant Growth

The CLPRD currently owns three large-scale aquatic plant harvesters that prior to 2010 were used to remove CLP and other nuisance aquatic plant growth. If the amount of CLP in the Clam Lakes begins to increase again, harvesting operations will be started again.

There are a wide range of small-scale mechanical management techniques, most of which involve the use of boat mounted rakes, scythes, and electric cutters. As with large-scale mechanical harvesting, removing the cut plants is required and often accomplished with a rake. Commercial rakes and cutters range in prices from $100 for rakes and cutters that can be thrown from the shore to around $3000 for electric cutters that can be attached to a boat with a wide range of sizes and capacities.

One of the best ways for riparian property owners to gain navigation relief near their docks is to actively use their watercraft to create open channels. Although not truly considered mechanical management, plant disruption by normal boat traffic is a legal method of management. Most macrophytes do not grow well in an area actively used for boating and swimming. It should be noted that purposefully navigating a boat in circles to clear large areas is not only potentially illegal, but it can also re-suspend sediments, clear paths for aquatic invasive species growth and cause ecological disruptions.

16.2.3 Suction Dredging

Suction dredging is a form of mechanical harvesting where diver-operated suction tubes connected to barge- or pontoon-mounted pumps and strainer devices are used to vacuum plants uprooted by hand. This management technique is considered harvesting and not dredging because sediments are not removed from the system. Suction dredging is expensive and used mostly for control of isolated, new infestations of aquatic invasive species, and therefore not recommended for use in the Clam Lakes.

16.2.4 Other Mechanical Management

The mechanical aquatic plant control methods described below are not recommended for use on the Clam Lakes because they are often extremely disruptive to aquatic ecosystems. These methods are, however, used in other states or inappropriately employed in Wisconsin and are therefore discussed.

Cutting without plant removal, grinding and returning the vegetation to the water body, and rotovating (tilling) are also methods employed to control nuisance plant growth in some lakes. Cutting is just like harvesting except the plants are left in the lake. Grinding incorporates cutting and then grinding to minimize the biomass returned to the lake. Smaller particles disperse quicker and decay more rapidly. Rotovating works up bottom sediments dislodging and destroying plant root crowns and bottom growth.

Bottom rollers and surface sweepers are devices usually attached to the end of a dock or pier and sweep through an area adjacent to the dock. Continued disruption of the bottom area causes plants to disappear and light sediments to be swept out. The use of rollers may disturb bottom dwelling organisms and spawning fish. Plant fragmentation of nuisance weeds may also occur. In soft bottom areas, sediment disturbance can be significant. These devices are generally not permitted in Wisconsin. A permit under Section 30.12(3) is required which governs the placement of structures in navigable waters.

Another common method for removing aquatic plants from a beach or dock area is for riparian owners to hook a bed spring, sickle mower blade, or other contraption to the back of a boat, lawn mower, or ATV and drag it back and forth across the bottom. This type of management is considered mechanical and is generally not permitted by the WDNR.

16.3 Biological Controls

Management based on biological control is based on two different approaches: biological control, and biological manipulation. It is often necessary to implement both of these biological approaches at the same time.

Biological control for aquatic plant management involves using animals, fungi, insects, or pathogens as a means to control nuisance plants or other undesirable species. The goal of bio-control is to develop a predator-prey relationship where the growth or population of an undesirable species is reduced, but not eliminated. Generally this is accomplished by introducing a new predator in the form of an insect or an animal. Introducing fox to control rabbits, introducing ladybugs to control aphids, and introducing cats to control mice are gross examples of biological control. Introducing a new predator provides some risk. If the new predator cannot be controlled it could become a bigger issue than the initial problem presented. There may be factors that prevent the introduced control agent from being successful: inappropriate habitat, lack of reproduction, predation by other members of the ecosystem and so on. As a result, a great deal of research is necessary before even considering biological control. A special permit is required in Wisconsin before any biological control measure can be introduced into a new area.

Biological manipulation is defined as manipulating a particular trophic level in a body of water to make changes in the lake that may benefit management goals. A trophic level is considered one layer in the many layers that make a lake system work. For example, small often microscopic critters called zooplankton feed on algae, like cows feed on grass. If there a significant decline in zooplankton, perhaps because an over-abundance of small panfish eat them, then it is possible for the levels of algae to go up in a lake. It may be possible to reduce the number of small panfish by introducing larger predator fish. If panfish are reduced, then zooplankton can rebound again impacting the amount of algae in a system. Another version of this is to reduce predators on insects that may help to control a given undesirable species.

Specific biological controls of curly-leaf pondweed are not known at this time. Ongoing research on naturalized and native herbivores and pathogens that impact nuisance aquatic and wetland plants is increasing the number of potential biological control agents that could be incorporated into invasive plant management programs (36).

The grass carp, which feeds on aquatic plants and has been used as a biological tool to control nuisance aquatic plant growth in other states, is not permitted in Wisconsin. These fish can severely disrupt the aquatic ecosystem and have been known to nearly wipe out all aquatic vegetation in the lakes they inhabit.

There are several insects that have been studied and approved for biological control purposes of purple loosestrife. One species of insect has been proven to be extremely effective for control of purple loosestrife, the Galerucella beetles. These beetles have been used extensively across North America to manage purple loosestrife, including in and around the Clam Lakes. Use of Galerucella beetles for purple loosestrife management should be continued.

The milfoil weevil (*Euhrychiopsis lecontei*) is a native aquatic weevil that feeds on aquatic milfoils. Their host plant is typically northern watermilfoil, but they prefer Eurasian watermilfoil when it is available. Studies of utilizing the milfoil weevil for Eurasian watermilfoil control have resulted in variable levels of control, with little control being achieved on lakes with extensive motorized boat traffic.

One company, EnviroScience, Inc took out a patent on rearing and distributing the milfoil weevil. Recent information indicates they successfully introduced weevils to more than 100 lakes in the United States and Canada in the last ten years. Costs for using the EnviroScience program run about $1.50 per weevil purchased, but includes the costs of mapping, stocking, and monitoring of effects. Unfortunately, EnviroScience is no longer providing weevils in WI, making it harder to incorporate weevil introduction as a control agent in lakes where they are not already present. Researchers in Wisconsin have been developing a protocol for layperson rearing of the milfoil weevil. This process involves setting up large tanks with EWM and obtaining starter weevils from EnviroScience or some other source. With proper care and management, it is anticipated that this rearing method may be able to produce a 10 to 100 fold increase in weevils to be released into an affected area.

Plant fungi and pathogens are currently still in the research phase. Certain species for control of hydrilla and Eurasian watermilfoil have shown promise, but only laboratory tests in aquariums and small ponds have been conducted. Methods are not available for widespread application. Whether these agents will be successful in flowing waters or large-scale applications remains to be tested (37).

16.4 Physical Habitat Alteration

Reducing nutrient loading from the watershed (for example, reducing fertilizer use or controlling construction erosion) provides fewer nutrients available for plant growth. Runoff from development in the near-shore area and from other parts of the watershed can increase the amount of phosphorus available for plant and algae growth. The limited light penetration due to increased algae in the water will be beneficial for plants adapted to low light conditions, such as curly-leaf pondweed. Higher nutrient concentrations also favor other non-native plants such as Eurasian watermilfoil and native plants that tend to be nuisance such as coontail.

Research has shown that as shoreline development increases, the amount of aquatic plant growth near that lake shore decreases. In a Minnesota study of 44 lakes with varying amounts of developed shoreline, the average loss of aquatic plants in developed areas was 66% (38). On a lake wide basis, this loss of aquatic plant growth can lead to higher levels of phosphorus and an increase in the growth of algae, including filamentous algae that may attach to structures within the littoral zone or form surface mats. Reducing nutrient loading from the watershed (for example, reducing fertilizer use, controlling construction erosion, or shoreland restoration and buffers) is a viable option in the Clam Lakes.

Dredging is usually not performed solely for aquatic plant management but to restore lakes that have been filled in with sediments, have excess nutrients, have inadequate pelagic and hypolimnetic zones, need deepening for navigation, or require removal of toxic substances. A WDNR permit is required to perform any dredging in a waterbody or wetland. This method can be detrimental to desired plants, as all macrophytes would be prevented from growing for many years. This high level of disturbance may also create favorable conditions for the invasion of other invasive species. Dredging is not recommended for aquatic plant management in the Clam Lakes.

Benthic barriers or other bottom-covering approaches are another physical management technique that has been in use for many years. The basic idea is that the plants are covered over with a layer of a growth-inhibiting substance. Many materials have been used, including sheets or screens of organic, inorganic and synthetic materials, sediments such as dredge sediment, sand, silt or clay, fly ash, and combinations of the above. WDNR approval is required and screens must be removed each fall and reinstalled in the spring to be effective over the long term.

Dropping the lake level to allow for the desiccation, aeration, and freezing of lake sediments has been shown to be an effective aquatic plant management technique. For control of certain aquatic plants, such as Eurasian watermilfoil, repeated winter drawdown lasting 4 to 6 months that include a freezing period are the most effective. Control of aquatic plants in these cases can last a number of years. The low lake levels may negatively affect native plants, provides an opportunity for adventitious species such as annuals, often reduces the recreational value of a waterbody, and can impact the fishery if spawning areas are affected. The cost of a drawdown is dependent on the outlet of the lake; if no control structure is present, pumping of the lake can be cost prohibitive whereas costs can be minimal if the lake can be lowered by opening a gate. Raising water levels to flood out aquatic plants is uncommon and has a number of negative effects including the potential for shoreland flooding, shoreland erosion, and nutrient loading.

16.4.1 Shoreline Stabilization

Shoreline erosion caused by wind and waves contributes sediment and phosphorus to a body of water, but can be minimized by stabilizing the shoreline area that is eroding. Typically this is done by installing rock rip-rap, an unnatural, but effective way to stabilized shorelines. Proponents of rock rip rap believe that it provides a cleaner look, requires little maintenance, and will withstand the ravages of waves and ice. Installation of rock rip however does away with most of the habitat for frogs, reptiles, amphibians, and the like, provides little filtering of runoff from a property, and is not as easy to maintain as many people think.

Bio-stabilization is an alternative. Bio-stabilization takes advantage of the dense and deep rooted structure of many native plants to anchor soil on the shoreline. Vegetative material like coconut fiber and wood fiber bound tightly in a bundle is used instead of rock to provide protection from wave erosion. Deep rooted native plants are generally planted in and around these vegetative alternatives to rock. Purple coneflowers, iris, and black-eyed Susan's are just a small sample of the colorful plants that can add a blaze of color to a shoreline that used to be just mowed grass, and still protect from erosion. Restoring and protecting shorelines through bio-stabilization, even of just a few feet, also discourages ducks and geese from visiting better than rock rip rap.

These types of projects can minimize nutrient loading from the shoreline by preventing erosion and filtering runoff. By reducing nutrients, there is less phosphorus to feed aquatic plant and algae growth in the lake. They are not however, low or no maintenance projects, at least for the first year or two after installation. Shoreland stabilization through bio-engineering can vary widely in costs depending on how elaborate a project is and how much "sweat equity" a landowner is willing to invest. A professional assessment and design can costs as little as a few hundred dollars, while a full-scale project that involves hiring a crew to do all the installation and planting can exceed ten times that amount.

16.4.2 Shoreland Restoration

Shoreland restoration is used on many lakes to reduce erosion, increase and improve native habitat, and improve water quality. Restoration not only improves the lake aesthetic enjoyed by so many, it also keeps invasive species ay bay. A study performed in west-central Wisconsin found the mean occurrence of non-native aquatic invasive species to be significantly greater at disturbed shoreline sites than at natural shorelines (39). The study also found that the occurrence of non-native species and filamentous algae increased with the amount of disturbed shoreline on a lake.

To minimize locations in a lake where invasive species like EWM can get established, making improvements to the shoreland and shallow water areas adjacent to that shoreland can be important. Figure 40 demonstrates the difference between a healthy, invasive species resistant, shoreline and a shoreline that invites an invasive species to become established. There are many public and free resources available for planning and implementing shoreland and shallow water restoration projects. There are many examples of best management practices BMPs that property owners can implement. Property owners can create buffer strips of an acceptable width between the lake and the mowed lawn, create/install rain gardens, plant native species in the buffer area, or complete a full shoreland restoration project. One of the easiest ways to do this is to stop mowing down to the edge of the lake in the upland buffer zone and to limit physical removal of aquatic plants in the aquatic buffer zone (Figure 40).

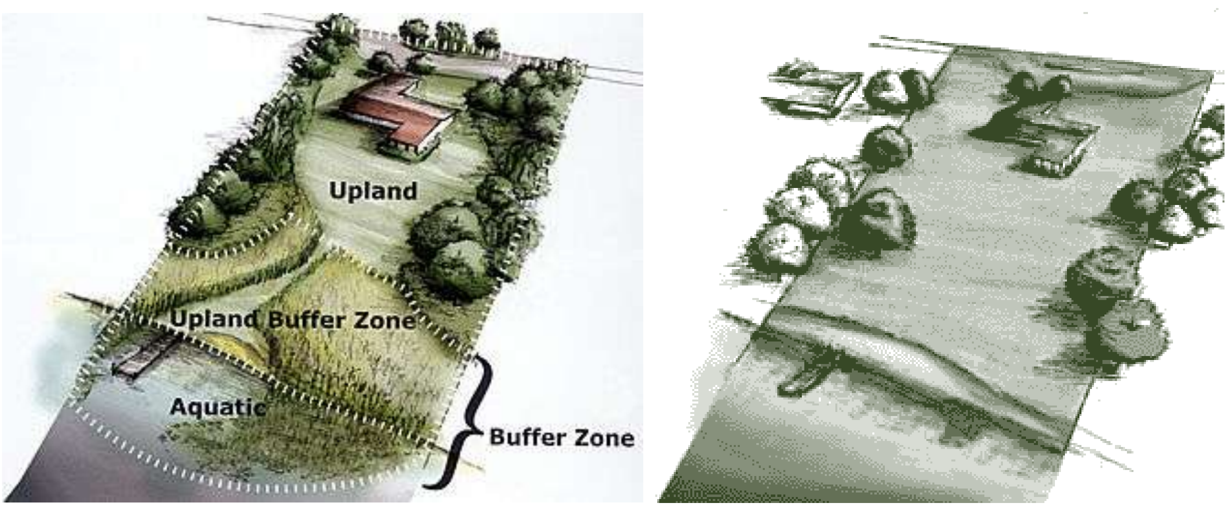


Figure 40 – Healthy, AIS Resistant Shoreland (left) vs. Shoreland in Poor Condition

In one section of the 2010 Lake Use Survey, survey respondents were asked about BMPs that are or could be installed around the lake to reduce surface water runoff from their properties. When asked if the respondent thought they had best management practices like shoreline buffers, shoreland restorations, and rain gardens in place already, 44% of respondents on both lakes stated that they did not. Of those that did, the most common BMPs were shoreline buffers, shoreland restorations, and native tree or flower plantings. Only one of the respondents had a rain garden in place.

When asked what BMPs hold the most interest for respondents, shoreland restoration, native tree and flower plantings, shoreline buffers, and rain gardens were the top vote getters.

16.4.3 Native Aquatic Plant Enhancement

Once the carp population in the Clam Lakes is brought under control, and areas where dense growth of CLP once existed are minimized, native plants may re-establish naturally provided seeds and other propagules are still present. But in some cases, artificially restoring this habitat is required. If desirable native plants do not come back by themselves in places where more vegetation is needed, it may be possible to collect and transplant aquatic plants from other areas of the lakes. It may also be necessary to collect plants from other lakes or to purchase then from commercial vendors. Collecting plants from the same or other water bodies may require a permit. If commercial plants are purchased, care should be taken to not introduce unwanted vegetation at the same time. Because many submergent and floating leaf plants are susceptible to failure during restoration, a good rule of thumb to follow is to plant as many as possible.

Restoring native shoreland plant communities is undertaken on many lakes to reduce erosion, increase and improve native habitat, reduce shoreland runoff, improve water quality, and compliment the lake aesthetic. The restoration or re-establishment of aquatic plants in the shallow waters adjacent to the shore, which focuses on emergent plant species like rushes, sedges, pickerel weed, wild rice, and other plants that make up the wetland fringe, is less frequently completed. These species hold sediments in place fend off the invasion of non-native species, buffer against shoreland erosion, and improve fish and wildlife habitat.

Restoring the entire wetland fringe (both on the land and in the water) not only protects the lake, it may improve the lake aesthetic enjoyed by many. The importance of native plants preventing the establishment of invasive species cannot be underplayed. An analysis of 55 lakes in west-central Wisconsin found the mean occurrence of non-native aquatic invasive species to be significantly greater at disturbed shoreline sites than at natural shorelines. The study also found that the occurrence of non-native aquatic plant species and filamentous algae increased with the amount of disturbed shoreline on a lake.

Artificially reintroducing native aquatic plants is often difficult and costly and requires a fairly large source of new plants and substantial short-term labor for collecting, planting, and maintaining the stock. Maintenance of plantings may require protection from fish and birds and temporary stabilization and protection of sediment in the planting area from wind and waves (Figure 41).

Figure 41 – "Buffer Blocker" System for Protecting Native Macrophyte Plantings

There are many sources for more information regarding native aquatic plant restoration. Smart and others (40) discuss numerous techniques for establishing native aquatic plants in reservoirs with an absence of vegetation or low species diversity. The Langlade County, Wisconsin Land Records and Regulations Department has a Shoreland Restoration Web Site which provides a great deal of information for re-establishing native plants: http://lrrd.co.langlade.wi.us/shoreland/index.asp (last accessed: December 2013). A complete review of these techniques and others should be completed before undertaking a planting project.

16.5 Chemical Control

Aquatic herbicides are granules or liquid chemicals specifically formulated for use in water to kill plants or cease plant growth. Herbicides approved for aquatic use by the U.S. Environmental Protection Agency are considered compatible with the aquatic environment when used according to label directions. Some individual states, including Wisconsin, also impose additional constraints on herbicide use. There are a number of aquatic herbicides registered for use in Wisconsin. Factsheets for each can be found on the WDNR website at http://dnr.wi.gov/lakes/plants/factsheets/ (last accessed October 2012).

A WDNR permit is required to use chemical herbicides in aquatic environments and a certified pesticide applicator is required for application on most lakes. The WDNR requires aquatic plant surveys before and after chemical application when introducing new treatments to lakes where the treatment size is greater than 10 acres or greater than 10% of the lake littoral area and more than 150 feet from shore. The pre- and post-treatment survey protocol can be found at: http://www4.uwsp.edu/cnr/uwexlakes/ecology/APM/Appendix-D.pdf (last accessed October 2012).

The advantages of using chemical herbicides for control of aquatic plant growth are the speed, ease and convenience of application, the relatively low cost, and the ability to somewhat selectively control particular plant types with certain herbicides. Disadvantages of using chemical herbicides include possible toxicity to aquatic animals or humans, oxygen depletion after plants die and decompose which can cause fishkills, a risk of increased algal blooms as nutrients in released into the water by the decaying plants, adverse effects on desirable aquatic plants, loss of fish habitat and food sources, water use restrictions, and a need to repeat treatments due to existing seed/turion banks and plant fragments. Chemical herbicide use can also create conditions favorable for non-native aquatic invasive species to outcompete native plants (for example, areas of stressed native plants or devoid of plants).

When properly applied, the possible negative impacts of chemical herbicide use can be minimized. Early spring to early summer applications are preferred because exotic species are actively growing and many native plants are dormant, thus limiting the loss of desirable plant species; plant biomass is relatively low minimizing the impacts of deoxygenation and contribution of organic matter to the sediments; fish spawning has ceased; and recreational use is generally low limiting human contact. The concentration and amount of herbicides can be reduced because colder water temperatures enhance the herbicidal effects. Selectivity of herbicides can be increased with careful selection of application rates and seasonal timing (26). Lake hydro-dynamics must also be considered; steep drop-offs, inflowing waters, lake currents and wind can dilute chemical herbicides or increase herbicide drift and off-target injury. This is an especially important consideration when using herbicides near environmentally sensitive areas or where there may be conflicts with various water users in the treatment vicinity.

Due to the current status of CLP and other vegetation in the Clams Lakes, chemical control is not recommended as a management action for control of curly-leaf pondweed in the Clam Lakes at this time. With a combination of physical removal and harvesting, if vegetation, native or non-native, once again reaches nuisance levels, the CLPRD is in a good position to keep it under control. The use of chemical herbicides in the Clam Lakes is only recommended as part of an integrated management approach for control of purple loosestrife and any new infestations of aquatic invasive species such as Eurasian watermilfoil.

16.6 Lake User Preferences for Aquatic Plant Management

Prior to 2010, CLP and other aquatic plant growth in the Clam Lakes were managed by removing large amounts of vegetation through large-scale mechanical harvesting. There are other common and readily applied aquatic plant management methods that could potentially be used in place of, or in cooperation with large-scale mechanical harvesting operations. Respondents were asked to indicate what two out of six alternatives to mechanical harvesting they would most support, assuming they were all safe and legal in Wisconsin. If respondents needed more information to make their decision, an opportunity for them to state this was provided. Many respondents chose the additional information answer, but of those who did pick two, large-scale (greater than 10 acres) herbicide application was most supported and biological control and small-scale herbicide applications were equally supported as a second alternative.

Several not so common aquatic plant management alternatives also exist including water level manipulation, dredging, and trophic food web manipulation. Respondents were asked which of these methods they would support. Many respondents wanted more information before making such choices, but those who did were most in support of lowering the lake level over the winter to kill aquatic plants. The CLPRD already completes a drawdown in the fall of the year, which might explain why more people support this option. There is a fair amount of support for dredging operations to reduce sediment and plant growth, but this option has little support by the state.

16.6.1 Shoreland Improvements

In this section of the survey respondents were asked about best management practices that are or could be installed around the lake to reduce surface water runoff from their properties.

When asked if the respondent thought they had best management practices like shoreline buffers, shoreland restorations, and rain gardens in place already, 44% of respondents on both lakes stated that they did not. Of those that did, the most common BMP's were shoreline buffers, shoreland restorations, and native tree or flower plantings. Only one of the respondents had a rain garden in place.

When asked what BMP's hold interest for respondents, the top BMP's holding interest for respondents were shoreland restoration, native tree and flower plantings, shoreline buffers, and rain gardens were the top vote getters.

17.0 Management Discussion

Until such a time as management efforts being spearheaded by SCTES and the WDNR to control carp in the Clam Lakes are considered successful, specific recommendations for aquatic plant and water quality management cannot be made. This document lays out a list of general management recommendations for both aquatic plants and water quality that can be implemented regardless of the status of the carp population. Specific goals and allocations for nutrient reduction have not been made. However, if the general goals, objectives, and actions contained in this document are implemented, there will be improvements or at least, no negative changes to the status of aquatic plants currently in the lakes or the current water quality conditions. Other entities, including St. Croix Tribal Environmental Services and the Wisconsin Department of Natural Resources, are currently driving management in the Clam Lakes. That management is focused on reducing the carp population and protecting, enhancing, and restoring the wild rice beds in both lakes.

There are concerns about the water quality in the lakes, the status of the current fishery, and changes in lake use brought on in part by the carp, and the CLPRD should continue to identify these and other concerns, and address as soon as it makes sense to do so. At the present time, there are no recommendations for the CLPRD to pursue additional grant funding to complete additional planning for the lakes.

CLPRD resources at the current time are best concentrated on those things that property owners and lake users can control, like the condition of shorelines, monitoring for aquatic invasive species, and lake use issues. Maintaining an active status in all current management discussion and actions will help keep the CLPRD and its constituency informed and educated. And when the opportunity to contribute CLPRD resources is identified, the CLRPD can act quickly and responsibly.

18.0 Management Goals, Objectives, and Actions

Based on data collected, conversations with the CLPRD, SCTES, and the WDNR, the following eight general lake management and management related goals have been established. Each goal has an associated list of objectives, and the actions necessary to reach the objective, and ultimately the goals.

1) Protect, preserve, and enhance native aquatic plant communities in the Clam Lakes
2) Complete annual monitoring and management of aquatic invasive species currently identified in the Clam Lakes
3) Complete aquatic invasive species education, monitoring, and prevention
4) Improve in-lake habitat for fish and wildlife and for reducing available nutrients
5) Reduce nutrient loading to the Clam Lakes
6) Provide property owner and lake user education and awareness of issues impacting the Clam Lakes
7) Collect lake related data to enhance and support current and future lake management planning and implementation
8) Implement this plan following adaptive management practices

Appendix G provides a detailed list of the management goals, objectives, and actions included in this plan.

19.0 Implementation and Evaluation

This plan is intended to be a tool for use by the LRPD to move forward with aquatic plant management actions that will improve issues of concern as they pertain to Lake Redstone. However this plan is not intended to be a static document, but rather it is a living document that will be evaluated on an annual basis and updated as necessary to ensure goals and community expectations are being met. This plan is also not intended to be put up on a shelf and ignored. Implementation of the actions in this plan is highly recommended. An Implementation and Funding Matrix is provided in Appendix H.

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Appendix A

2010 Public Use Survey

Appendix B

Phase Lake Use Survey Report

Appendix C

Clam Lakes Sensitive Areas Study

Appendix D

WDNR Clam Lake Wildlife Area Map

Appendix E

St. Croix Tribal Water Resources Study Area

Appendix F

Clam Lakes EWM Rapid Response Plan

Appendix G

Clam Lakes Management Goals, Objectives, and Actions

Appendix H

Clam Lakes Implementation and Funding Matrix