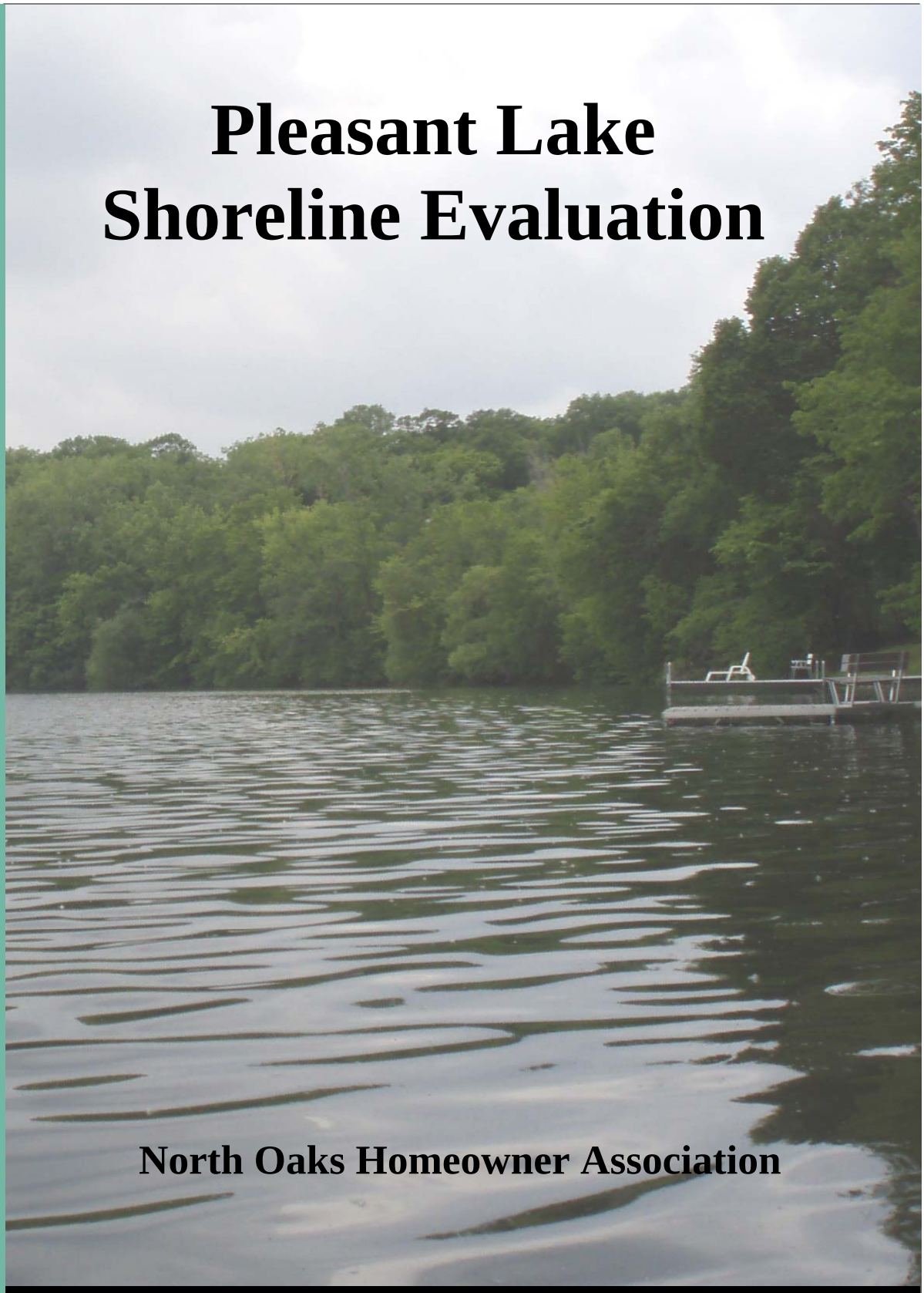
Pleasant Lake Shoreline Evaluation



North Oaks Homeowner Association

July 2009

GREAT RIVER GREENING

restoring the land, renewing communities

SUMMARY

The community of North Oaks was created to be a model residential community based on respect for the natural environment. At its center is Pleasant Lake, consisting of about 31,000 feet (nearly 6 miles) of shoreline. Like most lakes in the Twin Cities metropolitan area, over the past several decades, the area surrounding the lake has been virtually all developed, leading to increased impervious surfaces due to houses, lawns, driveways, streets, trails, etc. The result has been large increases in stormwater runoff into the lake. Coupled with altered vegetative cover and the introduction of invasive exotic species, the lakeshore has suffered.

The North Oaks Home Owners Association (NOHOA) owns the entire buffer area surrounding the lake, an approximately 50-feet strip up from the Ordinary High Water Line (OHWL). Funded by NOHOA, this report outlines the findings and recommendations stemming from the shoreline assessment that was performed by Great River Greening in June and July of 2009.

ACKNOWLEDGEMENTS

Preparation of this Report was made possible through funding provided by the North Oaks Home Owner Association.

The author would like to thank Chris Mann, Jackie Crandall, and Lugene Olson who have been enthusiastic supporters of this plan from the beginning.

ABOUT GREAT RIVER GREENING

Great River Greening is a non-profit conservation organization that leads and promotes community-based restoration of natural areas and open spaces. Our team of experienced ecologists and landscape ecologists brings over 50 years combined experience managing and restoring native habitats, conducting natural resource inventories, fundraising for restoration projects on public lands, and engaging over 21,000 volunteers.

NATURAL AREA RESTORATION AND PLANNING SERVICES

- **Site Analysis**: assessment of site context, soil condition, topography, hydrology, physical characteristics, cultural features, and existing and potential vegetation
- **Natural Resource Inventories**: classification, evaluation and mapping of native plant communities, wildlife species, geography, soils, and invasive and rare plant species
- **Natural Resource Planning**: mapping and analysis of spatial information using GIS software to guide restoration and other conservation activities
- **Management and Restoration Plans**: recommending goals and strategies for managing, restoring and reconstructing native plant communities
- **Restoration and Reconstruction**: enhancement of existing natural areas with the reintroduction of species and ecosystem processes, and reconstructing natural areas where no natural vegetation exists
- **Invasive Species Abatement**: monitoring and control of invasive species
- **Prescribed Burning**: identifying the appropriate type of burn, creating a burn plan, securing permits and implementing the burn, as well as handling questions from neighbors
- **Restoration Consulting**: advising and assisting local governments, private organizations and individuals with the management and improvement of natural habitats

ABOUT THE AUTHOR

Great River Greening has an expert staff of ecologists, designers and restoration technicians.

Joe Walton, Conservation Ecologist (M.S. Urban Forestry, forthcoming) is responsible for project management and natural resource management planning. Projects include dry oak savanna restoration in the Anoka Sandplain, riverbank restoration, lakeshore restoration, and neighborhood natural areas restoration. He has also designed and implemented community raingardens and boat launch retro-fits. In addition, he writes natural resource management plans and lakeshore evaluation reports.

Prior to working at Greening (2001-2007), Joe worked as the head of the Urban Ecology division for S&S Specialists and Kunde Co., Inc., expanding the division to include major ecological restoration as well as traditional urban forestry where he designed, installed, maintained, and monitored native plant community restoration projects, stormwater best management practices (BMPs), invasive species control, and erosion control/bioengineering projects in various locations throughout the Twin Cities metropolitan area.

jwalton@greatrivergreening.org

Contact Information
Wayne Ostlie, Director of Conservation Programs
Great River Greening
35 W Water St #201
St. Paul MN 55107
wostlie@greatrivergreening.org
651 665.9500 ext 19
www.greatrivergreening.org

TABLE OF CONTENTS

BACKGROUND AND HISTORY OF SITE

What is a Shoreline?

A shoreline is a conceptual reality. It is the transition between water and land (McComas, 2003). It is dynamic, constantly moving and changing depending on several factors. It is made of the integration of abiotic and biotic components, including soil, rocks, gravel, plant roots, microscopic soil fauna, bacteria, etc. Shoreline variation also results from many forces and factors acting on the ecosystem of the lake-land interface, such as wind, wave action, and stormwater runoff.

Shorelines are in equilibrium with all of these factors, being cut or built, as certain factors either result in instability (a net gain or a net loss of shoreline), or stability (no net change in shoreline.) In order for stability to prevail, the erosive forces of wind and water must be balanced or somehow held in check. Restorationists like to say that shorelines remain stable by virtue of "armor" or "protection" against erosion and degradation. There are two types of this armoring: *hard armoring* and *soft armoring*. Hard armoring is protection provided by rocks, dead trees, snags, dead root wads, etc., and is what has been commonly and traditionally perceived to be the best solution for bank stabilization (e.g., rip-rap). Soft armoring is protection provided by the plants, animals, and microorganisms that grow and live in the soil/rock/gravel matrix of the shoreline. In particular, soft armoring protection is provided by the roots of plants, since they form an elaborate, interwoven structure that binds and holds soil particles in place. Without this woven tapestry of roots, soil particles simply wash away into the lake.

As wave action inflicts damage onto degraded shorelines, sediment washes away from the shallow roots of the cottonwoods, silver maples, elms, basswoods, green ash, etc., that line the banks. Over time strong winds will topple trees, causing the bank to rip out, and thus the shoreline retreats and the bank becomes shallower and wider. This is a natural response of the shoreline; in essence it is trying to come into equilibrium with the forces acting on it. Unfortunately, this does not always coincide with property boundaries, trails, and other man-made structures or entities. Often, the shoreline recedes into the trail surrounding the lake, and then, given enough time, it would recede through the North Oaks Homeowner Association (NOHOA)-owned property up to private property, obviously something to be avoided, which is why stabilization techniques need to be employed to slow or halt this situation.

Target Communities

Over the course of many thousands of years, plants and animals have evolved and adapted to both large and small-scale conditions, and have formed what biologists call "communities," or assemblages of populations that are in some sort of equilibrium state. With the advent of European settlement of the New World in the 1700s and 1800s, the old equilibrium was thrown out of balance. Fire suppression, agriculture, over-grazing, and the introduction of non-native species seriously changed the functioning of the ecosystem. Today, we have a host of new problems that will be described in this report.

A starting point for the desired target communities would be those found pre-settlement. By using soils data, historical aerial photos, and clues from existing vegetation cover, pre-settlement vegetation can be deduced. For instance, the plant communities surrounding Pleasant Lake were a mix of forest, shrub-carr, marsh, and savanna communities. Notably, the land surrounding the lake was much more open and savanna-like in the pre-settlement era.

Depending upon soil moisture conditions (which changes according to drainage, topography, light exposure), fire frequency, browsing pressure and plant competition, native plant communities will vary. Since the soils and topography vary around the lake, this influences community composition. Much of the lakeshore has high relief, with sandy/rocky slopes rising steeply from the waters edge, but some areas are less steep with sandy mineral soils, and others are relatively flat with a prevalence of organic soils. Steep, mineral soils will contain a different suite of plants than flat, mucky soils. See Appendix 3 for lists of recommended plant species to plant for Pleasant Lake shoreline restoration projects.

Today, as in the recent past, one of the biggest factors affecting the composition of plant communities is still the influence of humans. Tree and vegetation removal, introduction and replacement of native vegetation with mowed turf, removal of emergent native vegetation, installation of docks, beaches and stairways, and other disturbances, are major problems caused by humans today. Most of these "people-derived" factors also have negative repercussions on the stability of shorelines.

Brief Land Use History of Pleasant Lake Site

Pre-Settlement Vegetation (with figures)

The vegetation that existed before settlement by Euro-Americans can be deduced from the notes and bearing tree data that was collected by the first Public Land Survey of Minnesota. The Public Land Survey System (PLSS) is a way of subdividing and describing land in the United States. All lands in the public domain are subject to subdivision by this rectangular system of surveys, which is regulated by the U.S. Department of the Interior, Bureau of Land Management (BLM).

According to the National Atlas website (http://nationalatlas.gov/articles/boundaries/a_plss.html), "the PLSS typically divides land into 6-mile-square townships, which is the level of information included in the National Atlas. Townships are subdivided into 36 one-mile- square sections. Sections can be further subdivided into quarter sections, quarter-quarter sections, or irregular government lots. Normally, a permanent monument, or marker, is placed at each section corner. Monuments are also placed at quarter-section corners and at other important points, such as the corners of government lots. Today permanent monuments are usually inscribed tablets set on iron rods or in concrete. The original PLSS surveys were often marked by wooden stakes or posts, marked trees, pits, or piles of rock, or other less-permanent markers."

Of particular interest to us are the "marked trees," also called "bearing trees," because each bearing tree was identified by species and also by vegetation type that surrounded it. Today the bearing tree data has been compiled for most of the state of Minnesota, and can be accessed as a Geographical Information System (GIS) layer. Figures 1 and 2 show maps of the Bearing Tree species and Pre-settlement vegetation. Most of the pre-settlement vegetation points were marked "K" which designates "scattering oak/scattering timber," which means, scattered oaks and other trees that could be used for building. Sharron Nelson, MN DNR Ecological Services Department, stated that the term "K" usually represented areas predominated by oak savanna, which contained scattered oaks and other trees that tended to be taller individuals, rather than groupings of scrub trees (which would have been called "oak openings and oak barrens").

Still, it is hard to be certain about the specifics of the land cover; there was probably a mix of scrub oak, oak groves, prairie, oak woodland, swamp, marsh, sedge meadow, and wet prairie..

Following are some of the notes from these original public land surveys from the area north of Pleasant Lake:

ANOKA COUNTY

General Description T031N R22W

"This township presents a variety of surface. The interior is interspersed with numerous lakes of various sizes. The water is clear and cold, sand and gravel banks and numerous springs along the margin. There are intensive marshes in this township singularly interspersed with islands of various sizes covered with several kinds of timber. A small portion of this township is dry land rising abruptly above the level of the marsh and thereby covered with short grass and sparse Jack Oak trees, other portions are thickly covered with brush of small growth."

A.J. Hewett 1847

General Description T031N R23W

"This township presents a surface almost level to the eye of the beholder. It is one dense marsh, interspersed at intervals with numerous islands, small lakes or ponds and Tamarac swamps. The islands vary in size from 1-10 acres and most of them covered with thick brush and timber of various kinds. The water in the lakes or ponds is generally clear and cold and most of them have fish in them of various kinds. The margins of them are generally marshy and springy. This township is almost unacceptable either for man or beast excepting when frozen up. A small portion in the north portion of this township is barrens covered with short thin grass and scattering White, Burr and Jack Oak trees. The soil on the barrens is light, loose sand, third rate."

A.J. Hewett 1847

General Description T030N R24W

"This township is rolling second rate sandy soil. Timber is Burr, Black and White Oak. There is about one section of prairie in the SW part of this township that will some time contain some good farms. The NE part is wet and marshy."

Isaac Higbee 1847

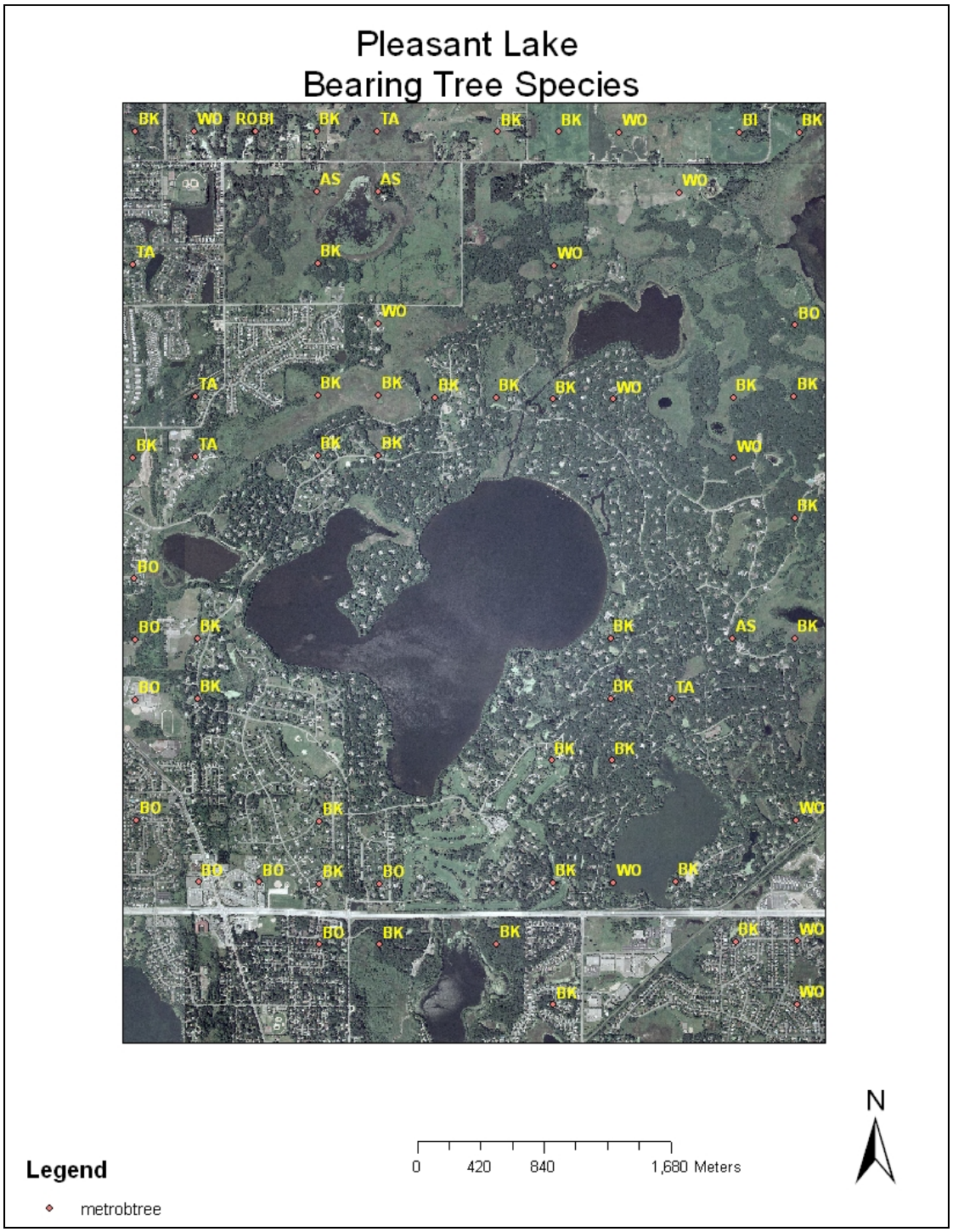


Figure 1. Bearing Tree species and locations, from Original Public Land Survey, 1847-1853. BK = "black oak" (for this area *Quercus ellipsoidalis*, pin oak), BO = bur oak (*Quercus macrocarpa*), WO = white oak (*Q. alba, Q. macrocarpa* [in part]), TA = tamarack (*Larix laricina*), AS = aspen (*Populus tremuloides, P. grandidentata*, and *P. balsamifera* [in lesser part]), RO = red oak (*Q. rubra, Q. ellipsoidalis* [in part or as hybrid]), BI = birch (*Betula papyrifera, B. cordifolia*).
From http://deli.dnr.state.mn.us/metadata/pveg_buckthornreept3.html

Figure 2. Plant community data from Original Public Land Survey, 1847-1853. K = "scattering oak, scattering timber", F = "forest, timber", M = "marsh", S = "swamp", A = "creek". From http://deli.dnr.state.mn.us/metadata/pveg_buckthornreept3.html

In examining a 1940 aerial photo (see Figure 3) of the Pleasant Lake area, you can see that the vegetation had already started to fill in with trees and shrubs; although there are still many spaces between trees and groups of trees. This makes sense since by 1940 there would have already been about 100 years of fire suppression. Fire is the key element in keeping land cover more open. Without fire, (unless an area is grazed) trees and shrubs slowly fill in the gaps in the prairie or savanna (see *Tall Grass Restoration Handbook, edited by Packard and Mutel, page74)* Areas that were grazed would have maintained their savanna structure by virtue of cattle keeping the brush down, and these areas would show up on an aerial photo as having more spaces between trees. Once grazing was lost, in the presence of fire suppression, a former savanna would become overgrown with brush, and in a matter of a few decades it would convert to woodland (50%-80% canopy cover), and eventually to a fully closed-canopy forest (100% canopy cover). Today, most of the plant community/landscape surrounding Pleasant Lake would be classified as a Mesic Oak Forest.

Figure 3. Historical air photo of Pleasant Lake area from 1940.
From http://www.co.ramsey.mn.us/prr/index.htm, "GIS On-Line Mapping".

The 1940 aerial photo shows that the plant community on the "island" is a closed canopy forest, as well as the northwest of the lake. This makes sense, and most likely was more closed even in pre-settlement times, considering that fire would have found it difficult to penetrate into this area. Examination of the soil maps of this region (see Figure 4) shows that there is a large band of mucky soils running in a southeast-northeast direction from Charlie Lake all the way up to Deep

Lake, and then south from Deep Lake, along a present day canal, to the north end of Pleasant Lake. (Muck soils were formed from the long-presence of wetlands.) This would effectively cut off entry of fire to this zone during years of normal moisture conditions, which would tend to result in more mesic forest types. However, during dry years and periods of drought, fire would have swept across shallow wetlands, entering into this area, which would tend to result in either a more open woodland community or possibly even a more savanna-like community.

The soils surrounding the east, south, and southwest side of the lake are generally fine sands and loamy sands, which would tend to dry out readily during even normal moisture years, and thus be prone to fire. There are relatively few large bands of wetlands to protect from fire that would most likely have swept right up to the lakeshore in these locations. This situation would have resulted in a more open, savanna plant community, since the frequency of fire would have been greater than that occurring in the northwestern side of the lake. Evidence of this scenario exists even today. Other than cottonwood and silver maple, both fast-growing, floodplain/lowland forest species, the largest existing trees are mainly oaks. A few remaining large white, bur, and red oak are found growing very near the shore scattered all around the lake. Many of these old trees have evidence of an original growth form typical of open-grown specimens: large lower limbs, or large knobs indicating the former presence of large lower limbs. Thus restoration to a more savanna-like setting around the lake would not be out of line.

St. Paul Water

In 1876, Charles Gilfillan purchased approximately 3,000 acres of land surrounding the lakes in present day North Oaks, with the purpose of supplying the city of St. Paul with drinking water

Today, the St. Paul Water Utility derives drinking water from the chain of lakes that includes Pleasant Lake. Water levels of Pleasant Lake are artificially manipulated by adding water directly from the Mississippi River (via nearby Charlie Lake) through a nine-mile long 60-inch conduit (underground pipe) that emanates from Fridley, MN. Depending on water demands from the City of St. Paul and surrounding suburbs, water levels in Pleasant Lake are either raised or allowed to lower by means of a gate and pump system. During high water demand periods (summer season), the pumps and gates are running almost continuously. The input of water from the Mississippi River, the canals connecting Pleasant Lake with Charlie Lake and Deep Lake, and the concomitant rise and fall of water levels in Pleasant Lake have all contributed to altering the natural ordinary high water levels, natural inundation cycles, natural flooding and drought cycles of Pleasant Lake. The natural dynamic of the shoreline has no doubt been altered because of these changes.

Hill Property

In 1883, James J. Hill purchased the land from Mr. Gilfillan, and increased the area to 5,000 acres. James J Hill transformed much of the land into farmland to help support his railroad business. The effects on the lake and shoreline would have been quite profound, since the amount of runoff and sedimentation would have increased due to the vegetation clearing and plowing of land nearby the lake.

In 1950, Louis W. Hill, Jr. and family incorporated the North Oaks Company “to develop North Oaks Farm into a model residential community centered on the respect and preservation of the natural environment.” (City of North Oaks website: http://www.cityofnorth-oaks.com/index.asp?Type=B_BASIC&SEC={D365D666-395F-4DB4-BCD8-8FF860B71DEA}&DE=) Development would have further impacted the lake, as more soil became disturbed, and more vegetation was cleared.

Today Pleasant Lake is surrounded by residential homes and lots, which continue to impact the lake and lakeshore.

Lakeshore Ordinance
The city of North Oaks has a Lakeshore Ordinance that regulates activities in the buffer zone surrounding the lake. Notably, this ordinance limits the amount of vegetation clearing that is allowed in the buffer zone. For the most part, the ordinance is being followed, but several examples were seen during the evaluation, of potential ordinance infractions in terms of over-clearing of vegetation in the buffer zone.

Since no motors are allowed on the lake, by ordinance, one might expect not much erosion from wave action, but in fact there are actually many areas that are actively eroding. Powerful waves can form from very strong winds that develop on the lake, especially on the east and south east sides, and also on the southwest side of the island peninsula. This is because the prevailing westerly and northwesterly winds have a significant fetch distance (distance of unencumbered surface—no obstacles to the wind.) Nevertheless, west and north sides of the lake are also subject to plenty of wind and wave action also.

Exotic Invasive Species

A number of exotic species have invaded the area of Pleasant Lake. Both upland vegetation invaders like common buckthorn, Tartarian honeysuckle, and spotted knapweed, wetland invaders like reed canary grass, purple loosestrife, and hybrid cattails, yellow iris, and aquatic invaders like curly-leaf pondweed were seen on this evaluation. Other exotic invaders that are known to inhabit the waters of Pleasant Lake are Zebra muscles, but they were not observed during this evaluation.

Soils Map of Site

Both upland and wetland soils surround Pleasant Lake (see map in Figure 4.) Upland soils consist primarily of loamy sands and sandy loams. Wetland soils consist mainly of organic soils: mucks, udifluvents, aquolls, and histosols. Appendix 4 lists the soil units found at Pleasant Lake site.

These soils would have interacted with aspect and fire to form a mosaic of wetlands, mesic forest, fire dependent woodlands, and savannas, with possibly some open prairie in drier more fire-prone areas. The pre-settlement condition of most of the upland areas would have been much more open and savanna-like. Since Euro-American settlement, fire suppression has resulted in a gradual filling in of oak openings and woodlands.

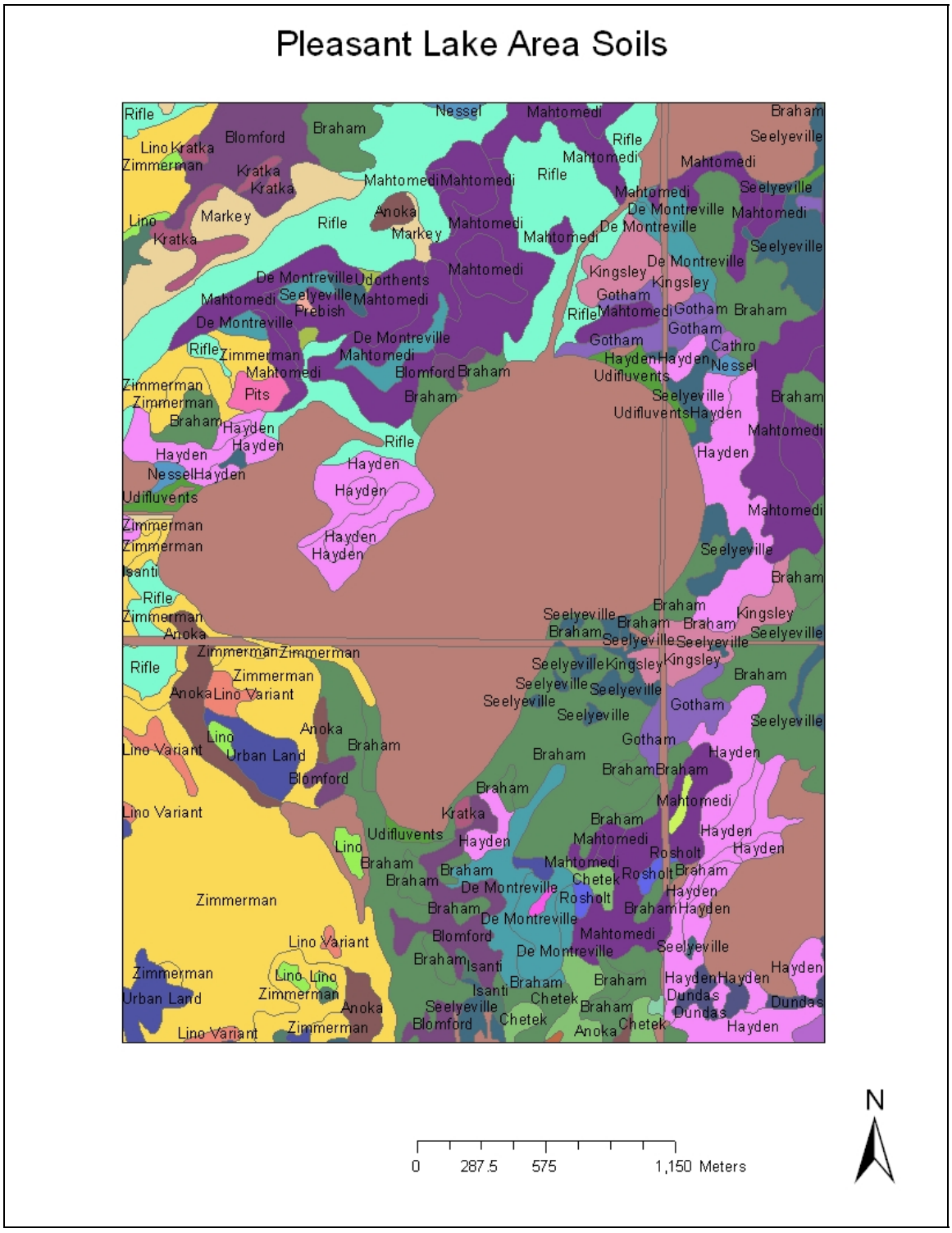


Figure 4. Map of the soils in the Pleasant Lake area.

METHODOLOGY

During June and July, 2009, Great River Greening staff conducted an evaluation of the entire lakeshore of Pleasant Lake. The lakeshore was examined closely from both the lake side (via canoe) and the land side (via walking the trail) to gain a comprehensive perspective of the shoreline's condition. The goal was identification of threats to the shoreline and to water quality. Problem areas were identified that had signs of erosion and degradation of the shoreline, as well as areas where the shoreline was receding close to the trail. Problem areas and threats were marked with Geographic Positioning System (GPS) (see Figure 5), described in detailed field notes, prioritization, and recommendations.

Problem areas were prioritized on a scale of urgent, high, medium or low. The high priority areas were further given an "urgent status" (designated by a red "U" in the spreadsheet) if they were seriously encroaching upon the trail.

Signs of Degradation

Signs of degradation of the shoreline usually involve evidence of some sort of active or recent erosion. The following are a list of signs of degradation that were encountered during the evaluation:

- Exposed bare soil
- Sloughing of soil
- Rutting
- Gully formation
- Undercutting/incision of bank or toe
- Receding bank
- Wash out areas
- Steep/sheer bank at toe
- Sunken or cracked upland soils
- Over-removal of vegetation

Other signs of degradation involve high densities of invasive, exotic plants that can indirectly lead to soil erosion and also result in a reduction of overall species diversity and richness. For example, common buckthorn, *Rhamnus cathartica*, forms shrubby thickets that produce dense shade (and possibly produce allelopathic root exudates), which result in an almost complete lack of vegetation on the ground layer and bare, erosion-prone soil underneath their canopy.

Many photographs were taken of the various problem sites around the lake (See Appendix 8 for a full log of all of the photos and the attached CD of photos).

Identifying Lakeshore Type

Once problem sites have been identified, the next step is to determine how best to stabilize them. The first thing to determine, is what type of lakeshore exists. The following are categories taken from McComas (2003):

Category	Bank Ht plus the wave runup on the bank	High or low energy environment (based on wave height)
Low Bank, Low Energy	Less than 3 feet	Less than 1 foot
Low Bank, High Energy	Less than 3 feet	Greater than 1 foot
High Bank, Low Energy	Greater than 3 feet	Less than 1 foot
High Bank, High Energy	Greater than 3 feet	Greater than 1 foot

Once the lakeshore has been categorized, notes on site specific conditions will direct the best options for how each specific site is to be stabilized.

RESULTS

At first glance, the condition of the shoreline of Pleasant Lake seemed good. There was quite a bit of vegetation in the buffer zone (an area of at least a 30-foot-wide vegetation zone surrounding the edge of the lake, see Case Study #6: Assessing Vegetated Buffers Using Synthetic Residential Runoff, Contributing Author: S.M. Stai (sarah.stai@westwoodps.com), Westwood Professional Services), and there were many rocks and large trees lining the shoreline. But upon closer examination, many stretches and spots of shoreline were in fact not in very good condition. There were many areas that had signs of active erosion, including exposed bare soil, sloughing of soil into the lake, undercutting/incision of the shoreline toe, encroachment of the bank upon the trail, and invasions of non-native plant species. By far the most common cause of these problems is due to a lack of vegetation in the buffer zone, including, and most importantly, the emergent and transitional zones, but also the upland zone. There is a general lack of, or removal of, the emergent vegetation throughout the entire lakeshore, which will result in erosion of the bank.

Existing Natural Communities at Pleasant Lake

The findings showed that most of the shoreline was made up of forest or woodland plant communities. Green ash, black willow, silver maple, cottonwood, pin oak, red oak, bur oak, white oak, red cedar, and basswood are all common constituents of the canopy in these communities. On the southern and western shores, where exposure to the sun is less intense and frequent, trees like maple, basswood, and even ironwood are more common, whereas on the northern and eastern shores, where exposure to the sun is more intense and longer in duration, oaks, red cedar, and even paper birch and black cherry are more common. Very few pines and spruce were found on the shoreline, but red cedar was quite common in the upland buffer throughout the lakeshore. This, combined with the presence of many large, old bur and white oaks, both common dominants of oak savanna, is evidence of a past time when the canopy was much more open and savanna-like.

Shrub layers were sparse to dense, comprising primarily of common buckthorn (exotic), Tartarian honeysuckle (exotic), false indigo bush (native), and red osier dogwood (native), with some sandbar willow (native), arrow wood (native), smooth sumac (native), black raspberry (native), and others.

Upland/transitional forb layers were sparse to dense, depending on the amount of canopy cover. Common constituents include Pennsylvania sedge (native), woodland tick trefoil (native), smooth brome (exotic), reed canary grass (exotic), tall meadow rue, stinging nettle (native), poison ivy (native), and in mowed areas, Kentucky blue grass (exotic) and fescue spp (exotic).

Emergent vegetation was generally lacking throughout the entire lakeshore. Where it was present, the main species found were the following: hybrid cattails, hard and soft stem bulrush (both native), river bulrush (native), and large and narrow leaved arrowhead (both native).

Submerged vegetation consisted mainly of the following native plants: white lilies, elodea, Pontedaria species, and coontail. Also observed at scattered location in the lake was the exotic, invasive Curly Leaf Pond Weed. We did not extensively sample for submerged vegetation, rather we recorded our observations from the canoe.

Priority Sites

Priorities with associated management timeliness categories for problem areas are listed as follows:

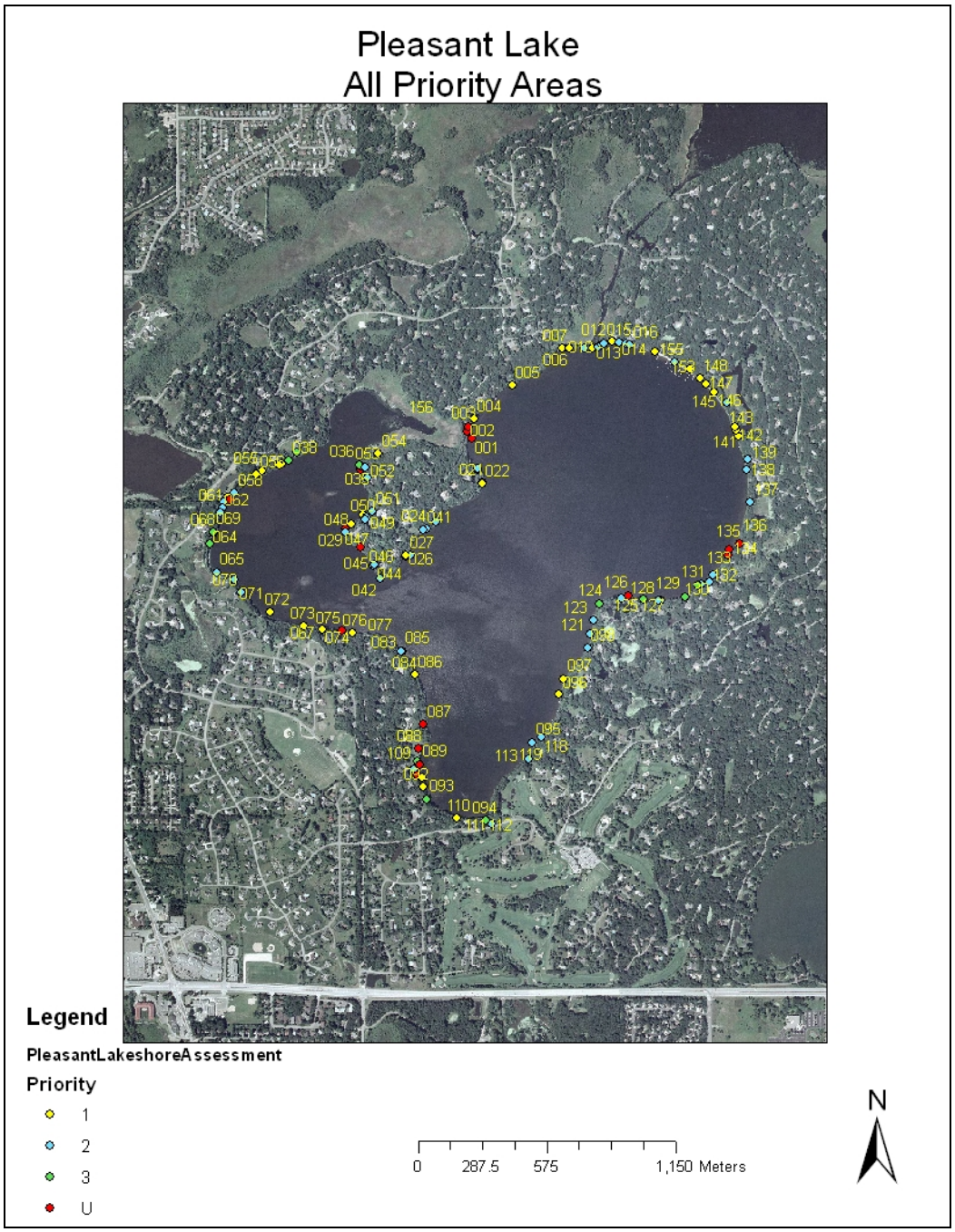


Figure 5. Map of all priority areas for Pleasant Lake Shoreline.

"**Urgent Priority**" areas are shown in Figure 6. These are problem sites where active erosion is occurring very close to a trail or a road, etc. It is recommended that action be taken to stabilize the shoreline within the next 1 to 3 years to slow/halt degradation of the shoreline before it undermines trails or roads, etc. NOTE: Bank re-shaping may not be an option for most of these sites, since there is no space to grade back to (trail or road is too close), so other stabilization options will be needed, like building up the bank with vegetated or soft-armor wall (for example Bio-D-Blocks, Enviro-Lok or Delta-Lok systems) at a higher than 1:4 slope ratio.

Figure 6. Map of Urgent Priority areas.

- *High Priority Areas ("Priority 1")*: it is recommended that action be taken to stabilize the shoreline within the next 5 years to slow/halt degradation of the shoreline before it undermines trails or roads. NOTE: for most of these sites, there is still adequate space to perform bank re-shaping, if needed, but if stabilization activities are delayed too long, this opportunity will be lost.

Figure 7. Map of Priority 1 areas.

- M*edium priority areas (Priority 2)*: it is recommended that action be taken to stabilize the shoreline within the next 10 years to slow/halt degradation of the shoreline or upland bank. NOTE: for most of these sites, there is still plenty of space and time to perform bank re-shaping, if needed.

Figure 8. Map of Priority 2 areas.

- L*ow priority areas (Priority Area 3):* it is recommended that action be taken to stabilize the shoreline within the next 10 to 20 years to slow/halt degradation of the shoreline or upland bank. Even though labeled "low" priority, these are still problem areas that require attention. NOTE: for most of these sites, there is still plenty of space and time to perform bank re-shaping, if needed.

Figure 9. Map of Priority 3 areas.

Specific Locales on the Lakeshore

For simplicity's sake, the shoreline has been divided into ten *stretches*, or *reaches*, and taken the liberty to name them. Sometimes names were evident, like "blue water lagoon", because this area was already named on the North Oaks map, but other times new descriptors were created where appropriate. See Figure 10 for locations of stretches of shoreline. For each stretch/reach, a map of that stretch is included, and a table listing the Priority Sites with recommendations and an index of photographs for each Priority Site (from the field notes), with associated descriptions and recommendations, is included. Also, each waypoint has photographs associated with it, which can be found listed in each table and in the field notes.

Note that all "Urgent Priority Sites" are printed with red font color. Also note that in the "Waypoint #" column, if a listing is designated "end", this means that it is the end of the previous entry, which was the beginning of the problem site. For instance, waypoint 35 is the end of waypoint 34, which is a stretch of approximately 100 feet of shoreline, located on the Island Peninsula, which is actively eroding and very close to undermining the trail. A list of all priorities, with associated recommendations and notes and associated photos, for each stretch/reach of the lake can be seen in the table in Appendix 1.

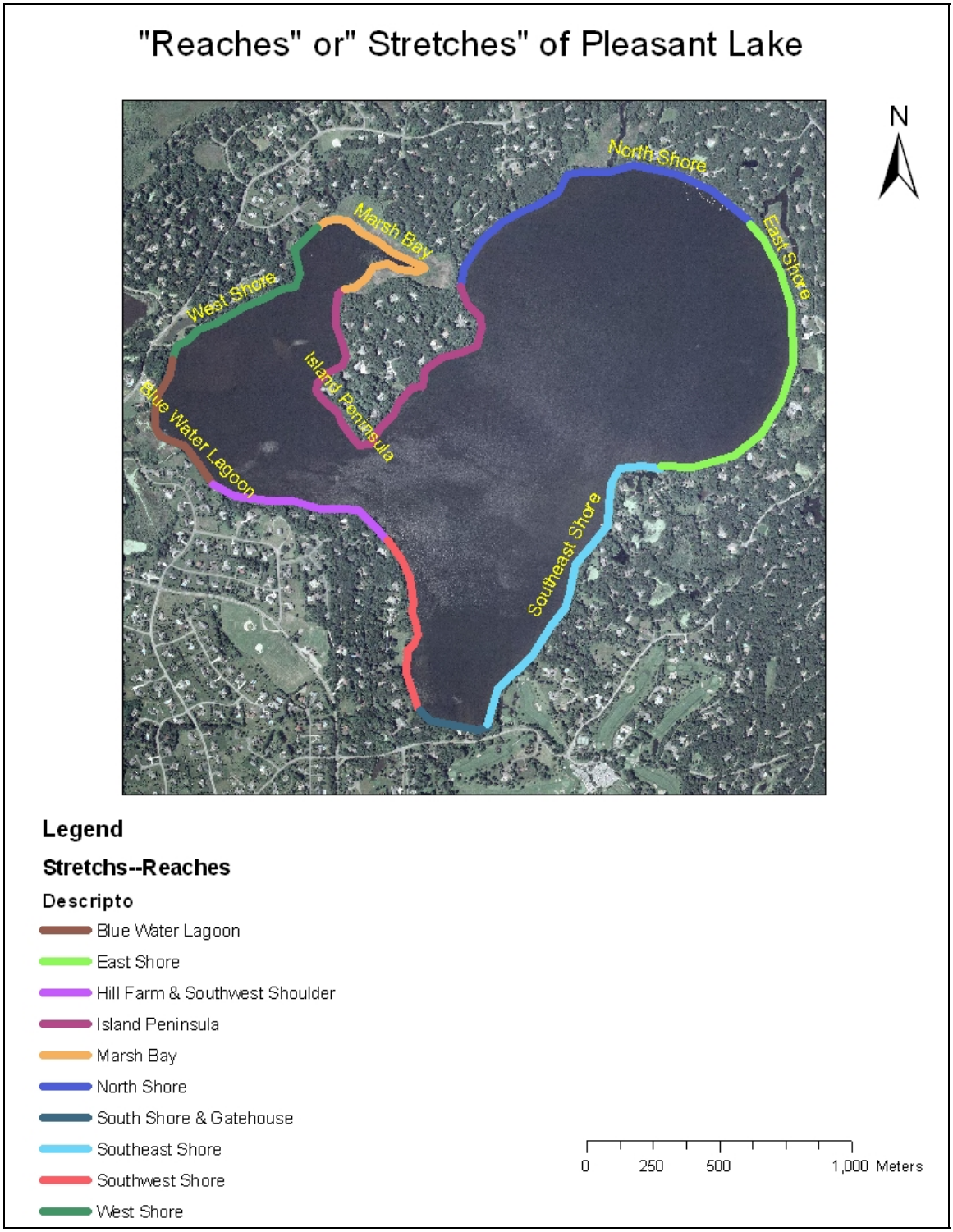


Figure 10. Reaches or Stretches of Pleasant Lake Shoreline.

North Shore

The shoreline that extends from south of the Swimming Beach westward around the north side of the lake to the start of the Island Peninsula (approximately 4500 feet long) (Figure 11) is referred to in this report as the *North Shore of Pleasant Lake*. The banks of this stretch were moderate in height and consisted mostly of mineral soil, except for the canal area that connects to Deep Lake, which are organic soils. Along the north side and the Island Peninsula were observed many boulders on the toe of the bank. Most of this shoreline was classified as a *low-bank, high energy* shoreline.

This section has several sites that require attention, including the road at the beginning of Island Road, the boat mooring area, the swimming beach area, the Foot Bridge, and the area of discontinuous trail (referred to as "Tract X").

The areas flanking each end of the Foot Bridge are sustaining quite a bit of bank erosion, so vegetative stabilization of these areas is recommended, but only after any work that needs to be done on the bridge itself is first completed.

The shoreline at "Tract X" is in poor condition, since it has been completely cleared of native vegetation in the buffer zone. This area is a high priority for stabilization. If stabilization gets postponed too long here, it may be too late for any trail installation to occur, since there will be an insufficient width of land to build a trail upon.

In the location where Island Road comes close to the lakeshore (waypoint 3, and to some extent waypoints 1 and 2), this is an urgent priority, since erosion is actively occurring here. To prevent the road from becoming undermined, which would result in a very costly project to rebuild the road, the shoreline should be stabilized as soon as possible.

For the canoe storage area, by the swimming beach, it is recommended that it be re-designed so that the following criteria are met:

- Build racks for the canoes to get them off the ground and contained to one area.
- Install the racks on the upland side of the path so people are more reluctant to drag them to the water and have to portage them to the water's edge.
- Thicker vegetation, fencing or both to direct people to the launch area to put the canoes in and protect the bank.

Figure 11. Map of North Shore of Pleasant Lake, showing priority areas. Note that "urgent" priority areas are marked with a red dot.

Priorities for North Shore of Pleasant Lake

Way-point	Photo #	Description	Priority	Recommendation
1	1:49	Erosion from walking to lake from road. About 10 feet of shoreline.	U	Trees or shrubs; dogwood live stakes/Amorpha planting; black willow tree planting sandwiched between willows and basswood-southwest maybe to west of the area
2	1:49	Yellow gas/bench. 10' wide area of eroding, sloughing bank.	U	Planting trees, shrubs, live stakes.
3	1:49	Lake access; 3' wide buffer to Island Road. High Priority! Not much time before road starts to undermine. Must do something now to head this situation off.	U	Trees or shrubs; dogwood live stakes/Amorpha planting; black willow tree planting sandwiched between willows and basswood-southwest maybe to west of the area. About 50' of shoreline.
4	1:33	Purple loosestrife coming in. 100 ' of shoreline bare with no vegetation.	1	
5	1:42-43, 50-51	Mowing to water's edge; no native vegetation in the buffer zone. ("Tract X"). No trail exists on this section of lakeshore.	U	Replant buffer zone with native shrubs and herbaceous plants. Live stakes at toe. If trail construction project is approved, wait until trail is installed before vegetation is installed.
6	1:27, 47, 55-56	Extension of problem area from #5. Steep bank (3' high).	1	Cut ash and basswood. Use cut tops to stabilize shoreline. Plant shoreline with dogwood and willow (black and sandbar). Use biologs if possible.
7	1:28	End of problem area (cottonwood)	1	
8	1:27	Small area of erosion due to unauthorized access to the lake (foot path)	2	Plant shrubs to screen and block access. Re-plant in buffer with herbaceous plants or shrubs or live stakes or seed with blanket.
9	1:21, 24-26	Bridge: erosion on both sides of bridge. Rip-rap added into gully/washout to stop erosion here. Fallen cottonwood on north side of bridge.	1	Wait until bridge is rebuilt. Then remove ash trees and replant with native shrubs, plugs, and/or seed in transitional and upland zones, and with live stakes along toe. Use removed trees and biologs and blanket with plantings/seeding.
10	1:23-23	Erosion behind willow. Unauthorized lake access problem.	2	Replant in buffer zone.

11		Erosion area (10' wide). Shady.		Remove cedar, ash, buckthorn (buckthorn); replant with natives and stakes
12		Erosion by oak tree.	2	Hazelnut/Penn sedge planting. Remove basswood and ash trees.
13	1:13-16	Erosion by old broken down stairs. Exposed sandy shore.	1	Remove stairs; restore shoreline at stair area and east of it 15' or so. Use Calamagrostis, Amorpha, etc.
14	1:20	Falling tree at shoreline.	2	Remove tree. Replant with black willow, Amorpha. Use coir log too.
15	1:19-20	Erosion at shoreline with falling tree	2	Remove tree. Replant with black willow, Amorpha. Use coir log too.
16	1:16	Erosion problem at stairs.	2	Remove stairs and replant with shrubs and black willow.
148	5:82	End of 107-108-109. One or two spiderwort growing on ice ridge; also scattered Amorpha, milkweeds, dogbane. At north end of stretch, a cute little sedge with upright spikes.	1	Control exotics and re-vegetate along buffer. Re-establishment of emergents will be a challenge due to ice ridge formation. Consider installing some sort of root wad (but very expensive)?
149	5:83-85	Nice patch of 3-square. Some are pounded down by waves and flotsam. Sterile spurge on sandy ice ridge.	G	
150	5:86	Lots of Solomon's Seal on and just behind ice ridge, under green ash.	G	
151	5:94-95	Rutting on sides of boat launch ramp.	1	Add gravel/trap rock on net-lawn/re-vegetate.
152	5:93, 96-97	Boat Bay shoreline.	2	Re-vegetate all along this stretch. Use 3-square, Amorpha, sedges, spiderwort, etc.
153	5:98-99	Swimming Beach	-	
154		end swimming beach	-	
155		High sand ice ridge. Bare soil eroding into lake.	1	Stabilize and re-vegetate.

Table 1. Priorities for North Shore of Pleasant Lake

Figure 12. Erosion caused by un-authorized lake access (waypoint #1).

Island Peninsula

The shoreline that extends from the beginning of the Island Peninsula, or "the Island", (where the trail starts up again from Island Road), all the way around the peninsula to the start of the Cattail Marsh, approximately 5200 feet long (Figure 13). The majority of this shoreline was classified as *low bank, high energy*. This stretch had several urgent high priority areas (see Table 2), including the area where Island Rd approaches the water's edge, and most of the stretch of west- and southwest-facing shoreline on the west side of the peninsula.

Figure 13. Map of Island Peninsula of Pleasant Lake, showing priority areas. Note that "urgent" priority areas are marked with a red dot.

Priorities for the Island Peninsula shoreline of Pleasant Lake

Waypoint	Photo #	Description	Priority	Recommendation
17	2:1-6	Cattails in bay. Shoreline encroaching on trail. Starts at big cottonwood and goes until the tip of the peninsula where the homeowner is mowing and clearing on both sides of trail. About 4 canoe lengths.	2	Remove about 6 leaning trees (ash, silver maple). Revet with cut trees along shore line.
18		end		
19		Beginning of 17		
20		End of 18		
21	2:7-8, 12	Narrow buffer to trail.	1	Remove some trees--selective clearing. Re-vegetate with herbaceous plants and shrubs (red-osier is present here).
22		end		
23	2:09	New lot site. Steep upland slope on other side of trail.	2	Re-vegetate with seed/plugs/shrubs. Continue to work on the upland slope. Re-vegetate bare spots. which is about 25% of the slope. Shoreline is OK for now, but will suffer if upland is not corrected.
24		end		
25	2:13	3 or 4 leaning ash trees.	2	Remove trees and live stake.
26		end		
27	2:17	Undercutting at toe on 10 feet either side of this point. 1 dead buckthorn. Closely encroaching on trail.	1	Add boulders and hardstem plus live stakes.
28	2:18, 23-26	Undercutting at toe. Closely encroaching on trail. Signs of erosion/bare soil. Sparsely vegetated buffer and upland slopes with much buckthorn. About 100 feet of shoreline.	U	Remove 10 to 20 trees (some ash, red oaks, and basswood). Live stake. Revet with removed trees. Plant emergent plugs (iris, river bulrush, hardstem/softstem, 3-square) with wave breaks. Also plant transitional vegetation on narrow buffer. Plant upland slopes after removing buckthorn.
29		end		
30		More of same from #28-29.	1	
31	2:36	Point within 30-32. Sagittaria bay (narrow leaved arrow head with some sensitive fern on bank and Thalictrum spp.)	G	Although Sagittaria is a good native emergent macrophyte, it appears that it is not sufficient to stop undercutting

				of the bank (just planted?). Still need to revet and stake.
32		end		
33	2:19, 48	Good example of a solution that someone has implemented: large log (22-24" diameter) revetment that is wedged into the shore the long way. Behind it have been planted native emergent and transitional vegetation: blue flag, bottle brush sedge, tussock sedge, softstem/hardstem, prairie rose, chokeberry--hardly any RCG.	G	
34	2:49	Active erosion, with bank sloughing. Steep too and touching trail.	U	Soft-wall system and re-vegetate with wave breaks, etc. About 100' of shoreline.
35		end		
36	2:68	Removed lake edge/marsh. Not urgent. The problem is that it can induce muskrat damage and weakening of organic soil due to tunneling of soil at shoreline	3	Allow vegetation to regrow.
41	2:15	Point of island: cleared for view. Now all turf by sitting bench.	2	Should have more 3-square and transitional veg.
42		end		
43		Hardstem bay.	2	Needs biolog or compost socks and plant into that.
44	2:79	Large boulder, without associated vegetation: not working to stop erosion on shoreline	2	Plant vegetation around boulder
45	2:20-21, 80	Upland slope and limestone steps. Steps are good example of vegetated steps: low-mow turf, which fills in nice and thick. Upland slope has had buckthorn removed, which is good, but the stumps were not treated, so slope is continuing to slowly erode.	G	Nice to remove buckthorn, but no follow-up. Follow-up by replanting/seeding with natives in buckthorn's wake.
46		end		
47	2:83	Severe erosion very close to trail		

48	2:85	Point on the peninsula. Shallow limnetic zone. Good possibility of restoring emergents.	2	Restore emergent veg.
49	2:50	Steep upland slope (60 degrees) with bare soil. Has been cleared.	2	Re-vegetation slope.
50		Some newly installed plants		
51	2:52	Some newly installed plants, and end of 49-51.		
52	2:88, 53-55, 91-93	New house. Steep slope (50 degrees). Buckthorn was removed, but no follow-up. Slope is eroding with bare soil on slope.	2	Stump-treat buckthorn and replant with natives.
53		end		
54		Drain pipes on shoreline. Stormwater actively draining into lake. Fallen (oak) tree on shoreline--should leave this--good example for rest of shoreline. South of dock, shoreline is eroding/bare soil/total lack of emergent vegetation	1	Stabilize drain pipe inlet area. Restore shoreline south of dock.

Table 2. Priorities for the Island Peninsula shoreline of Pleasant Lake

Figure 14. Undercutting at toe and closely encroaching on trail (waypoint 28).

Marsh Bay

The approximately 2700 foot long stretch of shoreline on this marshy bay, located northwest of the Island Peninsula consisted almost exclusively of cattail marsh plant community species (Figure 15). This shoreline was classified as *low bank, low energy*. Here, hybrid cattail, reed canary grass, Canada blue joint, dominate, but many other species such as tussock sedge, lake sedge, bottle brush sedge, marsh fern, and other marsh species live in this mucky soil. See Appendix 6 for a list plant species encountered during this evaluation. The main priority of this stretch would be to identify and remove exotic yellow iris. Currently, yellow iris is in the early stages of invasion here, and it would be relatively easy to snuff it out before it gets a stronghold on the marsh. The best time to identify it is in early to mid June, when it is in flower (Figure 16). Blue flag iris, the native blue-flowering iris, should be left alone Figure 17).

Figure 15. Map of Marsh Bay of Pleasant Lake, showing priority areas.

Figure 16. Yellow Iris (*Iris pseudocorus*) in Marsh Bay, an exotic invasive wetland plant.

Figure 17. The native wetland plant Blue-flag iris (*Iris versicolor*) growing in Marsh Bay of Pleasant Lake.

West Shore

The West Shore is approximately 2700 feet long (Figure 18). Mineral soils resume on the west side of the lake (at approximately the location of 1 or 2 Ironwood Lane), and the plant communities, reflecting the soils, contain larger trees (silver maple, green ash, oak, etc.). Not as many rocks were evident on this part of the shoreline, extending down to the boat landing at Charlie Lake inlet. The majority of this shoreline was classified as *low bank, high energy*.

There are several priority areas here; including the large Urgent Priority area associated with the Charlie Lake Inlet canal (Figures 19-20), which is very eroded at the point, and potentially eroding the footings of the bridge. Included are plan and sections drawings of recommended practices for the Charlie Lake Inlet Canal area. A full, vegetated restoration of the point area is recommended, and rock vanes for the canal (see Appendices 5 and 7). Rock vanes are a practice that redirects the channel (the "thalweg") away from the shoreline and towards the middle of the canal.

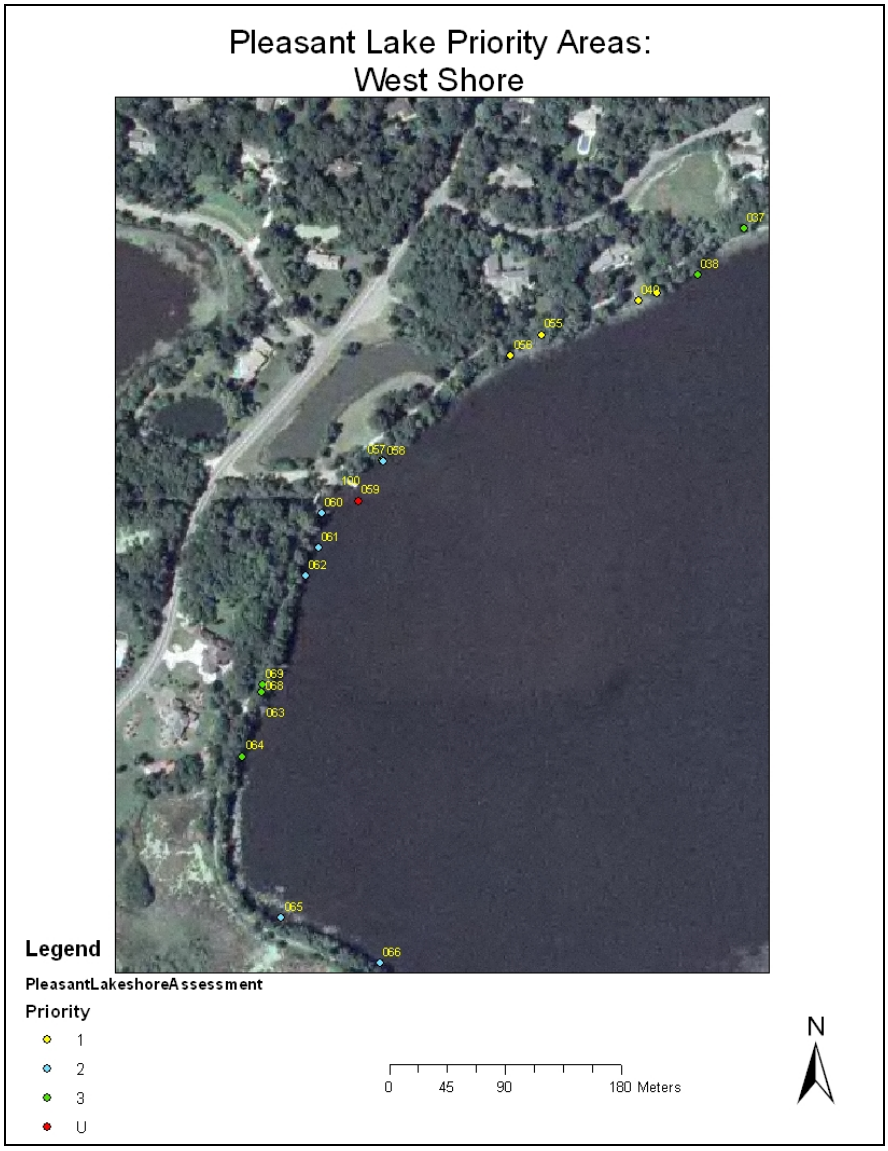


Figure 18. Map of West Shore of Pleasant Lake, showing priority areas. Note that one "urgent" priority area is marked with a red dot.

Priorities for the West Shore of Pleasant Lake

Waypoint	Photo #	Description	Priority	Recommendation
37	2:69, 72-73	Isolated undercut caused by silver maple tree; but a good wide buffer up to trail. In this case it is adding habitat for fish (shelf).	3	Allow tree to fall for fish habitat. Monitor for erosion.
38	2:74	Dead/dying green ash. Fetch distance is large here, so waves are stronger.	3	Remove tree and use to armor shoreline.
39	2:75-77	Actively eroding--bare soil sloughing--no cover--mow to edge of water. Shore bed is far less rocky and shallow/gradual than before.	1	Use erosion product to build it back up
40		end		
40a	2:75-77	Mucky soil gives way to rocky, mineral soil. Textbook example of emergent vegetation holding shoreline. One side of dock was removed just upland buffer and emergent vegetation is intact, but shoreline has not receded. The other side of dock was removed both upland and shoreline vegetation of buffer, and shoreline has receded a lot and is actively eroding now. GREAT EXAMPLE. I took lots of pictures.	1	Stabilize shore on north side of dock with emergent veg. Plant transitional vegetation buffer on both sides of dock also.
55		end		
56	2:3-4, 63-64	From trail side. A combination of factors contributes/results in destabilization of the shoreline. Upland side of trail is a large mowed field. Drain pipes causing erosion. No emergent veg. Clearing for dock.	1	Reduce mowed turf on upland side of trail. Stabilize drain pipe outlets. Plant emergent veg. and transitional vegetation, especially around dock area.
57	3:6	About 100 feet north of dock at Charlie Lake outlet. Big white oak--not tipping--roots exposed on toe; undercutting; bare soil; steep, 5' bank. Nearby patch of river bulrush, hard/soft stem	3	Monitor for tree falling.
58	3:7-9	Bridge/dock to Charlie Lake. Boat Launch-ramp made of blacktop. The St. Paul Water Dept launched a motorboat (6-25-09). No sediment build-up. Not much erosion--a little at corners	2	Recommend emergent vegetation planting.

		of launch. South side of launch slightly concave shoreline.		
58b		Boat launch clearing area. Graded flat and somewhat toward pond, but not too much, so not much direct runoff to lake—good. Large area of mowed turf near boat launch area—not sure why.	3	Stop mowing To set a good example for the rest of the community, recommend replacing mowed turf with no-mow turf, if that look is desired, otherwise it would be best to restore the area with prairie/wet prairie..
58c		Bridge at Charlie Lack inlet to Pleasant Lake. Steep bank sides that are eroding slowly. Footing of bridge may be undermined at some time in future--not super urgent, but should be addressed.	1	Use rock vanes to redirect channel. Armor the point and plant between the hard armoring. There is a good shallow "bench" to plant emergents at the point. Re-grade where necessary.
59	3:10	Point near sitting bench at south side of bridge. High priority area! Bad erosion; active sloughing; unauthorized access to water. About 100' of shoreline.	U	Stabilize with products and vegetation. Use vegetation to screen and discourage access. There is a nice shallow lake bed at this corner of shoreline--can use it to establish emergent vegetation. See Appendix
60	3:14-16	Two, 15-20' long places to create a screen/vegetated buffer to discourage access to water. Steep slope--sandy/rocky--some undercutting; lots of exposed tree roots--some bare soil.	2	Screens and toe stabilization.

Table 3. Priorities for the West Shore of Pleasant Lake

Figure 19. Erosion and degraded shoreline by Charlie Lake inlet canal.

Figure 20. Eroded shoreline by the bridge over the canal at Charlie Lake inlet canal.

Figure 21. Text book example of shoreline erosion due to the removal of emergent vegetation (waypoint 40 & 40A). Both sides of dock have a lack of *transitional* vegetation, but notice that the right side bank is steep and is actively sloughing off into the water, where the left side bank is gradual and is stable. The reason is that the left side has intact *emergent* vegetation, whereas the right side has no emergent vegetation at all. Nevertheless, mowing of transitional vegetation should be discontinued.

Blue-Water Lagoon

The shoreline located at "Blue Water Lagoon" and extending for about 2,000 feet to the southeast (until about the Hill Farm) is lower in height, and is connected to open wetlands, sedge meadows, and forested swamps to the west (see Figure 22). This shoreline was classified as *low bank, low energy*. The soil is a mosaic of organic soils and mineral soils. There are several priority areas here, but not urgent ones.

Figure 22. Map of Blue Water Lagoon of Pleasant Lake, showing priority areas.

Priorities for the Blue Water Lagoon stretch of Pleasant Lake

Waypoint	Photo #	Description	Priority	Recommendation
61		end and beginning of next one		
62	3:17-18	Steep upland slope stabilization on bank. Towards 62 gets gradually lower.	2	
63		Willow for harvesting		
64	3:19-21	End of "Blue Water Lagoon". Erosion; some bare soil; foot access issue. Shallow, rocky.	3	Discourage access: plant/stake/dogwood/elderberry.
65	3:25-26	Foot access from sitting bench and vegetation clearing. Led to some erosion.	2	Live stake with dogwood /elderberry. If it gets too tall, would this be a problem?
66-67		Entire southern shoreline, east and west of this point: medium slopes; good vegetated buffer; 10-20' from- trail; not a lot of erosion, but fairly steep, but not high bank (2-3'). Rocky-lined toe, with mostly green ash, some basswood, and a few oaks (whites and pins) and a few silver maple and cottonwood. Lots of buckthorn. Naturally wooded--lots of deadwood along shoreline. Lack of emergent vegetation on this whole side, but lower priority.	2	Remove buckthorn and use it for brush bundles/mattresses where needed anywhere on lakeshore. Establish emergent vegetation and some live willow stakes.
68	3:65	Over-clearing of upland slope for retaining wall and steps. Blue Water Lagoon: eroded area on shoreline: due to overflow from wetland channel/flowage. Culvert may help trail, but would not be good for lake water quality.	3	Plant vegetation around steps. Deal with flowage across trail: create a drained causeway?
69	3:66	By broken top branch. Clean cut over-cleared slope.		
70		Large expanse of turf.	2	Recommend prairie restoration or raingardens
71		Nice wide, forested buffer (because homes are up higher on slope and thus the clearing for sight lines doesn't have to happen). What this whole side should be like, except for a big buckthorn by shoreline	G	

Table 4. Priorities for the Blue Water Lagoon stretch of Pleasant Lake

Figure 23. Erosion by sitting bench at Blue Water Lagoon.

Hill Farm and Southwest Shoulder

The stretch of approximately 2300 ft of shoreline rounding the bend approximately from Hill Farm to about 22 Evergreen Road has a very high bank and gets quite steep at times (see Figure 24). This shoreline was classified as *high bank, high energy* and *high bank, low energy.* This stretch has a couple of Urgent and High Priority areas where the bank is eroding very close to the trail.

Figure 24. Map of Hill Farm and Southwest Shoulder stretches of Pleasant Lake, showing priority areas.

Note that one "urgent" priority area is marked with a red dot.

Priorities for the Hill Farm & Southwest Shoulder stretch of Pleasant Lake

Waypoint	Photo #	Description	Priority	Recommendation
72		Shoreline very close to trail	1	Buckthorn mattresses/bundles installed in bad spot along trail, and live stake to armor toe.
73		Lakeshore incision and close to trail (7' from trail)	1	Buckthorn mattresses/bundles installed in bad spot along trail, and live stake to armor toe.
74		Over-clearing of upland slope. Turfed to trail. Steep/sheer, 5' bank with bare soil and erosion/incision	1	Stop mowing to trail. Plant native vegetation to replace turf to trail. Buckthorn mattresses/bundles installed in bad spot along trail, and live stake to armor toe.
75		High priority! 100 feet both sides of this point. 4-5' steep/sheer bank, very close to trail (1-3'). Incision and slow erosion occurring.	U	REC: Black willow/elderberry/highbush cranberry live stakes in patches every 50-70'. Live stake through mattresses with black willow and dogwood. REC: volunteer event that will help our crew cut buckthorn and make brush bundles/mattresses. Crew will key then into the toe.
76		Large cottonwood on shoreline, with roots being exposed. If it goes, the whole bank rips out and part of the trail. The tree looks sparse in the crown--may be stressed.	1	Remove tree.

Table 5. Priorities for the Hill Farm & Southwest Shoulder stretch of Pleasant Lake

Southwest Shore

From about 22 Evergreen Road along the east-facing shoreline to the Gatehouse (see Figure 25). This approximately 2000 feet of shoreline is typified by low relief with gradual, shallow limnetic zones. This shoreline was classified as *low bank, high energy*. This stretch contains some Urgent High Priority areas where the bank is eroding very close to the trail. There are several properties that mow large areas of turf down to the water's edge.

Figure 25. Map of Southwest Shore of Pleasant Lake, showing priority areas. Note that "urgent" priority areas are marked with a red dot.

Priorities for the Southwest Shore of Pleasant Lake

Waypoint	Photo #	Description	Priority	Recommendation
86	4:1	Some soil exposed just up from the toe. Some undercutting. About a 1' drop. Lots of buckthorn. Also, lots of sumac on this side of lake	2	Upland is vegetated, but to stop erosion, need some armoring of toe/emergent zone.
87	4:2-12	16 Evergreen Resto. Biologs: most didn't stay put--they worked their way inland--2nd side of logs were not staked Bio-D-blocks are doing great These species survived and are doing well in spots: bottlebrush sedge, river bulrush, hardstem/softstem bulrush, Glyceria grass, iris. Overall it's working. The shoreline seems to be getting stabilized. Plants in between the bio-d-blocks did best.	1	Re-stake biologs and build-up on a couple of them. Try to establish more emergent vegetation that will spread outward into "bay". Try planting some 3-square bulrush. The middle of the restoration shoreline needs wave breaks. Try planting into the Soft-Wall System on the north end of the restored shoreline. Need to weed the transitional and upland bank. Sow thistle, pepper grass, toad flax, hoary alyssum.
88	4:13-17	High priority. 3 lots in a row that are mowing right up to the water. This stretch is encroaching on trail: north side is about 15-20' away from trail and south side is 1-2' from trail and actively eroding.	U	3' steep bank needs to be hand re-graded (no biologs on top of river bulrush), or fit small logs into crevasses and install fabric w seed/plugs on bank and/or with live stakes or shrubs. South end has quite a bit of river bulrush, but could be supplemented. Stop mowing to edge. Replant transitional zone.
89		end		
90	4:18-29	High priority. No vegetation: mowing to edge of bank. 2-3' sheer bank, 2-3' from trail. Lots of undercutting, active erosion, sloughing, especially on north end.	U	Same as 87-88. About 300 feet of shoreline total from 88-91.

Waypoint	Photo #	Description	Priority	Recommendation
91		end		
92	4:34-43, 5:16-16	3/4 of the length is a great raingarden on the upland side of the trail. However, the shoreline is being mowed right up to the bank and is still actively eroding. No emergent vegetation on shoreline. (Seems to be a disconnect between raingarden and shoreline.)	1	Stop mowing up to bank. Needs biologs, live stakes, plugs, erosion control blanket, seed, etc. Re-establish emergent vegetation.
93		end		
108	5:25-32	Mowed turf to edge and cutting of river bulrushes--freshly cut by people, not geese.	2	Public education campaign on merits and beauty of native vegetated buffer. Enforce shoreline ordinance. Stop mowing/weed whipping/cutting of native vegetation.
109	5:36	Bench-like shoreline between mowed swath and water's edge. Probably floods in spring. Start of ice ridge. Mostly basswoods, some shrubs (buckthorn, gooseberry, etc.), Solomon's seal. Very shady.	3	Plant more natives and/or seed in here. Smooth brome on edge--replace with Calamagrostis canadensis.

Table 6. Priorities for the Southwest Shore of Pleasant Lake

Figure 26. Slumping bank due to complete lack of native buffer.

Figure 27. Bank slumping close to trail on southwest shore.

South Shore and Gatehouse

This is an approximately 1600 foot stretch of shoreline that encompasses the public trail from 2 Evergreen Road to the Golf Club, just north of East Pleasant Lake Road (see Figure 28). This shoreline was classified as *low bank, high energy*. Ice ridge formations are present, starting about 300 feet west of the Gatehouse. For the most part, the shoreline is in good shape here, probably owing to the fact that there is a nice, wide, continuous buffer throughout most of this stretch (punctuated by the boat launch). The Golf Course, by virtue of its presence, prevents homes from occupying this space, and thus prevents clearing vegetation in the buffer, which is a good thing for the shoreline.

Figure 28. Map of South Shore and Gatehouse of Pleasant Lake, showing priority areas.

Priorities for the South Shore and Gatehouse stretch of Pleasant Lake

Waypoint	Photo #	Description	Priority	Recommendation
94	4:44-45	Boat launch at Pump house. Generally OK. Asphalt is uneven. Existing black willow is protecting the shoreline from eroding, luckily, otherwise it would probably be much worse.	3	Consider reconstructing ramp to concrete slabs--like new launch on Big Marine in Washington County
94a	5:37	Boat Ramp at pump house	3	Idea: vegetate between concrete ramp strips with no-mow turf, clover, spike rush, or something.
110		Garlic mustard by pump house.	1	Remove (bag) and dispose in trash. Monitor and keep up on it or else it will spread and be a big problem. We removed most of it now.
111	5:47	"Seating element" (bench) by golf course. This causes the buffer to narrow way down. Buckthorn, Honeysuckle present here. Also, serviceberry.	2	Remove buckthorn and honeysuckle and replant with natives (viburnums and serviceberry) to discourage any more loss of the buffer here.
112		Quercus alba. Big beautiful white oak (2' Diameter at Breast Height [DBH]).	3	Encourage the planting of white oaks at upland side of buffer.

Table 7. Priorities for the South Shore and Gatehouse stretch of Pleasant Lake

Southeast Shore

This reach includes area approximately 3800 feet long, stretching from the Golf Course (or at 5 Skillman Ln) to the point at 5 Raccoon Road (see Figure 29). This shoreline was classified as a combination of *low and high bank, high energy*. Generally this stretch is in relatively good condition. There are a few spots that warrant attention, however. Also, the entire stretch has evidence of ice ridge formation.

Figure 29. Map of Southeast Shore of Pleasant Lake, showing priority areas.
Note that one "urgent" priority area is marked with a red dot.

Priorities for the Southeast Shore of Pleasant Lake

Waypoint	Photo #	Description	Priority	Recommendation
95	4:48	Model shoreline. Very vegetated. Cleared only a little around the deck. Trees left intact which gives structure. Shrubs are along the bank. Upland gardens, about 25' off the trail. Landscape trees and perennial beds on slope leading down to water. Quite refreshing to see. Weed wacking/mowing a little, but not to excess.	G	
96	4:49	30' wide, 12' high slope, 60 degree angle--super steep. Clearing of shrub and ground layer down to bare soil—poor practice. Downed tree lying parallel to shoreline is beneficial.	2	Seed with erosion control blanket in bare spots and then plant shrub/plugs into that.
97	4:50-51	Patch of willow stakes on shoreline	-	
101	5:3-6	All vegetation removed except for large trees. Mowing to edge, for most part. A little undercutting, not too bad.	2	Re-vegetate the buffer and stop mowing.
102		end		
113	5:38-40	Nice attempt at buffer planting, but not good idea to plant annuals and beware of invasives. Perennial cultivars may be OK otherwise. Too much turf upland.	G	Public education campaign on what and what not to plant for the shoreland buffer. Add mulch or more plants to bed. Replace turf with prairie upland.
114	5:41-43	Large, wood-chip mulched garden at base of hill on upland side of trail. Used fabric with 3 inches of mulch. Mostly non-natives, but nice looking and effective at controlling stormwater. Better than turf. Note presence of landscaped rolling hills—adds visual interest, but not necessary for effective vegetative buffer.	G	Part of public education and outreach plan. Consider starting program to reward good stewards of the lakeshore.
115	5:48	End of canal.	-	
116		Eroding by trail.	2	Re-vegetate with shade tolerant native species (spikenard, elderberry, Jacob's ladder, etc.)

117		end		
118	5:46	Lots of big buckthorn.	2	Remove buckthorn and replace with native shrubs.
119	5:49	The "Ruins"	-	
120		end		
121	5:46	Lots of buckthorn in shoreline buffer.	2	Remove buckthorn and replace with native shrubs
122		Shore bank gets steep and high (20-25').	-	
123		Vegetation too sparse due to over-clearing.	2	Plant more native shrubs and plugs.
124		Past gully erosion. Lower priority.	3	Regrade and replant/seed.
125		Bank tapers back down (2-3').	-	
126	5:51-56	Shoreline buffer is mowed--erosion on shoreline. Close to trail on south end of 200' stretch. High priority! Other side of trail is a pond that needs attention/buffer.	U	Full-blown shoreline restoration for at least 100 feet.

Table 8. Priorities for the Southeast Shore of Pleasant Lake

Figure 30. Problem site on southeast shoreline.

East Shore

This section stretches from the point at 5 Raccoon Road all the way around in an arc to approximately 800 feet south of the Swimming Beach (at about 15 Oriole), for a total of approximately 4200 ft. This stretch is characterized by high relief and high, relatively steep banks for most of its distance. This shoreline was categorized as *high bank, high energy,* but punctuated with *low bank, high energy*. The buffer is fairly wide and forested throughout, but there are some significant "holes" in the vegetation at several spots (see map in Figure 31).

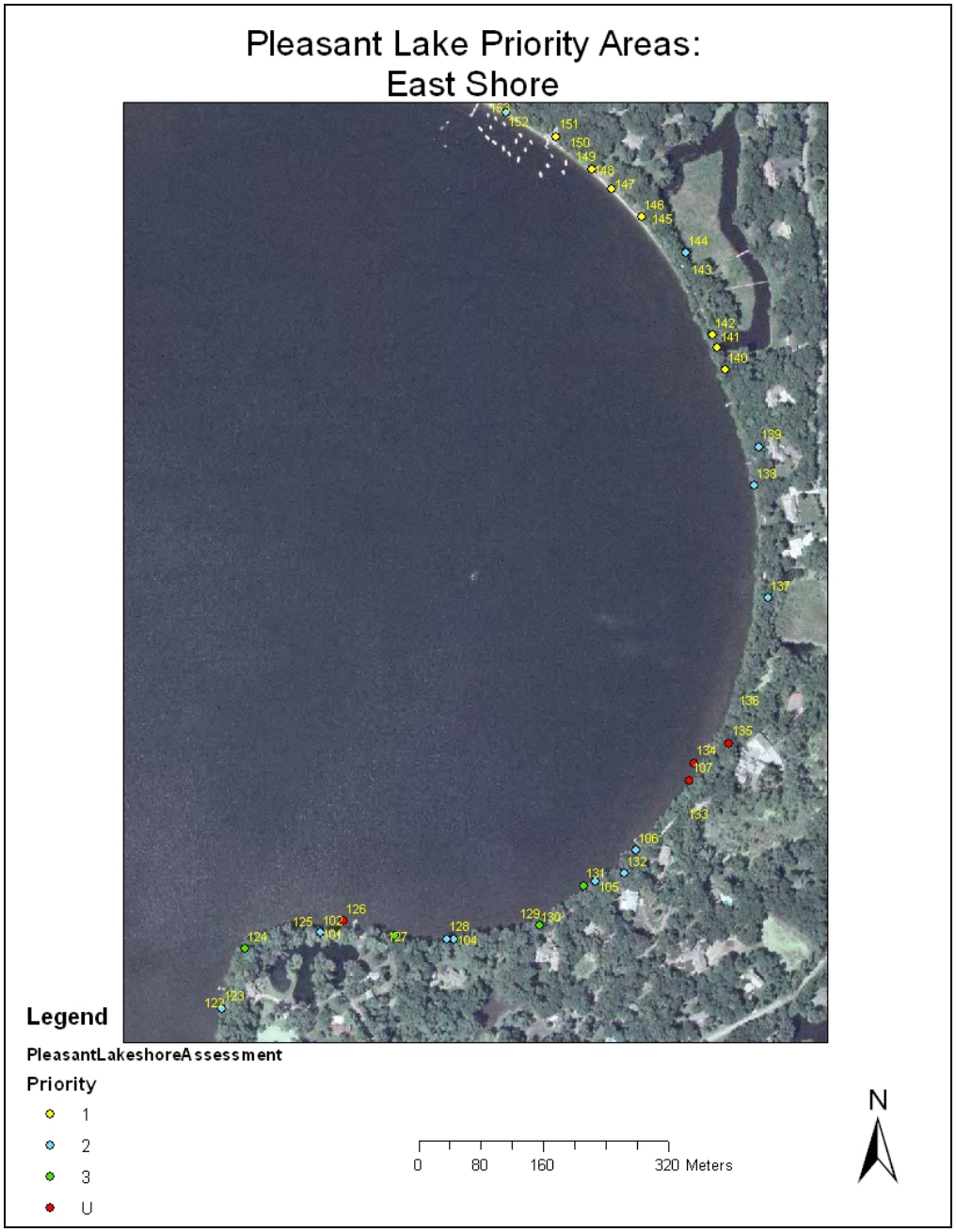


Figure 31. Map of East Shore of Pleasant Lake, showing priority areas.
Note that "urgent" priority areas are marked with a red dot.

Priorities for the East Shore of Pleasant Lake

Waypoint	Photo #	Description	Priority	Recommendation
103	5:7-8	Some vegetation, but sparse. Could use some more. Lots of: jewel weed, night shade, Virginia creeper (filling a void); some Amorpha, bane-berry, raspberry, nannyberry. Big rock/boulder--looks cool. Birch leaning out.	3	Plant vegetation to higher overall density in buffer.
104	5:11	Lots of buckthorn in shoreline.	2	Remove and replant with native plugs and shrubs.
105	5:10	Cleared the vegetation at bank--mowing to edge blue grass turf.	2	Re-vegetate.
106	5:33-35	200 feet of only tree veg.	2	Re-vegetate with shrubs and seed/plugs.
107		Undercutting and on top of trail	U	Soft-Wall System, revegetate, emergent and transitional veg. About 50' of shoreline.
127		Bank starts to rise up again. Buffer is 30' wide.	-	
128		Buffer sparse.	2	Could use shrub layer/dense forb layer.
129		Burning-bush on bank. Has escaped from homeowner plantings.	3	Control Burning-bush.
130		Highest bank (40').	-	
131	5:57	Shrubs sparse.	3	Could use shrub layer/dense forb layer.
132		Mowed bank.	2	Re-vegetate bank and stop mowing.
133		Bank low again. Buffer 20' wide.	-	
134	5:58-62	Eroding bank very close to trail (2-3'). High priority!	U	Full-blown shoreline restoration for at least 50 feet.
135		end		
136	5:44-45, 63	Ice ridge formation evident.	-	
137		Culvert under trail. Other side needs re-grading/stabilization; rock too.	2	Plug/seed around culvert. Regrade and stabilize.
138	5:64	High/steep bank again. Outlet pipe from house runoff creating erosion on bank.	2	Change outlet or add rock/armor outflow area and vegetate.
139	5:65-66	Another bad outlet pipe.	2	Change outlet or add rock/armor outflow area and vegetate.

140	5:71-73	Culvert at canal inlet. Mowed on both sides of trail. Bad erosion on lake side in spots.	1	Re-vegetate entire length of buffer. Plant on upper sides of culvert slopes.
141		More.	1	
142		end	1	
143	5:77	Ice ridges still	-	
144	5:78	Much big buckthorn. Void ground layer due to shading out.	2	Remove buckthorn and replace with native shrubs/plugs.
145	5:78	Nice example of 3-square on buffer, upland ice ridge, below trail. About a 20' wide strip of it, under green ashes.	G	
146	5:79	Mowed buffer. Filling in with mullein. Right next to (3-5' from) trail. Big ice ridge extends all the way along shoreline here.	1	Control exotics and re-vegetate along buffer. Re-establishment of emergents will be a challenge due to ice ridge formation-consider installing some sort of root wad

Table 9. Priorities for the East Shore of Pleasant Lake

Figure 32. Ice ridge formation on open shoreline area.

Positive Notable Sites on the Shoreline of Pleasant Lake

Not all of the sites noted on our evaluation were problem areas. Some were noted for their beneficial or interesting features or practices. The following list and map discusses these points.

Figure 33. Sites of positive note.

Positive notable sites

Waypoint	Description	Priority	Recommendation
31	Point within 30-32. Sagittaria bay (narrow leaved arrow head with some sensitive fern on bank and Thalictrum spp.)	G	Although Sagittaria is a good native emergent macrophyte, it appears that it is not sufficient to stop undercutting of the bank (just planted?). Still need to revet and stake.
33	Good example of a solution that someone has implemented: large log (22-24" diameter) revetment that is wedged into the shore the long way. Behind it have been planted native emergent and transitional vegetation: blue flag, bottle brush sedge, tussock sedge, softstem/hardstem, prairie rose, chokeberry--hardly any Reed Canary Grass.	G	
45	Upland slope and limestone steps. Steps are good example of vegetated steps: low-mow turf, which fills in nice and thick. Upland slope has had buckthorn removed, which is good, but the stumps were not treated, so slope is continuing to slowly erode.	G	Nice to remove buckthorn, but no follow-up. Follow-up by replanting/seeding with natives in buckthorn's wake.
71	Nice wide, forested buffer (because homes are up higher on slope and thus the clearing for sight lines doesn't have to happen). What this whole side should be like, except for a huge buckthorn by shoreline.	G	
95	Model shoreline. Very vegetated. Cleared only a little around the deck. Trees left intact which gives structure. Shrubs are along the bank. Upland gardens, about 25' off the trail. Landscape trees and perennial beds on slope leading down to water. Quite refreshing to see. Weed wacking/mowing a little, but not to excess.	G	Photo 4:48
113	Nice attempt at buffer planting, but not good idea to plant annuals and beware of invasives. Perennial cultivars may be OK otherwise. Too much turf upland.	G	Public education campaign on what and what not to plant for the shoreland buffer. Add mulch or more plants to bed. Replace turf with prairie upland.

114	Large, wood-chip mulched garden at base of hill on upland side of trail. Used fabric with 3 inches of mulch. Mostly non-natives, but nice looking and effective at controlling stormwater. Better than turf. Note presence of landscaped rolling hills—adds visual interest, but not necessary for effective vegetative buffer.	G	Part of public education and outreach plan. Consider starting program to reward good stewards of the lakeshore.
145	Nice example of 3-square on buffer, upland ice ridge, below trail. About a 20' wide strip of it, under green ashes.	G	
149	Nice patch of 3-square. Some are pounded down by waves and flotsam. Sterile spurge on sandy ice ridge.	G	
150	Lots of Solomon's Seal on and just behind ice ridge, under green ash.	G	

Table 10. Positive notable sites

Figure 34. Model shoreline. Very vegetated. Cleared only a little around the deck. Trees left intact which gives structure. Shrubs are along the bank. Upland gardens, about 25' off the trail. Landscape trees and perennial beds on slope leading down to water (waypoint # 95).

Note: Steps are not allowed on NOHOA property. For steps leading to the lake on private property, adjacent to NOHOA property, permission is required from NOHOA and the Architectural Committee.

RECOMMENDATIONS

These recommendations are addressed primarily to the North Oaks Homeowner Association (NOHOA), but may also be heeded by private landowners that own property surrounding the lake, as well as any users of the lake and trail.

Planning

Planning out the process of lakeshore restoration is critical. A buffer of natural vegetation protects the shoreline from bank erosion and helps prevent sediment and nutrients (especially nitrogen and phosphorus) from washing into the lake. Nutrients trigger algal blooms that decrease water clarity. Plants growing in the water provide shelter for young fish, such as bass, sunfish, and yellow perch; without aquatic plants there will be fewer fish. Clearing shoreland vegetation during property development reduces food and cover for animals such as birds, turtles, frogs, and deer. Most owners want to add to the enjoyment of their property as they develop newly-acquired lakeshore, but instead diminish it by landscaping in a way that increases maintenance time and decreases lake quality. When you replace woods and meadows with turf and beach you not only diminish environmental quality but also increase the time spent mowing, raking, fertilizing, and controlling weeds

Lakeshore Categories

Depending on the category of the lakeshore, varying degrees of restoration intensity will follow.

- A *high bank, high energy* situation is the most challenging. It calls for onshore or offshore permanent wavebreaks, structural shoreline protection, and bank reshaping. Then to complete the project, install wattles, brush mattresses, willow staking, or posts, along with erosion control matting that is staked.
- *Low bank, high energy* situations generally require offshore wavebreaks, structural toe protection, bank reshaping, and rugged erosion control mats. Plantings of native plants should be installed into the mats.
- *High bank, low energy* situations will generally require temporary or permanent offshore wavebreaks and materials (coir Biologs, etc.) to control undercutting banks. If the bank can be reshaped to a 2:1 slope, or flatter, then do it. If not, then stabilize the toe as best as possible, and stabilize the high banks with plant mattresses, live stakes, or wattles. Another option is to use native prairie grasses
- *Low bank, low energy* situations are easiest to fix and require minimal bank reshaping followed by installation of erosion mats and native plantings. Wavebreaks may sometimes be needed.

Practices

Although most of the practices listed in the following section would be considered “innovative”, most of them have been used, in some form or other, for many years. As early as 1878 on the Upper Mississippi River, shoreline armoring was practiced. During the Four-and-One-Half-Foot Channel project, 1907-1927, (Fremling, 2005), engineers and construction companies used wing dams, closing dams, and shoreline fortification to maintain a deep, navigable channel from St. Paul to St. Louis. According to Fremling:

> “To prevent riverbanks from caving away, willow mats and rocks were used. The river bank was divided into three zones: the first was beneath the water surface extending from the lowest point of erosion up to the historic low water mark; the second from the low water mark up to a level where willows would grow; and the third from the latter point to the top of the bank. The lower zone was protected with a brush mattress weighted with rocks. Because rotting was prevented by constant inundation, the mats lasted indefinitely.

> In the second zone where rotting would occur, rock riprap was used. Willows were planted in the upper zone. Water rushing around the ends of the wing dams intensified erosion on the opposite shore. Consequently, the shore was usually fortified with mattresses and rock to keep it from being washed away."

After the 1930's, the use of vegetation gave way to rock and concrete, until about the 1990's when vegetation made a comeback (McComas, 2003). Today's practices usually involve the use of more numbers and more diversity of plants to anchor the soil of the shoreline and lake bank. Rock, still used to stabilize the toe of a bank where there are high flows, is usually used in combination with planting. Another term for this type of erosion control is "bio-engineering", which simply means the integration of biological organisms, aka plants, into stabilization designs/plans.

Generally, bioengineering follows this prescription (McComas, 2003):

1. Stabilize the toe of the bank (base of the bank under the waterline)
2. Reshape the unstable bank (above the waterline)
3. Remove some of the canopy to allow sunlight to reach the bank
4. Revegetate the buffer zone, both above and below the waterline (transitional and emergent vegetation zones). Install erosion control fabric with native plantings
5. Insert willow stakes for erosion control
6. Use wattles or live fascines (bundles of willow twigs, 6-8" in diameter and up to 6-8 feet long) staked on the contour with spacing of the rows 3-5 feet apart.

Stabilizing the Toe of the Bank

Stabilizing the toe of the bank can be done with structural protection, such as rip-rap, wire baskets filled with rocks ("gabions"), retaining walls, sea-walls, or bulkheads. Generally for Pleasant Lake, rip-rap would be recommended, since these other forms are not only unsightly but not needed. It is recommended that rip-rap only be used on high bank, high energy shorelines that do not have existing emergent vegetation strongly established. It is also recommended vegetating into the rip-rap while it is being placed, with live stakes.

Other softer protection methods for stabilizing the toe include using biologs and various forms of vegetation (see succeeding sections).

Bank Reshaping

Banks that are sheer, steep, or undercut should ideally be reshaped to a slope of 1:4 (rise :run) or flatter (see Figure 35). This is because the natural tendency of soils to reach their "angle of repose", which is simply the slope at which the slope becomes stable and does not slough off. Different soil types reach different angles of repose. Soils that are of homogeneous particle size will have more gradual angles than heterogeneous particle size soils. With a heterogeneous soil, smaller particles will fall into the openings created between larger particles, thus making the whole matrix pack tighter and allowing the slope to become steeper. Generally, though, it's best to maintain a slope of 1:4 or flatter, since wave action will tend not to erode as easy on a gradual slope. Also it is easier to establish vegetation on a gradual slope than a steeper slope.

The challenge at Pleasant Lake is that often times the eroding bank is right on top of the trail that surrounds the lake, which restricts the amount of bank re-shaping that is possible. First, it is recommended to reshape the bank as much as will be allowed by the site conditions and proximity to the trail. When conditions preclude a slope of 1:4 or flatter, there are no easy answers. One strategy is to strengthen toe and slope protection. Another strategy is to install revetment or wattles in the toe zone, which will accumulate sediment over time, thus allowing the

bank to reshape outward into the lake, upon which plantings can be installed later. One more strategy is to build steeper slopes using soft-armor wall or sediment pillows, which can be stacked and planted into. These strategies, however, may not work, depending on degree of ice heaves, the amount of wave action, and the success of emergent vegetation establishment. (NOTE: all proposed practices and design strategies for lakeshore restoration must be approved by permitting authorities—see section below entitled "Permitting Requirements".)

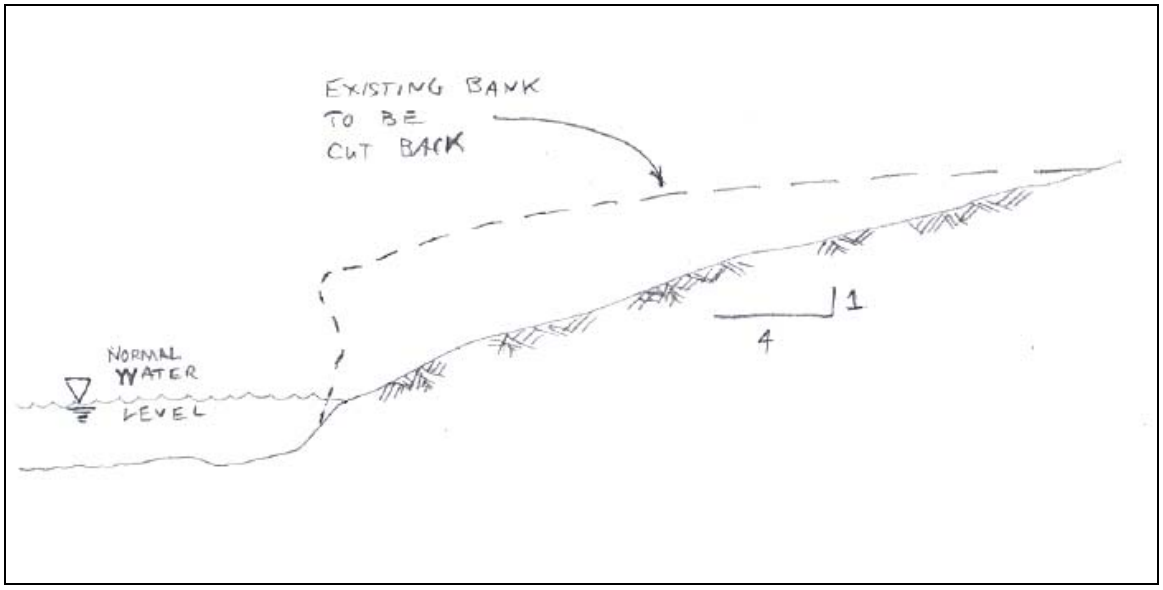


Figure 35. Generalized bank re-shaping.

Ice Ridges, or Ice "Jacking"

Ice ridges or "jacks" form as the result of expanding ice on the lake during the winter. Although a natural phenomenon, ice ridges can damage docks, retaining walls, and shoreline restorations. In most cases, ice ridges should be left alone, because they actually can reduce runoff to the lake by acting like a berm. To protect against ice ridge damage, follow these guidelines (McComas, 2003 and Blickenderfer, personal communication, 2005):

- Re-shape the bank to make a gradual slope that the ice will ride over and upon, so as not to rip out the restoration materials. If expanding ice meets a vertical face, it catch on it and push it—almost all structures loose this battle.
- Aerate the shallow lake zone (4 to 5 feet of water) to keep the ice open during the winter
- Install flexible shoreline protection, such as vegetation or rip-rap that can easily be repaired in the spring.

Black Willow: an Amazing Shoreline Protector

Many examples exist of black willow, *Salix nigra*, by virtue of its root system, protecting the toe of the shoreline of Pleasant Lake (see Figure 36 for a photo of tree's root wad). This species of tree has a tendency to grow right along the water's edge, and often leans out over the surface of the water. It has a peculiar characteristic of producing a long, root mass or "wad", which runs parallel to the intersection of the lake water and the shore—right along the toe. This root wad is easily identified, upon close examination, by its red color that comes from the many little red root hairs that make up the component structure of the wad (see Figure 37). Many examples were observed where these root wads extended many feet (up to 50 feet) out from the base of the tree. This quality makes black willow an ideal shoreline protector, and it is highly recommended for use in the restoration of Pleasant Lake Shoreline.

Figure 36. Black willow root wad at toe of shoreline.

Figure 37. Red root hairs of Black Willow root wad.

Willows have evolved the adaptive characteristic of being able to sprout from cuttings. Willow cuttings that are driven into shoreline banks are called *live stakes* (see Figure 38). Live stakes are one of the most cost effective shoreline stabilization practices available, which holds true for Pleasant Lake, since there is an abundant source of material all around the lake. Many feet of shoreline at Pleasant Lake could be cheaply stabilized by using live willow stakes. Over-use of any one species, though, is not a good thing, so a diversity of species is recommended. Other species also can be used for live staking including red dogwood, elderberry, chokeberry, high-bush cranberry, and sand bar willow.

Figure 38. Live willow stakes just after installation on a shoreline.

Emergent Plantings

Emergent plants, those that can root in the submerged lakebed and protrude or emerge above the surface of the water with leaves, stems, and fruits, are vital to the ecological health of the lakeshore (see Figure 39 and Figure 41). Emergent vegetation, in conjunction with submerged vegetation, like water lilies and pondweeds, acts to slow down or "baffle" waves as they pound on the shoreline. The denser and thicker the growth of emergent vegetation, the greater the baffling ability.

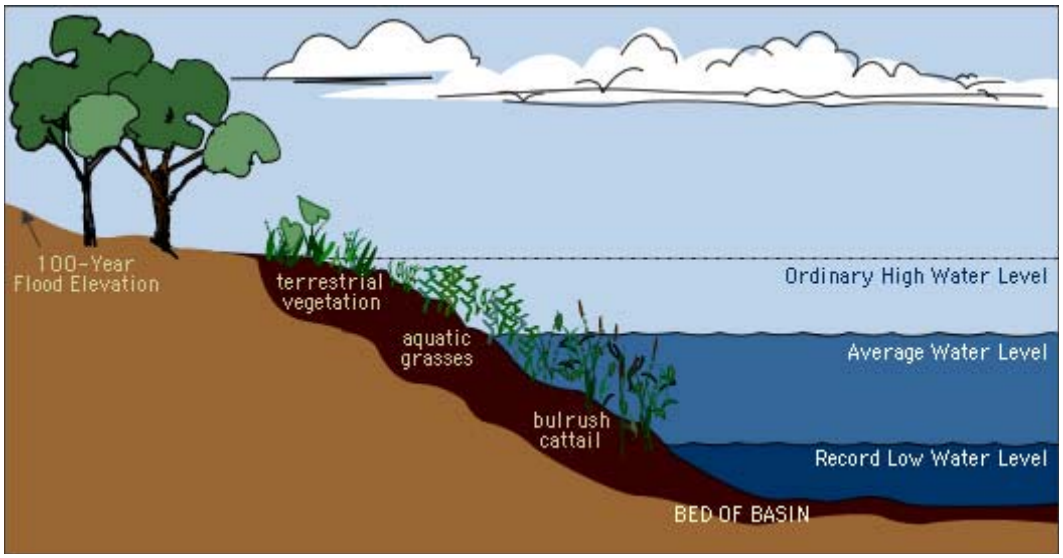


Figure 39. Cross-section of a typical lakeshore. (Minnesota Shoreland Management Resource Guide, http://www.shorelandmanagement.org/index.html All rights reserved.)

The deep root systems of native plants also act to hold onto soil particles in the shore and toe of the bank zones, preventing erosion of these areas. Introduced grasses have much shallower root systems than do most native plants (see Figure 40). Without plants, wave action will erode soil away from the bank area, causing undercutting and recession of the bank. When combined with the loss of transitional vegetation (vegetation that occupies the zone between the water and the upland) from the upland side of the bank, erosion is accelerated. Without vegetation to protect it, chunks of bank soil will fall into the lake and get washed away forever. Over time, the bank will slowly recede further and further inland. This is what has been happening in many locations along the shoreline of Pleasant Lake. To halt this process, it is imperative that emergent vegetation be re-established around the lake.

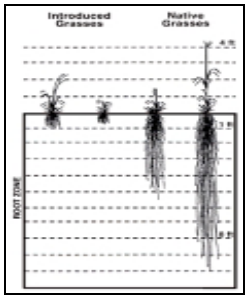


Figure 40. Grass root systems. (Minnesota Shoreland Management Resource Guide, http://www.shorelandmanagement.org/index.html All rights reserved.)

Often times emergent vegetation has been viewed by people as "weeds" that need to be gotten rid of. This attitude is probably the prime cause of the loss of emergent vegetation. In actuality, emergent vegetation not only helps beautify the shoreline, but also provides essential spawning beds for fish and other aquatic organisms. Much of the cause of decline in fish populations in fresh water lakes is due to the loss of emergent plants. Learning to appreciate the beauty and value of emergent plants is a very important part of a successful shoreline restoration program.

There is a general lack of emergent vegetation all around Pleasant Lake. Restoring this vegetation zone is a key goal in the restoration and stabilization of the shoreline here. Emergent plantings typically consist of the use of small or medium sized transplants: plugs or gallon-sized containers. Pre-vegetated mats can also be used for covering larger expanses of bare soil. Seed is not an option in the emergent zone since it gets readily washed away by inundating waters.

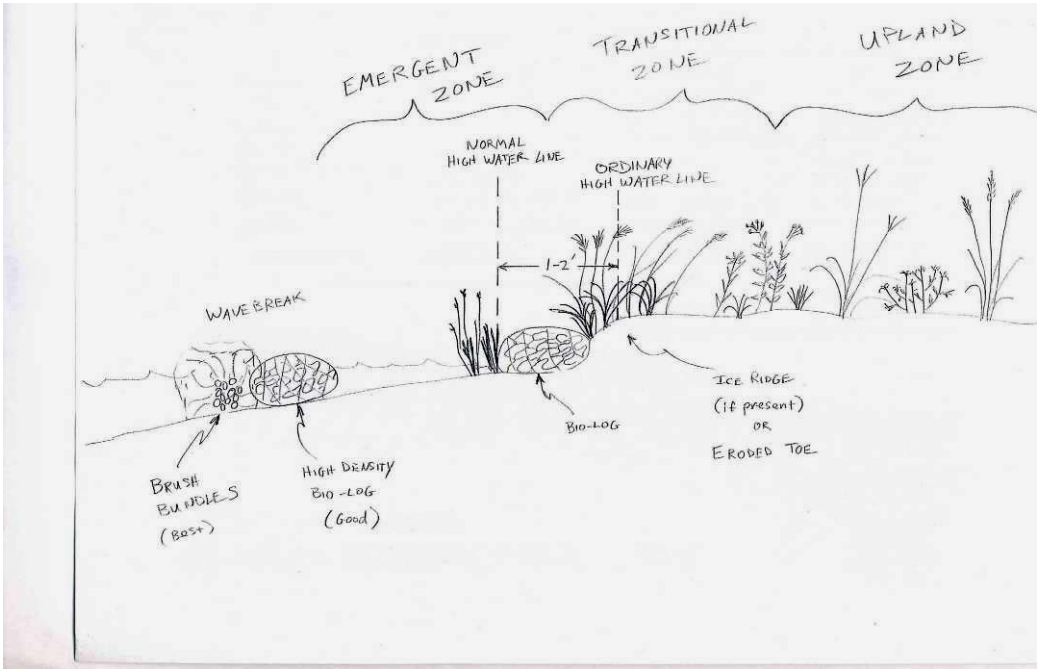


Figure 41. Typical shoreline restoration zones. (sketch by Joe Walton).

Typically, the approach restorationists have towards restoring the emergent zone is this: plant a variety of species at a more shallow depth, allowing for the plants to move into deeper waters over time, as they can. The easiest places to restore emergents are on long, shallow shores that are protected from wave action. The most difficult places are in deeper, steeper shores that are buffeted by waves. Interestingly, the restoration of the shoreline at Mary Hill Park (Kunde Company, 2003) proves that emergent plants can be established even on a difficult stretch of shoreline. Here, the shore drops relatively steeply into the water, providing little area for emergent plants to take root. Yet, even with these less-than-ideal conditions, many of the restoration sites from 2003 have successfully established some emergent plants (see Figures 42). In deep-water conditions, it is best to utilize taller species like hardstem bulrush. In shallower conditions, many species can be used, including river bulrush, giant bur reed, soft-stem bulrush, common 3-square, tussock sedge, lake sedge, broad-leaved arrowhead, blue flag iris, sweet flag, wool grass, manna grass, etc. See Appendix 3 for a listing of emergent plants

NOTE: Always install anti-browsing fence ("goose fence") on water side of planting to protect newly installed transplants from animal browsing.

Figure 42. Bulrushes established in deepwater shoreline at Mary Hill Park.

Transitional and Upland Plantings

Upland and transitional vegetation is also of key importance to the health of a shoreline. The upland, transitional, and emergent vegetation together make up what is called the *buffer zone* of a shoreline (see Figure 43). The larger the buffer zone, the more stable the shoreline will be. Studies have been conducted that show that a minimum of 30 feet of upland/transitional zone is needed for a buffer to be effective in slowing down and filtering out upland runoff, in essence *treating* runoff prior to it's entering the lake or stream (see *Case Study #6: Assessing Vegetated Buffers Using Synthetic Residential Runoff***,** contributing Author: S.M. Stai, Westwood Professional Services). Most total solids and phosphorous were reduced in the first 20 feet of buffer, but 30 feet is recommended. Less than at least 20 feet does not allow runoff to be slowed down and infiltrate into the soil/plant matrix. Runoff carries substances with it that can negatively affect water quality, like nitrates and phosphates from fertilizer and grass clippings, and pesticides and herbicides, and oils and sludge from surrounding street pavement.

Figure 43. Example of a working shoreland buffer. (Minnesota Shoreland Management Resource Guide, http://www.shorelandmanagement.org/index.html All rights reserved.)

There are many instances of insufficient lake buffers at Pleasant Lake. Oftentimes these are caused by poor management practices, for instance mowing turf right down to the waters edge (or very close to the edge) (see Figure 44), mowing large expanses of turf in the transitional and upland approaches to the buffer, excessive clearing of buffer vegetation for sight lines and lake access (Figure 45). Other times it appeared that woody invasive management had started, primarily buckthorn removal, but had not been completed, thus leaving patches of erosion-prone bare soil (Figure 46). These management practices need to stop and be changed into practices that promote a healthy shoreline and lake.

Figure 44. Mowing down to the water's edge: a poor lakeshore practice.

Figure 45. Excessive clearing of buffer vegetation and mowing turf to the water's edge.

Figure 46. Clearing of a steep slope without treating buckthorn stumps and without adequate re-vegetation.

Upland plantings, for shoreland projects, typically consist of shrubs and herbaceous plants, since trees tend to fall and rip out eroded banks (except for black willow). The cheapest way to plant shrubs are by using live stakes or by bare root in the spring. Shrubs can also be planted from container on gradual slopes or flat bank tops. Establishing herbaceous plants (grasses, sedges, wildflowers, and ferns) is done by seeding or planting small transplants or "plugs". Seeding is the cheapest, but is more difficult to get established because weed competition is greater and usually takes more maintenance effort. Planting plugs is more expensive up front, but usually requires less maintenance effort, especially when mulch is used with the planting. See Appendix 3 for a list of recommended transitional and upland plant species.

The planting of raingardens or the restoring of native forest, savanna, or prairie, in the upland zones that border the lakeshore buffer, will vastly improve water quality and reduce erosion of the shoreline. Increasing the "roughness coefficient" of the vegetative cover slows down runoff and infiltrates water. The increased evapotranspiration due to the increased leaf area of trees, shrubs, grasses, sedges, ferns, and wildflowers acts to reduce runoff also. In addition, native vegetation stores carbon in roots, shoots, and stems, thus helping to reduce greenhouse gases that ramp up climate change.

NOTE: Always install fence on upland side of planting to protect newly installed transplants from animal browsing and people traffic.

Biologs

Biologs are erosion control products that are designed to be used as part of shoreline stabilization projects and as perimeter control in construction projects. There are several different types of biologs available on the market. They are made from materials that will bio-degrade over various lengths of time, primarily coconut fiber and wood fiber. Coconut fiber biologs will last longer (3-7 years) than wood fiber biologs (1-2 years), and are more durable and rugged. Wood fiber logs are more flexible than coconut fiber logs, and can be conformed to very irregular shapes, which is sometimes advantageous. Both types are used in shoreline restoration projects. The most typical scenario is for a biolog is to be fitted into or shoved under the toe of an undercut bank or along the base of a scour line along the bank (see Figure 21). Biologs should generally not be used as wavebreaks. The only time they can be used as wavebreaks is in very shallow, gradual lakebeds, where water levels are not expected to rise above the top of the log. Biologs always need to be keyed into the bank (dug in place) and should be securely staked down. Always check the manufacturer's instructions for installation before using biologs (or any other erosion product). Once a biolog becomes saturated, plants can be installed directly into it. Take care not to cut the outer netting; plant between the criss-crossed netting. When used properly, and in combination with other techniques, biologs are very effective shoreline stabilizers.

Figure 47. Use of wood-fiber biologs for shoreline restoration.

Soft Armor Walls
Soft Armor Walls are products made to stabilize steep slopes. These products should be used when bank reshaping is not an option. Examples of this type of product are Enviro-Loc Systems and Versa-Loc Systems and Bio-D-Blocks. Enviro and Versa Loc Systems are composed of many sediment pillows that can build-up a bank, and can also be planted into. Bio-D-Blocks (Figure 48), a Rolanka product, is composed of coconut fiber, like biologs, except they are in the shape of a rectangle with two flaps on each end. They can be used in place of soil raps, and in fact are more durable and reliable than soil raps. Lakeshore vegetation can be planted in between and at the top of the Bio-D-Blocks, which over time anchor them in place and, as the product decomposes, the plant roots will be well established to protect the bank.

Figure 48. Use of Bio-D-Blocks at 16 Evergreen Road lakeshore site.

Rock Vanes
Rock vanes are designed to re-direct the flow of a stream to the middle of the stream, thus diverting the channel away from the banks. This is a very useful technique in streambank restoration, and can be used, for example, at the channel inlet from Charlie Lake, on the western side of Pleasant Lake. Proper installation and placement of rock vanes is the key to success. Heavy equipment is needed for rock vane installation, which must be taken into consideration when employing this technique. Access routes for the equipment need to be located and planned for. See Appendix 5 for a diagram of a typical rock vane.

Seeding and Erosion Control Blankets

Seeding eroded shorelines is a useful and cost effective way of re-establishing native plants (Figure 49). Usually it is necessary to use erosion control blankets to cover the seeded areas, or else the seed will wash away. There are several different types of erosion control blankets available. Depending on the site, blankets can be chosen for durability and decomposition rates. On sites that are subject to muskrat activity, highly durable blankets should be used. For most other sites, a blanket that decomposes in one or two year's time is recommended, since left over netting from un-decomposed material is unsightly and detrimental to wildlife movement. "Bio-blankets" or meshes made from natural fibers (hemp, cotton, etc.) are generally better than those made from plastic mesh. Even if they claim to be "bio-degradable", plastic meshes need ultraviolet light to break down, and oftentimes sites are so shaded that sunlight does not reach the ground level, and thus the plastic mesh remains intact for many years.

Figure 49. Use of erosion control blanket at Mary Hill Park, North Oaks, 2003.

Restricting or Discouraging Un-designated Lake Access

There were many cases of erosion problems stemming from paths worn into slopes from people trying to gain access to the lake. The erosion associated with these un-designated accesses is sometimes quite significant, and can lead to severe de-stabilization of the shoreline in localized areas. These "un-designated" lake accesses need to be restricted or discouraged. Planting dense masses or rows of shrubs and possibly some tall herbaceous plants at the head of the offending path will discourage use of the path. Alternately, by providing sufficient *designated access* strategically located throughout the lakeshore, disuse of un-designated access points will result. A good example of created access is at Phalen Lake in St. Paul, where access lanes were graded with a gradual slope and then large pieces of decorative limestone slabs were installed into the lane (see this website: http://www.rwmwd.org/index.asp?Type=B_BASIC&SEC={053585A8-052C-4B2A-B70D-EC784B4B062C}). "No-mow" turf can be seeded in between the rock slabs for erosion control. See the map in Figure 50 for proposed locations of designated access points at Pleasant Lake.

Figure 50. Proposed access points to the lake.

Wave Breaks

Brush Bundles: a Clever Use of On-Site Materials

The best wavebreaks for lakes are the natural, dense growths of emergent and floating-leaved vegetation. They act to dampen and baffle waves, not to completely stop wave action. But, since there is no emergent vegetation and the goal is to restore it, using materials that will mimic the natural wavebreaks in order to get newly emergent vegetation established is recommended. Wavebreaks must be installed or else the force of the waves will eventually wash out the plantings. The following is a list of potential wavebreaks:

- Jersey barriers make excellent wave breaks but are very difficult to move, need heavy equipment to be installed, eventually need to be removed, and are not very aesthetically pleasing.
- Rock berms can also be used as wavebreaks, but must be delivered and installed, which makes them more difficult, also.
- Fencing can be used in combination with a silt curtain, to dampen waves, but it must be removed afterwards, too.
- Coir Biologs can also be used for low energy situations, and they don't have to be removed because they will decompose over the course of 3 to 7 years. Coir logs were not designed to be used as wavebreaks, however, and should be used with caution—they can rip out and lose their stuffing, rendering them useless.
- Water dams (plastic tubes inside a woven fabric that are filled with water) can be used effectively for high energy situations, but are expensive and hard to find (McComas, 2003).
- Brush bundles are probably the best option (see Appendix 6) since they can be made from on-site materials, making them cost-effective and a good use of removed buckthorn and other brush! The brush eventually breaks down, leaving nothing to remove in succeeding years. Brush also forms a nice spawning area for fish and invertebrates.
- Drawdowns (either actively or passively allowing water levels to drop by 1 to 3 feet or more) will expose lake bottoms, allowing emergent plants to establish in a wave-free environment. Drawdowns may be a good option for Pleasant Lake, but must be done in dry spells and also must be coordinated with the St. Paul Water Utility.

Downed Trees

Downed trees, either ones that have fallen naturally or that have been removed on purpose, make excellent shoreline stabilizers. They can be used as wave breaks or jammed into the bank or shore-bed to help protect emergent vegetation. Among the many benefits of this technique are: 1) it's a good use of removed trees—no disposal necessary, 2) it looks natural, they serve as wildlife habitat (basking sites for turtles, spawning sites for fish, etc), and 3) they can be quite durable.

Tree Removal

Tree removal was sometimes recommended in this evaluation. However, the only times it is recommended are explicitly for purposes of erosion control, not for sight-line clearing purposes. There are several reasons for removing shoreline trees:

- Thinning overgrown shorelines allows more light penetration which is a requisite for establishing native forbs and graminoids (grasses and sedges) on the shoreline
- Native forbs and graminoids can hold bank soils better and longer than most trees
- Removing overgrown shorelines helps restore a more savanna-like structure, which existed pre-settlement
- Removing specific trees that are actually causing more potential problems than they are solving, can be advantageous. For instance, several examples exist of large cottonwoods that have exposed roots, are undercut, and are leaning or will be starting to lean soon

(Figure 51b). Removing such a tree before it falls and rips out the entire bank as it does so, will prevent a "blow-out" of the bank (Figure 51). Remember that only tops of trees are to be removed, not the roots. Root systems are to be left in place, thus promoting soil stabilization in the interim while other plants become established on the shoreline.

Figure 51. Cottonwood that has fallen causing a "blow out" of the bank.
(near foot-bridge on north shore of lake)

Figure 51b. Cottonwood succumbing to erosion and undercutting on shoreline.
Note that although some upland stabilization is being provided by the root system, little to no stabilization is occurring at the toe of the bank, where erosion is continuing unchecked.

Figure 52. Leaning tree that poses no concern. Leave it for fish habitat value.

Tree removal is not recommended if there is no plan to replant with native shrubs/forbs/graminoids, or if soil erosion will not result. In that case, leave the trees alone; they are doing more than if the site was allowed to convert to exotic invasive weeds. For example, many leaning trees shade the water of the shoreline, and offer good habitat for fish (Figure 52).

Another option might be to allow the trees to fall into the water, and then stabilize the area behind the fallen tree with live stakes, native plantings, etc. This is a good option if the tree falls in such a way so that it remains anchored to the shoreline by its roots. This may be difficult to determine while the tree is still leaning. The advantage is that no artificial anchoring need be done, thus saving time and resources.

Root Wads

Root wads are just large trees or logs that are submerged under the surface of the water, and jammed into the shoreline or bank. Root wads serve a dual function of wave breaks during the summer and ice blockers during the winter. They are recommended on shorelines that are subject to ice ridge formation during the winter (e.g. the east side of Pleasant Lake). Although effective, they are difficult and expensive to install. See Appendix 5 for a diagram of a typical root wad.

Brush Mattresses and Fascines

Brush can also be used to make “mattresses” by bundling many branches together and lashing or laying them down together on the surface of a slope or erosion-prone surface (Figure 53). Native transitional plants can be planted into the interstices of the criss-crossing branches, which gives much added stability to the system.

Fascines are bundles of branches made of either live or dead brushy material that are bundled and used as individual units for erosion control, usually on slopes or hillsides. Live fascines are made from willow cuttings or dogwood cuttings, or the like, and will sprout and form roots to hold onto soil.

Both brush mattresses and fascines are typically made from on site material, which is a great benefit and a good use of removed brush (like buckthorn and Tartarian honeysuckle).

Figure 53. Use of Brush Mattress at Silver Creek streamline restoration in Stillwater, MN.

Cedar Revetment

Revetment means "a facing used to support an embankment". Traditionally, this facing was made of masonry, but in the bio-engineering world it consists of natural materials from the local site, like trees, shrubs, branches, etc. The best natural material for shoreline restoration revetment made from whole red cedar trees, thus the term *cedar revetment* (Figure 54). Red cedars are a common invader of prairies and overgrown savannas, and need to be culled to promote prairie restoration. Because of this, they are often used for on-site erosion control projects. Red cedar needles have the quality of staying on the branch even after the tree has been removed, and therefore they make for excellent revetment material. The process of cedar revetment goes like this: 1) whole cedar trees are anchored in a line into the toe of an eroding bank, 2) the cedar line helps armor the bank, 3) water velocity is slowed down by the presence of the line of cedar trees because this material has a high roughness coefficient (due to all the branches and needles), 4) as water slows down, sediment drops out and accumulates into the cedar trees, and 5) over time sediment fills in the eroded bank toe, and plants will colonize the zone stabilizing the entire bank. Pleasant Lake has a surprising amount of red cedars surrounding it. These could be utilized in cedar revetment in areas of high energy situations on the shoreline.

Figure 54. Use of trees for revetment along toe of eroding slope on Vermillion River, Hastings, MN.

Combination of Practices

Although all of the practices mentioned above are excellent at stabilizing shorelines, using them in combination is even more effective. For instance, imagine a typical scenario from Pleasant Lake: a steep, eroding bank with a falling/tipping tree, and lots of buckthorn growing on the upland bank. You could do the following:

- first remove the tipping trees and anchor them into the shorebed for protection, then
- remove buckthorn and use the brush to make brush bundles and brush mattresses, then
- install the brush bundles as additional wavebreaks to help the tree logs, then
- plant emergent plugs behind the wave breaks, then
- install Bio-D-Blocks or cedar revetment at the toe, then
- install the brush mattresses on the steep bank, then
- plant into the mattresses with live stakes, bare root shrubs, and herbaceous plugs, and finally
- Seed the upland bank with a native seed mix of at least 25 species, using a bio-blanket product to protect the seeded area.

This is just one of many possible combinations of practices that can be used in a variety of situations to achieve similar results. See Figures 55 and 56 for more examples.

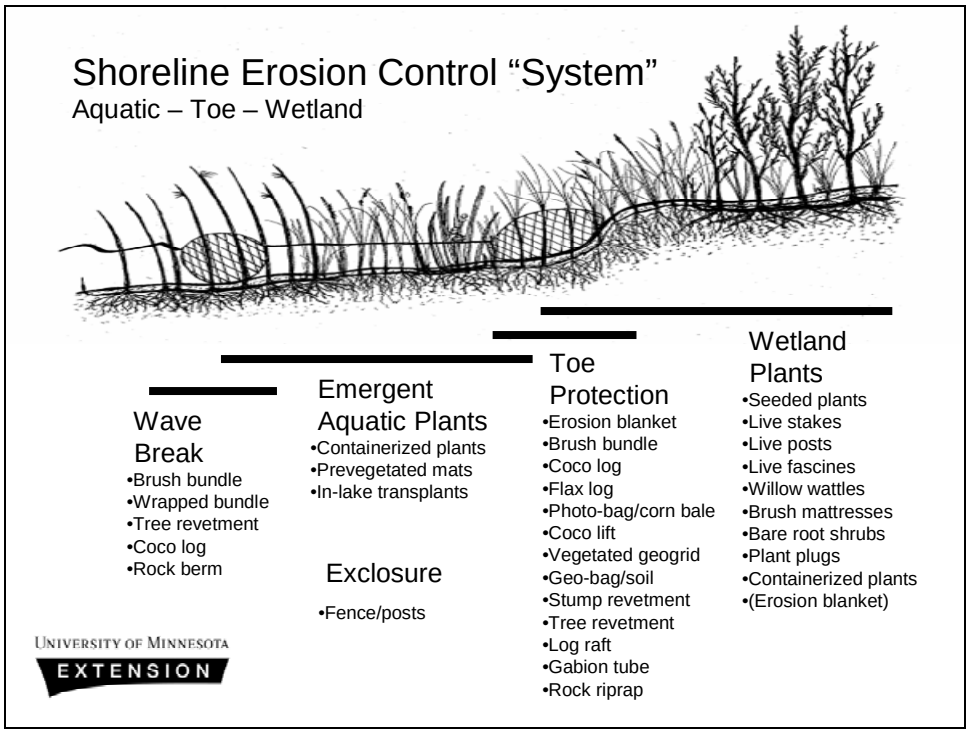


Figure 55. Bioengineering methods used in combination for shoreline stabilization. (Minnesota Shoreland Management Resource Guide, http://www.shorelandmanagement.org/index.html All rights reserved.)

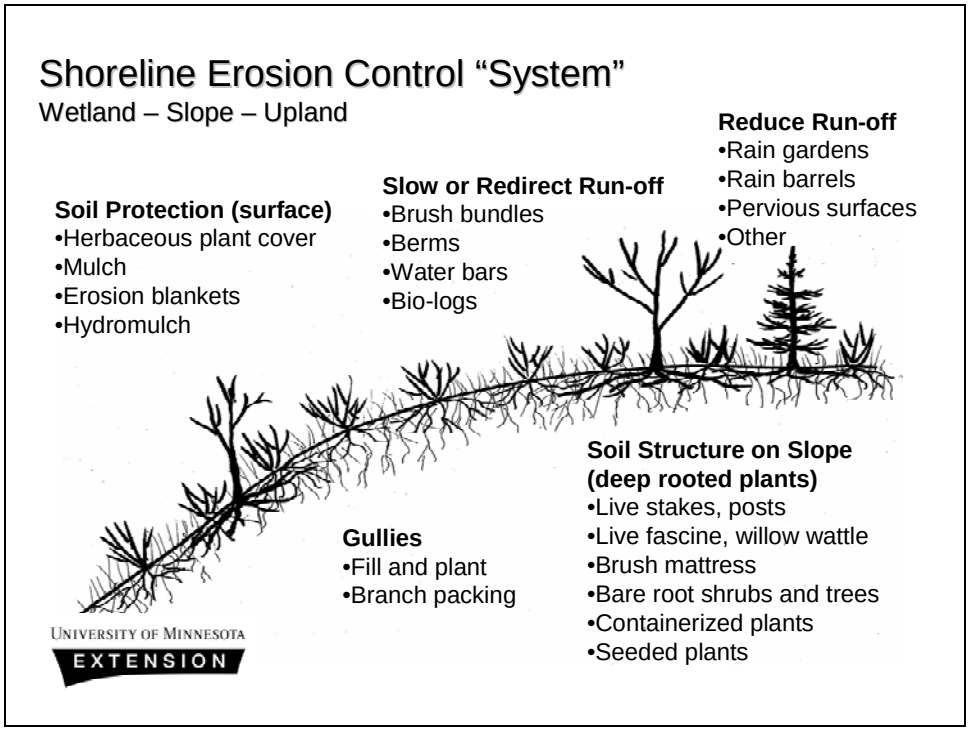


Figure 56. Bioengineering methods to be used in combination for erosion control of slope and upland. (Minnesota Shoreland Management Resource Guide, http://www.shorelandmanagement.org/index.html All rights reserved.)

Signage

With all restoration projects or stabilization sites, it is highly recommended that signage be posted describing the purpose of the project—why it is being done, what the goals are, and who are the partners involved. This informs and engages the public, and gives them a contact for their questions.

Use of Volunteers

Volunteers can be used to great effect on projects that require lots of labor-intensive work. Examples of good volunteer projects include buckthorn removal, brush hauling, brush bundling, and planting (Figure 57). For safety reasons, volunteers are generally allowed to use hand tools, but not motorized tools/equipment. They are not allowed to apply herbicides or be exposed to areas that have recently had herbicide applied.

Figure 57. Volunteers at a Great River Greening lakeshore restoration event in Forest Lake, MN, 2008.

Volunteers from the local neighborhood increase the success of projects because they are invested in the project since it is located by where they live. Studies have shown that if people "take ownership" of public plantings, the plantings are more likely to succeed. Great River Greening would be glad to organize a local volunteer group from North Oaks to work on projects on Pleasant Lake. One potential site is on the southwest shore at Waypoint #75. Here the shoreline is actively eroding up to trail, and the upland shore has buckthorn growing in high density. What could be done is the following:

- Organize a neighborhood volunteer group
- Volunteers work alongside the Great River Greening crew to cut buckthorn brush and to make brush mattresses and brush bundles
- Volunteers help Great River Greening crew install brush mattresses and bundles on eroding shoreline
- Volunteers help Great River Greening crew install native emergent and upland vegetation into the brush mattresses and along the shoreline buffer

This would not only help stabilize the shoreline and protect the trail, but it would build community at the same time.

Raising Awareness through Environmental Art

In addition to volunteer events, engaging artists in one or more of the Pleasant Lake projects will bring public appreciation to the effort as well as an innovative aesthetic piece to the conservation project. Great River Greening has experience in engaging artists in this way, and we would enjoy discussing with the North Oaks community such an opportunity.

BUDGETING, PERMITTING, AND MAINTENANCE ISSUES

Cost of Lakeshore Restoration

Lakeshore restoration can be as inexpensive as merely stopping mowing and allowing whatever vegetation currently exists on site to grow up, or as expensive as a major reconstruction of the shoreline with a variety of hardscape materials, plant materials, equipment costs, and intensive labor. Typically, costs range from as little as $4.00 per square foot of lakeshore, up to $10 per square foot. See Appendix 2 for a comprehensive list of estimated costs associated with lakeshore restoration in Minnesota.

Estimated Project Budgets*

There are eighteen sites identified as "Urgent Priority", comprising an approximate total of 1500 feet of shoreline. If all of this shoreline were to be restored and stabilized, the cost could range from approximately $39,000 to $90,000. If this were spread out over two years, then a budget of approximately $20,000 to $45,000 per year would be expected. If nothing is done to restore and stabilize these areas, the cost of road repair and trail repair would far outweigh the cost of bio-engineering of the shoreline. This estimate does not include the costs of any bridge or trail construction or reconstruction or the installation of rock vanes, which would be quite a bit extra.

There are 30 sites identified as "Priority 1", comprising an approximate total of 2,000 feet of shoreline. If all of these areas were restored and stabilized, the cost could range from $60,000 to $120,000 or more, depending on the degree of intensity. This cost could be spread out over the next five to ten years.

There are 43 sites identified as "Priority 2", comprising an approximate total of 2,000 feet of shoreline. If all of these areas were restored and stabilized, the cost could range from $50,000 to $80,000 or more (the cost is less because fewer costly materials are warranted). This cost could be spread out over the next ten to twenty years.

There are 15 sites identified as "Priority 3", comprising an approximate total of 1,000 feet of shoreline. If all of these areas were restored and stabilized, the cost could range up to as much as $20,000 or more (the cost is less because fewer costly materials are warranted). This cost could be spread out over the next ten to twenty years.

There are 5 proposed "designated access points" for the lake. Cost of installing these sites would range from $5,000 to $8,000 each.

NOTE: One cost conscious option would be to remove all of the buckthorn from the entire lakeshore buffer, replant with seed and some plugs, and then perform full-blown stabilization on just the worst problem sites (*Urgents* and a select *Priority 1*'s).

*All budget figures are estimates. Actual costs may exceed or fall-short-of these estimates.

Permitting Requirements

Be sure to comply with rules before starting on a plant control project. A permit is required if the area to be controlled is larger than 2500 square feet, extends more than 50 feet along the shore, or more than half of the shoreline length of your property, or if you intend to remove emergent or floating-leaf vegetation, or if you intend to use any herbicide or algaecide.

You do NOT need a permit if the area of submerged vegetation to be controlled is 2500 square feet or less, extends no more than 50 feet along the shoreline (or half of the property's shoreline length, whichever is less), if the submerged vegetation is cut or pulled, and if all the harvested plants are immediately removed from the lake or pond. A permit is not needed to maintain a 15-foot-wide boat channel connecting the lakeshore to open water thru floating-leaf vegetation.

Further information explaining permits is available in MN DNR's publication *A Guide to Aquatic Plants: Identification and Management.* If you are unsure of the identification of an aquatic plant, want information on the appropriate control measures, or if you need a permit, contact an aquatic plant management specialist at the MNDNR. The phone numbers are listed at the end of this publication.

Minnesota regulatory agencies usually do not allow any soil, gravel, or rocks ("fill") to be added to shorelines. Filling a shoreline would be considered "filling a wetland" which is prohibited by the Wetland Conservation Act (WCA). In some circumstances, a limited amount of fill is allowed, but it must be approved by permitting authorities. Wetland restoration projects that do not propose any soil filling or re-grading, and only propose removal of exotic vegetation and planting of native vegetation are most common. These types of projects still require a permit form the DNR, but are free of charge. Other projects require a permit from three agencies (US Army Corps of Engineers, MN DNR, and the local government unit (LGU), usually the Soil and Water Conservation District and/or the local Watershed District) and in addition require a fee, depending on the scope and size of the project. In the case of North Oaks, check with Ramsey Conservation District and Vadnais Lake Area Watershed Organization (VLAWMO).

For a list of contacts, see the section below entitled "Who to Contact".

Who to Contact

Great River Greening
- 35 W Water Street, Suite 201, St. Paul, MN 55107
- www.greatrivergreening.org

Minnesota Department of Natural Resources (MDNR)
- www.dnr.state.mn.us
- http://www.dnr.state.mn.us/lakes/index.html

Your County Soil and Water Conservation District (SWCD):
Ramsey Conservation District
- 1425 Paul Kirkwold Drive
  Highway 96 & Hamline Ave
  Arden Hills, MN 55112
- 651.266.7270
- http://www.co.ramsey.mn.us/cd/index.htm
- www.mn.nrcs.usda.gov/partners/maswcd/maswcd.html

Natural Resources Conservation Service (NRCS)

- www.mn.us.usda.gov

US Army Corps of Engineers, St. Paul District

- http://www.mvp.usace.army.mil/

Your local watershed district:
Vadnais Lake Area Watershed Management Organization (VLAWMO)

- http://www.vlawmo.org/
- 800 East Co. Rd E
  Vadnais Hts, MN 55127
- 651-204-6070

Your county, city, or township Planning and Zoning:
City of North Oaks, MN

- 100 Village Center Dr
  Suite 150
  North Oaks, MN 55127
- 651-792-7750
- http://www.cityofnorth-oaks.com/

Maintenance and Long Term Management

A shoreland restored with native vegetation should maintain itself. Re-apply mulch to new planting beds (to prevent soil erosion, hold moisture in the soil, and control weeds). Water and weed the first season, but once the plants are established, they will be able to out-compete most weeds. Native species should never be fertilized because they are adapted to the nutrient levels found in local soils. Fertilizers and pesticides applied to areas near shore can be a threat to aquatic life and water quality—they result in an overabundance of algae. Upland and transitional plants left standing in fall and winter provide seeds and shelter for wildlife, add interest to the winter landscape, and protect the soil from wind erosion. If some plants do not survive the first year, replant as quickly as possible to maintain a continuous vegetative cover. As your shoreland buffer grows, you may want to trim some tree branches or shrubs to keep your view of the lake clear. *Shoreland Editing* gives you a view while maintaining the benefits of a natural shoreline. This is especially important for the residences adjacent to the NOHOA land surrounding the lake, and also to abide by the City of North Oaks' Shoreland Ordinance (refer to this website for the ordinance: http://www.cityofnorth-oaks.com/index.asp?Type=B_LIST&SEC={EA082EB1-5FE5-43A3-A6FF-28F4DA7F8E38}). You can change a natural wooded lot to improve lake access and lakeshore views from homes without removing all natural vegetation (Figure xx). Keeping cleared areas for docks and beaches to a minimum allows you to leave some aquatic vegetation to provide critical shoreline protection. Selectively removing branches, shrubs, and even trees to create desired lake views can minimize shoreland impacts.

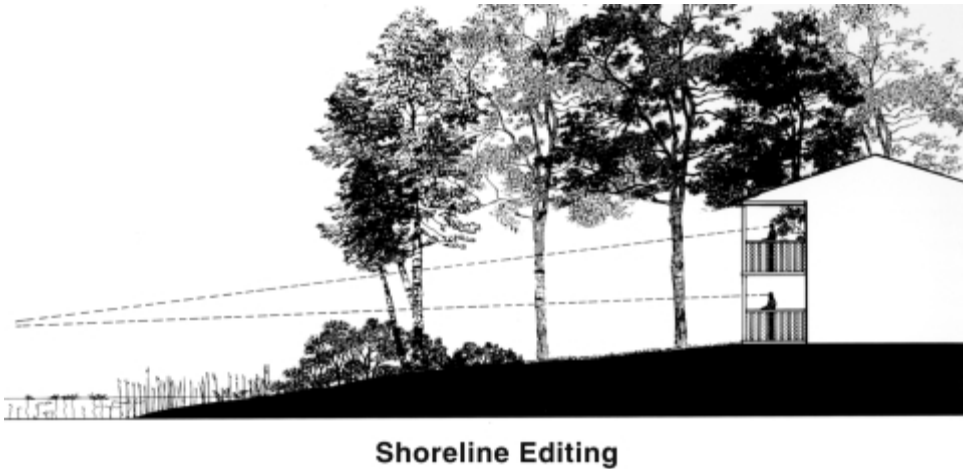


Figure 58. Example of Shoreline Editing. (U of MN Extension Service, All rights reserved)

According to the U of MN Extension Service, Shoreland Editing is:

> "A step-by-step process dictated by your own needs and tastes. Effective editing is done over several seasons using this basic approach. First you create a map of the buildings, vegetation and other features of your property. Next you determine where to put the paths, beach, dock, and boat storage, and make these alterations removing as little vegetation as possible. After assessing views from all windows and doors in the home as well as from the lake to the home, you decide which trees, shrubs, and branches need to be removed to improve the views and tag them. You can work with an arborist or other competent including aquatic (in water) and upland tree trimmer to remove the tagged vegetation. Wait at least a month before deciding whether additional editing is necessary. "

Oak Savanna Maintenance

Over time, without periodic fires or other artificial management techniques, the upland landscape will revert to an over-grown woodland condition. To avoid this situation, maintain uplands and transitional zones that border shoreline buffers so that they retain a more open or savanna-like state. Remove small invading brush and small trees and conduct prescribed burns periodically, or in lieu of burning, conduct periodic mowings and rakings of thatch. Protect small oaks from fire or mowing damage. Control invasive plants by spot treatment and hand pulling, as necessary. Provide access lanes (ten feet wide) for future oak wilt control, since that is a problem in North Oaks. Eventually, following these guidelines, the composition and structure of the beautiful oak savanna should return.

Cost Share

Many agencies have cost share money available for lakeshore restoration projects. Check with your local SWCD office (Ramsey Conservation District), watershed management office (VLAWMO), NRCS office, and DNR for more information.

NOHOA or the City of North Oaks may want to look into setting up a new cost share program for residents interested in improving their lakeshores, in terms of increasing water quality, reducing erosion, and increasing wildlife habitat value. State cost share money is available through Board of Soil and Water Resources (BWSR), who distribute them to local conservation districts and watershed districts. For more information on the BWSR program, see the following website: http://www.bwsr.state.mn.us/grantscostshare/nrbg/shorelandmanagement.html

REFERENCES

Fink, David, 1994. *A Guide to Aquatic Plants: Identification & Management.* MN DNR

Packard, Stephen and Cornelia F. Mutel (editors), 1997. *The Tallgrass Restoration Handbook, for Prairies, Savannas, and Woodlands.* Society for Ecological Restoration, Island Press, Washington DC

McComas, Steve, 2003. *Lake and Pond Management Guidebook.* CRC Press, LLC, Boca Raton, FL

Fremling, Calvin R., 2005. *Immortal River: The Upper Mississippi in Ancient and Modern Times.* The University of Wisconsin Press, Madison, WI

USDA Plant Database. http://plants.usda.gov/index.html

University of Minnesota Extension Service. http://www.extension.umn.edu/distribution/horticulture/DG6955.html

University of Minnesota Extension Service. http://www.shorelandmanagement.org/index.html

Rolanka Coconut Products. http://www.rolanka.com/index.asp?pg=welcome

US Department of Agriculture, National Resources Conservation Service, Web Soil Survey, http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Shaw, Daniel and Rusty Schmidt, 2003. *Plants for Stormwater Design: Species Selection for the Upper Midwest.* Minnesota Pollution Control Agency, St. Paul, MN

Boyle, John B. and Evelyn W. Moyle, 2001 (second edition). *Northland Wildflowers: the Comprehensive Guide to the Minnesota Region.* University of Minnesota Press, Minneapolis, MN

Hipp, Andrew L., 2008. *Field Guide to Wisconsin Sedges: an Introduction to the Genus Carex (Cyperaceae).* The University of Wisconsin Press, Madison, WI

Fuge, Ellen (editor), 2000. *Going Native: A Prairie Restoration Handbook for Minnesota Landowners.* Minnesota DNR, Section of Ecological Services, Scientific and Natural Areas Program, St. Paul, MN

U.S. Department of the Interior, Bureau of Land Management (BLM). National Atlas website (http://nationalatlas.gov/articles/boundaries/a_plss.html)

GIS On-Line Mapping. http://www.co.ramsey.mn.us/prr/index.htm

City of North Oaks website. (http://www.cityofnorth-oaks.com/index.asp?Type=B_BASIC&SEC={D365D666-395F-4DB4-BCD8-8FF860B71DEA}&DE=)

Stai, S.M., 2006. Case Study #6: Assessing Vegetated Buffers Using Synthetic Residential Runoff, Westwood Professional Services, (sarah.stai@westwoodps.com)

APPENDICES

APPENDIX 1: FIELD NOTES FROM GREAT RIVER GREENING'S EVALUATION

(In their entirety)

			Pleasant Lakeshore Evaluation	U = Urgent		
				1 = high		
				2 = medium		
				3 = low		
Way Point #	**Corrected Way points**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**
Day 1, Thursday, June 11, 2009						
1	1	1:49	Erosion from walking to lake from road	U	Trees or shrubs; dogwood live stakes/Amorpha planting; black willow tree planting. Sandwiched between willows and basswood-southwest maybe to west of the area	
2	2	1:49	Yellow gas/bench. 10' wide area of eroding, sloughing bank.	U	Planting trees, shrubs, live stakes.	
3	3	1:49	Lake access; 1st break area; 3' wide buffer to Island Road. High Priority! Not much time before road starts to undermine. Must do something now to head this situation off.	U	Trees or shrubs; dogwood live stakes/Amorpha planting; black willow tree planting. Sandwiched between willows and basswood-southwest maybe to west of the area	
4	4	1:33	Purple loosestrife coming in. 100 ' of shoreline bare with no vegetation.	1		
5	5	1:42-43, 50-51	Mowing to water's edge; no native vegetation in the buffer zone	1	Replant buffer zone with native shrubs and herbaceous plants. Live stakes at toe.	
Way Point #	**Corrected Way points**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**

6	6	1:27, 47, 55-56	Extension of problem area from #5. Steep bank (3' high).	1	Cut ash and basswood. Use cut tops to stabilize shoreline. Plant shoreline with dogwood and willow (black and sandbar). Use biologs if possible.	
7	7	1:28	End of problem area (cottonwood)	1		
8	8	1:27	Small area of erosion due to unauthorized access to the lake (foot path)	2	Plant shrubs to screen and block access. Re-plant in buffer with herbaceous plants or shrubs or live stakes or seed with blanket.	
9	9	1:21, 24-26	Bridge: erosion on both sides of bridge. Rip-rap added into gully/washout to stop erosion here. Fallen cottonwood on north side of bridge.	1	Wait until bridge is rebuilt. Then remove ash trees and replant with native shrubs, plugs, and/or seed in transitional and upland zones, and with live stakes along toe. Use removed trees and biologs and blanket with plantings/seeding.	
10	10	1:23-23	Erosion behind willow. Unauthorized lake access problem.	2	Replant in buffer zone.	
11	11		Erosion area (10' wide). Shady.		Remove cedar, ash, buckthorn (buckthorn); replant with natives and stakes	
12	12		Erosion by oak tree.	2	Hazelnut/Penn sedge planting. Remove basswood and ash trees.	
13	13	1:13-16	Erosion by old broken down stairs. Exposed sandy shore.	1	Remove stairs; restore shoreline at stair area and east of it 15' or so. Use Calamagrostis, Amorpha, etc.	
Way Point #	**Corrected Way points**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**
14	14	1:20	Falling tree at shoreline.	2	Remove tree. Replant with black willow, Amorpha. Use coir log too.	
15	15	1:19-20	Erosion at shoreline with falling tree	2	Remove tree. Replant with black willow, Amorpha. Use coir log too.	

16	16	1:16	Erosion problem at stairs.	2	Remove stairs and replant with shrubs and black willow.	
Day 2: Thursday, June 18, 2009						
17	17	2:1-6	Cattails in bay. Shoreline encroaching on trail. Starts at big cottonwood and goes until the tip of the peninsula where the homeowner is mowing and clearing on both sides of trail. About 4 canoe lengths.	2	Remove about 6 leaning trees (ash, silver maple). Revet with cut trees along shore line.	
18	18		end			
19	19		Beginning of 17			
20	20		End of 18			
21	21	2:7-8, 12	Narrow buffer to trail.	1	Remove some trees--selective clearing. Re-vegetate with herbaceous plants and shrubs (red-osier is present here).	
22	22		end			
23	23	2:09	New lot site. Steep upland slope on other side of trail.	2	Re-vegetate with seed/plugs/shrubs. Continue to work on the upland slope. Re-vegetate bare spots, which is about 25% of the slope. Shoreline is OK for now, but will suffer if upland is not corrected.	
Way Point #	**Corrected Way points**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**
24	24		end			
25	25	2:13	3 or 4 leaning ash trees.	2	Remove trees and live stake.	
26	26		end			
27	27	2:17	Undercutting at toe on 10 feet either side of this point. 1 dead buckthorn. Closely encroaching on trail.	1	Add boulders and hardstem plus live stakes.	
28	28	2:18, 23-26	Undercutting at toe. Closely encroaching on trail. Signs of erosion/bare soil. Sparsely vegetated buffer and upland slopes with much buckthorn...	U	Remove 10 to 20 trees (some ash, red oaks, basswood). Live stake. Revet with removed trees. Plant emergent plugs (iris, river bulrush, hardstem/softstem, 3-	

					square) with wave breaks. Also plant transitional vegetation on narrow buffer. Plant upland slopes after removing buckthorn.	
29	29		end			
30	30		More of same from #28-29.	1		
31	31	2:36	Point within 30-32. Sagittaria bay (narrow leaved arrow head with some sensitive fern on bank and Thalictrum spp.)	G	Although Sagittaria is a good native emergent macrophyte, it appears that it is not sufficient to stop undercutting of the bank (just planted?). Still need to revet and stake.	
32	32		end			
33	33	2:19, 48	Good example of a solution that someone has implemented: large log (22-24" diameter) revetment that is wedged into the shore the long way. Behind it have been planted native emergent and transitional vegetation: blue flag, bottle brush sedge, tussock sedge, softstem/hardstem, prairie rose, chokeberry--hardly any reed canary grass.	G		
Way Point #	**Corrected Way points**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**
34	34	2:49	Active erosion, with bank sloughing. Steep too and touching trail.	U	Install Soft armor wall system and re-vegetate with wave breaks, etc.	
35	35		end			
36	36	2:68	Removed lake edge/marsh. Not urgent. The problem is that it can induce muskrat damage and weakening of organic soil due to tunneling of soil at shoreline	3	Allow vegetation to regrow.	
37	37	2:69, 72-73	Isolated undercut caused by silver maple tree; but a good wide buffer up to trail. In this case it is adding habitat for fish (shelf).	3	Allow tree to fall for fish habitat. Monitor for erosion.	
38	38	2:74	Dead/dying green ash. Fetch distance is large here, so waves are stronger.	3	Remove tree and use to armor shoreline.	
39	39	2:75-77	Actively eroding--bare soil sloughing--no cover--mow to edge of water. Shore bed is far less rocky and shallow/gradual than before.	1	Use erosion product to build it back up	
40	40		end			

	40a	2:75-77	Where mucky soil gives way to rocky, mineral soil, is the example of emergent vegetation holding shoreline. One side of dock was removed just upland buffer and emergent vegetation is intact, but shoreline has not receded. The other side of dock was removed both upland and shoreline vegetation of buffer, and shoreline has receded a lot and is actively eroding now. GREAT EXAMPLE.	1	Stabilize shore on north side of dock with emergent veg.	
Way Point #	**Corrected Way points**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**
41	41	2:15	Point of island: cleared for view. Now all turf by sitting bench.	2	Should have more 3-square bulrush and transitional vegetation.	Island Trail. Upland vegetation: suspect formerly much more open canopy. Maybe savanna-like. Allow mesic oak woodland in southeast-facing side.
42	42		end			
43	43		Hardstem bay.	2	Needs biolog or compost socks and plant into that.	
44	44	2:79	Large boulder, without associated vegetation: not working to stop erosion on shoreline	2	Plant vegetation around boulder	
45	45	2:20-21, 80	Upland slope and limestone steps. Steps are good example of vegetated steps: low-mow turf, which fills in nice and thick. Upland slope has had buckthorn removed, which is good, but the stumps were not treated, so slope is continuing to slowly erode.	G	Nice to remove buckthorn, but no follow-up. Follow-up by replanting/seeding with natives in buckthorn's wake.	
46	46		end			
47	47	2:83	Active erosion very close to trail.			
48	48	2:85	Point on the peninsula. Shallow limnetic zone. Good possibility of restoring emergents.	2	Restore emergent vegetation.	
49	49	2:50	Steep upland slope (60 degrees) with bare soil. Has been cleared.	2	Re-vegetate slope.	
Way Point #	**Corrected Waypoints**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**

50	50		Some newly installed plants			
51	51	2:52	Some newly installed plants, and end of 49-51.			
52	52	2:88, 53-55, 91-93	New house. Steep slope (50 degrees). Buckthorn was removed, but no follow-up. Slope is eroding with bare soil on slope.	2	Stump-treat buckthorn and replant with natives.	
53	53		end			
Day 3: Thursday, June 25						
54	54		Drain pipes on shoreline. Stormwater actively draining into lake. Fallen (oak) tree on shoreline--should leave this--good example for rest of shoreline. South of dock, shoreline is eroding/bare soil/total lack of emergent vegetation	1	Stabilize drain pipe inlet area. Restore shoreline south of dock.	Nanny-berry, spatter dock.
55	55		end			
56	56	2:3-4, 63-64	From trail side. A combination of factors contributes/results in destabilization of the shoreline. Upland side of trail is a large mowed field. Drain pipes causing erosion. No emergent veg. Clearing for dock.	1	Reduce mowed turf on upland side of trail. Stabilize drain pipe outlets. Plant emergent veg. and transitional vegetation, especially around dock area.	
57	57	3:6	About 100 feet north of dock at Charlie Lake outlet. Big white oak--not tipping--roots exposed on toe; undercutting; bare soil; steep, 5' bank. Nearby patch of river bulrush, hard/soft stem	3	Monitor for tree falling.	
58	58	3:7-9	Bridge/dock to Charlie Lake. Boat Launch-ramp made of blacktop. We saw Water Dept launch a motorboat (6-25-09). No sediment build-up. Not much erosion--a little at corners of launch. South side of launch slightly concave shoreline.	2	Recommend emergent vegetation planting.	
Way Point #	**Corrected Waypoints**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**
	58b		Boat launch clearing area. Graded flat and somewhat toward pond, but not too much, so not much direct runoff to lake—good. Large mowed area—not sure why.	3	Stop mowing. To set a good example for rest of community, recommend replace with low-mow turf, if that look is desired, otherwise it would be	Lots of poison ivy on bank.

					best to restore the area with prairie/wet prairie.	
	58c		Bridge at Charlie Lack inlet to Pleasant Lake. Steep bank sides that are eroding slowly. Footing of bridge may be undermined at some time in future--not super urgent, but should be addressed.	1	Use rock vanes to redirect channel. Armor the point and plant between the hard armoring. There is a good shallow "bench" to plant emergents at the point. Re-grade where necessary.	Sand bar willow exists on north side of bank. Saw root wads at toe, but not as massive as black willow root wads.
59	59	3:10	Point near sitting bench at south side of bridge. High priority area! Bad erosion; active sloughing; unauthorized access to water.	U	Stabilize with products and veg. Use vegetation to screen/discourage access. There is a nice shallow lake bed at this corner of shoreline--can us it to establish emergent veg. Tory drew this spot.	
60	60	3:14-16	Two, 15-20' long places to create a screen/vegetation buffer to discourage access to water. Steep slope--sandy/rocky--some undercutting; lots of exposed tree roots--some bare soil.	2	Screens and toe stabilization.	
61	61		end and beginning of next one			
Way Point #	**Corrected Waypoints**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**
62	62	3:17-18	Steep upland slope stabilization on bank. Towards 62 gets gradually lower.	2		
63	63		Willow for harvesting			Carex scoparia
64	64	3:19-21	End of "Blue Water Lagoon". Erosion; some bare soil; foot access issue. Shallow, rocky.	3	Discourage access: plant/stake dogwood/elderberry.	
65	65	3:25-26	Foot access from sitting bench and vegetation clearing. Led to some erosion.	2	Live stake with dogwood/elderberry. If it gets too tall, would this be a problem?	Docks have some erosion on their corners. Perhaps set up a cost share program for people to be able to purchase from a list of showy

						plants to "beautify" their dock areas/shorelines.
66	66		Entire southern shoreline, east and west of this point: medium slopes; good vegetation buffer; 10-20' from-trail; not a lot of erosion, but fairly steep, but not high bank (2-3'). Rocky-lined toe, with mostly green ash, some basswood, and a few oaks (whites and pins) and a few silver maple and cottonwood. Lots of buckthorn. Naturally wooded--lots of deadwood along shoreline. Lack of emergent vegetation on this whole side, but lower priority.	2	Remove buckthorn and use it for brush bundles/mattresses where needed anywhere on lakeshore. Establish emergent vegetation and some live willow stakes.	
67	67		??????????			
68	68	3:65	Over-clearing of upland slope for retaining wall and steps. Blue Water Lagoon: eroded area on shoreline: due to overflow from wetland channel/flowage. Culvert may help trail, but would not be good for lake water quality.	3	Plant vegetation around steps. Deal with flowage across trail: create a drained causeway?	Large bur oaks just up from shoreline: evidence of a more "open" past.
Way Point #	**Corrected Waypoints**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**
69	69	3:66	By broken top branch. Clean cut over cleared slope.			
70	70		Large expanse of turf.	2	Recommend prairie restoration or rain gardens	
71	71		Nice wide, forested buffer (because homes are up higher on slope and thus the clearing for sight lines doesn't have to happen). What this whole side should be like, except for a big buckthorn by shoreline.	G		
72	72		Shoreline very close to trail.	1	Buckthorn mattresses/bundles installed in bad spot along trail, and live stake to armor toe.	
73	73		Lakeshore incision and close to trail (7' from trail)	1	Buckthorn mattresses/bundles	Tall meadow rue, zigzag

					installed in bad spot along trail, and live stake to armor toe.	goldenrod.
74	74		Over-clearing of upland slope. Turfed to trail. Steep/sheer, 5' bank with bare soil and erosion/incision	1	Stop mowing to trail. Plant native vegetation to replace turf to trail. Buckthorn mattresses/bundles installed in bad spot along trail, and live stake to armor toe.	Aralia nudicaulis, a butter cup.
75	75		High priority! 100 feet both sides of this point. 4-5' steep/sheer bank, very close to trail (1-3'). Incision and slow erosion occurring.	U	Black willow/elderberry/high bush cranberry live stakes in patches every 50-70'. Live stake through mattresses with black willow and dogwood. REC: volunteer event that will help our crew cut buckthorn and make brush bundles/mattresses. Crew will key then into the toe.	
Way Point #	**Corrected Waypoints**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**
76	76		Large cottonwood on shoreline, with roots being exposed. If it goes, the whole bank rips out and part of the trail. The tree looks sparse in the crown--may be stressed.	1	Remove tree.	Nearby "watercourse" that goes down through turfed upland slope--they installed an infiltration trench at base to help with runoff, which is good, but it would have been better to vegetate the trench.
77	77					
78	78					
79	79					
80	80					
81	81					
82	82					
Day 4: Thursday,						

July 9						
83	84		Shoreline vegetation has been removed, causing bare soil exposed.	2	Re-vegetate the spot.	The southwestern shoreline, in general, is forested to the edge, with not much willow. Existing vegetation is: cottonwood, ash, silver maple, basswood, red oak, Viburnum lantana (Mohican viburnum), lots of buckthorn, gooseberry, red osier dogwood, etc. Cottonwoods have exposed roots, generally. Very rocky toe and limnetic zone near bank. Saw anemone cylindrica (thimble weed).
84	85		end			
Way Point #	**Corrected Waypoints**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**
85	86	4:1	Some soil exposed just up from the toe. Some undercutting. About a 1' drop. Lots of buckthorn. Also, lots of sumac on this side of lake	2	Upland is vegetated, but to stop erosion, need some armoring of toe/emergent zone.	
86	87	4:2-12	16 Evergreen Resto. Biologs: most didn't stay put--they worked their way inland--2nd side of logs were not staked Bio-D-blocks are doing great These species survived and are doing well in spots: bottlebrush sedge, river bulrush, hardstem/softstem bulrush, Glyceria grass, iris. Overall it's working. The shoreline seems to be getting stabilized. Plants in between the bio-	1	Re-stake biologs and build-up on a couple of them. Try to establish more emergent vegetation that will spread outward into "bay". Try planting some 3-square. The middle of the restoration shoreline needs wave	

			d-blocks did best.		breaks. Try planting into the Bio-D-block on the north end of the restoration shoreline. Need to weed the transitional and upland bank. Sow thistle, pepper grass, toad flax, hoary alyssum.	
87	88	4:13-17	High priority. 3 lots in a row that are mowing right up to the water. This stretch is encroaching on trail: north side is about 15-20' away from trail and south side is 1-2' from trail and actively eroding.	U	3' steep bank needs to be hand re-graded (no biologs on top of river bulrush), or fit small logs into crevasses and install fabric w seed/plugs on bank and/or with live stakes or shrubs. South end has quite a bit of river bulrush, but could be supplemented. Stop mowing to edge. Replant transitional zone.	
88	89		end			
Way Point #	**Corrected Waypoints**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**
89	90	4:18-29	High priority. No vegetation: mowing to edge of bank. 2-3' sheer bank, 2-3' from trail. Lots of undercutting, active erosion, sloughing, especially on north end.	U	Same as 87-88.	
90	91		end			
Way Point #	**Corrected Waypoints**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**
91	92	4:34-43, 5:16-16	3/4 of the length is a great raingarden on the upland side of the trail. However, the shoreline is being mowed right up to the bank and is still actively eroding. No emergent vegetation on shoreline. (Seems to be a disconnect between raingarden and shoreline.)	1	Stop mowing up to bank. Needs biologs, live stakes, plugs, erosion control blanket, seed, etc. Re-establish emergent vegetation.	

92	93		end			Shoreline along trail to Pump house is good. No clearing of vegetation between trail and water. Not too steep. Many black willows lining shore. Not really any erosion present.
93	94	4:44-45	Boat launch at Pump house. Generally OK. Asphalt is uneven. Luckily, existing black willow is protecting the shoreline from eroding; otherwise it would probably be much worse.	3	Consider reconstructing ramp to concrete slabs--like new launch on Big Marine in Washington County	
	94a	4:48. 5:37	Boat Ramp at pump house	3	Idea: vegetate between concrete ramp strips with no-mow turf, clover, spike rush, or something.	
94	95		Model shoreline. Very vegetated. Cleared only a little around the deck. Trees left intact which gives structure. Shrubs are along the bank. Upland gardens, about 25' off the trail. Landscape trees and perennial beds on slope leading down to water. Quite refreshing to see. Weed wacking/mowing a little, but not to excess.	G		
Way Point #	**Corrected Waypoints**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**
95	96	4:49	30' wide, 12' high slope, 60 degree angle--super steep. Clearing of shrub and ground layer down to bare soil—poor practice. Downed tree lying parallel to shoreline is beneficial.	2	Seed with erosion control blanket in bare spots and then plant shrub/plugs into that.	Shoreline adjacent to golf course was in good condition due to fairly modest buffer!
96	97	4:50-51	Patch of willow stakes on shoreline	-		Ironwood, basswoods populating the southern shoreline--north-facing.

97	98	4:54-55	30-35' wide "beach". 15' deep. Completely devoid of vegetation and soil replacement with sand. Totally excessive.	1	Replant much of this area with natives.	
98	99	4:56	Removed shrub layer. Small trees remain, but much bare soil is exposed on steep slope.	2	Re-vegetate with herbaceous plants.	
Day 5: Thursday July 16						
62	101	5:3-6	All vegetation removed except for large trees. Mowing to edge, for most part. A little undercutting, not too bad.	2	Re-vegetate the buffer and stop mowing.	
63	102		end			
64	103	5:7-8	Some vegetation, but sparse. Could use some more. Lots of: jewel weed, night shade, Virginia creeper (filling a void); some Amorpha, bane-berry, raspberry, nannyberry. Big rock/boulder--looks cool. Birch leaning out.	3	Plant vegetation to higher overall density in buffer.	
Way Point #	**Corrected Waypoints**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**
65	104	5:11	Lots of buckthorn in shoreline.	2	Remove and replant with native plugs and shrubs.	
66	105	5:10	Cleared the vegetation at bank--mowing to edge blue grass turf.	2	Re-vegetate	
67	106	5:33-35	200 feet of only tree vegetation.	2	Re-vegetate with shrubs and seed/plugs.	
68	107		Undercutting and on top of trail			
69	108	5:25-32	Mowed turf to edge and cutting of river bulrushes--freshly cut by people, not geese.	2	Public education campaign on merits and beauty of native vegetation buffer. Enforce shoreline ordinance. Stop mowing/weed whipping/cutting of native vegetation	Species that would make a good buffer: Culver's root, mountain mint, Liatris, Calamagrostis, sweet black-eyed Susan, little blue stem, big blue stem, sawtooth sunflower, fox sedge, Baptisia spp., Diervilla, native lilies.

70	109	5:36	Bench-like shoreline between mowed swath and water's edge. Probably floods in spring. Start of ice ridge. Mostly basswoods, some shrubs (buckthorn, gooseberry, etc.), Solomon's seal. Very shady area.	3	Plant more natives and/or seed in here. Smooth brome on edge--replace with Calamagrostis canadensis.	
71	110		Garlic mustard by pump house.	1	Remove/bag and dispose in trash. Monitor and keep up on it or else it will spread and be a big problem. We removed most of it today.	
Way Point #	**Corrected Waypoints**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**
72	111	5:47	"Seating element" (bench) by golf course. This causes the buffer to narrow way down. Buckthorn, Honeysuckle present here. Also, serviceberry.	2	Remove buckthorn and honeysuckle and replant with natives (viburnums and serviceberry) to discourage any more loss of the buffer here.	
73	112		Quercus alba. Big beautiful white oak (2' diameter at breast height [DBH]).	3	Encourage the planting of white oaks at upland side of buffer.	White oaks and junipers = oak savanna!
74	113	5:38-40	Nice attempt at buffer planting, but not good idea to plant annuals and beware of invasives. Perennial cultivars may be OK otherwise. Large expanse of turf upland.	G	Public education campaign on what and what not to plant for the shoreland buffer. Add mulch or more plants to bed. Replace turf with prairie upland.	
75	114	5:41-43	Large, wood-chip mulched garden at base of hill on upland side of trail. Used fabric with 3 inches of mulch. Mostly non-natives, but nice looking and effective at controlling stormwater. Better than turf. Rolling hills installed into landscape add visual interest but not necessary in terms of buffer functioning.	G	Part of public education and outreach plan. Consider starting program to reward good stewards of the lakeshore.	
76	115	5:48	End of canal.	-		
77	116		Eroding by trail.	2	Re-vegetate with shade tolerant native species (spikenard, elderberry, Jacob's ladder, etc.)	
78	117		end			
Day 6: Friday, July 17						

Way Point #	Corrected Waypoints	Photo #	Description	Priority	Recommended Practice(s)	Notes
79	118	5:46	Lots of big buckthorn.	2	Remove buckthorn and replace with native shrubs.	
80	119	5:49	The "Ruins"	-		
81	120		end			
82	121	5:46	Lots of buckthorn in shoreline buffer.	2	Remove buckthorn ad replace with native shrubs	
83	122		Shore bank gets steep and high (20-25').	-		
84	123		Over-clearing on site.	2	Plant more native shrubs and plugs.	
85	124		Past gully erosion. Lower priority.	3	Regrade and replant/seed.	
86	125		Bank tapers back down (2-3').	-		
87	126	5:51-56	Shoreline buffer is mowed--erosion on shoreline. Close to trail on south end of 200' stretch. High priority! Other side of trail is a pond that needs attention/buffer.	U	Full-blown shoreline restoration for at least 100 feet.	
88	127		Bank starts to rise up again. Buffer is 30' wide.	-		
89	128		Buffer sparse.	2	Could use shrub layer/dense forb layer.	
90	129		Euonymus on bank. Has escaped from homeowner plantings.	3	Control Euonymus.	
91	130		Highest bank (40').	-		
92	131	5:57	Shrubs sparse.	3	Could use shrub layer/dense forb layer.	
93	132		Mowed bank.	2	Re-vegetate bank and stop mowing.	
94	133		Bank low again. Buffer 20' wide.	-		
95	134	5:58-62	Eroding bank very close to trail (2-3'). High priority.	U	Full-blown shoreline restoration for at least 50 feet.	
96	135		end			
97	136	5:44-45, 63	Ice ridge formation evident.	-		
98	137		Culvert under trail. Other side needs re-grading/stabilization; rock too.	2	Plug/seed around culvert. Regrade and stabilize.	
Way Point #	**Corrected Waypoints**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**
99	138	5:64	High/steep bank again. Outlet pipe from house runoff creating erosion on bank.	2	Change outlet or add rock/armor outflow area and vegetate.	

100	139	5:65-66	Another bad outlet pipe.	2	Change outlet or add rock/armor outflow area and vegetate.	
101	140	5:71-73	Culvert at canal inlet. Mowed on both sides of trail. Bad erosion on lake side in spots.	1	Re-vegetate entire length of buffer. Plant on upper sides of culvert slopes.	
102	141		More.	1		Canal pond has great vegetation on north side (arrowhead, rushes, sedges, native cattails, etc.), but on south side, it is mowed to the edge.
103	142		End.	1		Thimbleweed, geranium, Penn sedge, lg-leaf aster, sedges, marsh fern.
104	143	5:77	Ice ridges still	-		
105	144	5:78	Much big buckthorn. Void ground layer due to shading out.	2	Remove buckthorn and replace with native shrubs/plugs.	
106	145	5:78	Nice example of 3-square bulrush on buffer, upland ice ridge, below trail. About a 20' wide strip of it, under green ashes.	G		
107	146	5:79	Mowed buffer. Filling in with mullein. Right next to (3-5' from) trail. Big ice ridge extends all the way along shoreline here.	1	Control exotics and re-vegetate along buffer. Re-establishment of emergents will be a challenge due to ice ridge formation. Consider installing some sort of root wad	Found nice little flat sedge here too.
Way Point #	**Corrected Waypoints**	**Photo #**	**Description**	**Priority**	**Recommended Practice(s)**	**Notes**
108	147	5:80-81	More of buffer from 106. This is also a 3-square/river bulrush point that is slowing erosion of the shoreline.	1	Control exotics and re-vegetate along buffer. Re-establishment of emergents will be a challenge due to ice ridge formation. Consider installing some sort of root wad.	

109	148	5:82	End of 107-108-109. One or two spiderwort growing on ice ridge; also scattered Amorpha, milkweeds, dogbane. At north end of stretch, a cute little sedge with upright spikes.	1	Control exotics and re-vegetate along buffer. Re-establishment of emergents will be a challenge due to ice ridge formation. Consider installing some sort of root wad	
110	149	5:83-85	Nice patch of 3-square. Some are pounded down by waves and flotsam. Sterile spurge on sandy ice ridge.	G		
111	150	5:86	Lots of Solomon's Seal on and just behind ice ridge, under green ash. Spiderwort.	G		
112	151	5:94-95	Rutting on sides of boat launch ramp.	1	Add gravel/trap rock on net-lawn/re-vegetate.	
113	152	5:93, 96-97	Boat Bay shoreline.	2	Re-vegetate all along this stretch. Use 3-square, Amorpha, sedges, spiderwort, etc.	
114	153	5:98-99	Swimming Beach	-		
115	154		end swimming beach	-		
116	155		High sand ice ridge. Bare soil eroding into lake.	1	Stabilize and re-vegetate.	
	156	2:62-67	Marsh: shallow, mucky, floating bogs. Good area. No erosion. The main problem is spot occurrences of non-native, yellow iris. Also, quite a bit of reed canary grass and hybrid cattail. Lots of good native, though.	2	Remove (dig out) the yellow iris where it occurs. It is still early enough to "nip it in the bud". Early detection and rapid response. Reed canary grass and hybrid cattails are too far gone to control now.	Vegetation is dominated by RCG, hybrid cattail, and Calamagrostis. Other native vegetation is: marsh fern, sensitive fern, poison sumac, Siam suave, red osier dogwood, jewel weed, arrowhead, bugle weed, Joe-Pye weed, great water dock, river bulrush, softstem bulrush, blue flag iris, cinquefoil, lake sedge, Siam suave, Bebb's willow (bog), Eleocharis

						spp. Other non-native vegetation includes: Amur maple, purple loosestrife (beetle damage on leaf evident). Submerged vegetation: Potamogeton spp. Lots of bullfrogs.

APPENDIX 2: ESTIMATED COSTS OF SHORELINE RESTORATION METHODS AND MATERIALS

Shoreline Erosion Control Methods & Materials – TOE PROTECTION

Note: Cost, installation time, & maintenance time based upon ***trials of 20' in length***; costs may vary with distributor

TOE PROTECTION (requires MN DNR shoreland alteration and/or aquatic plant permits)	Cost/ 20 lin ft	Installation Time**	Maintain. Time	Install Date	Effectiveness and Other Notes
Emergent aquatic plants (see details under Plant Materials)	$0-100	0.25 -1 hr	0 hr	varies	Use species w/ rapidly spreading rhizomes; use wave break on most sites
Live fascine (back w/ geotextile)	$9	1 hr	0 hr	2005	No erosion; fascine did not root; replace
Brush bundle (coco blanket wrap)	$30	1 hr	0 hr	2007	No erosion after 1 yr; use with aquatic plants
Brush bundle (woven jute wrap)	$30	1 hr	0 hr	2007	No erosion after 1 yr; use with aquatic plants
Coco log w/ wood stakes	$157	0.5 hr	0 hr	2000	No erosion yrs 1-4, logs break down yr 5; "collects" soil; use with aquatic plants
Flax log w/ wood stakes	$212	0.5 hr	0 hr	2006	No erosion or break-down after one year
Photodegradable bag/corn bale * (plant w/ plugs)	$1,160	(included) **	0 hr	2006	Bags lost integrity after one year at high energy site; 5% plant survival
Coco "lift" – woven jute w/ attached coco log (line w/ erosion blanket; w/ live stakes and plugs)	$340	5 hrs	0 hr	2006	Sediment loss where seam in erosion blanket wasn't overlapped
Vegetated geogrid	(high)	5 hrs	0 hr	2001	No erosion with ice push and waves
Geotextile soil bag * (w/ plugs)	$800	(included) **	?	[2008]	[to be installed 2008]
Stump revetment	$136	(included) **	0 hr	2005	Minor erosion between stumps; plants rooted between and behind
Tree revetment w/ duck-bill	$50	0.5 hr	0 hr	2004	Collects soil to "rebuild" shoreline, streams
Log raft (8' each)					Minor erosion between rafts;
duckbill anchors/cable	$206	3 hrs	3 hrs	2004	duckbills ineffective in sand – use
earth anchors/cable	$180	1.5 hrs	0 hr	2005	earth anchors; plants rooted between and behind
Gabion tube (backed w/ geotextile)	$100	2.5 hrs	0 hr	2005	No erosion, voids filled with sediment; plants rooted in and behind
Rock riprap (w/ live stakes)	$1,200	(included) **	0 hr	2005	No erosion; live stakes rooted behind

* Installation only by certified contractors

** Installed by contractors – installation included in cost (all other treatments installed by volunteers)

Shoreline Erosion Control Methods & Materials – WAVE BREAK AND EXCLOSURE

Note: Cost, installation time, and maintenance time are based upon ***trials of 20' in length***; costs may vary with distributor.

WAVE BREAK (temporary)	**Cost/ 20 lin. ft.**	**Installation Time**	**Maintain. Time**	**First Installed**	**Effectiveness and Other Notes**
Brush bundle/tree revetment	$20	1 hr	0.5 hr	2001	Wooden stakes ineffective at high energy sites w/ sandy soils – use earth anchors
w/ wooden stakes/rope	$100	1 hr		2000	
w/ earth anchors/rope (earth anchors reusable)					
Wrapped brush bundle (with coco erosion blanket or woven jute blanket; earth anchors used)	$120	1 hr	0.5 hr	2007	erosion blanket decomposed in 1 yr; jute holding after one year; earth anchors withstood 60 but not 70 mph winds over 1 mi fetch; sediment deposited behind; try leaving in place one year to build-up sediment/organics before vegetating behind?
Coco log					Wooden stakes ineffective at high energy sites w/ sandy soils – use earth anchors; withstood 60 but not 70 mph winds over 1 mi fetch; sediment deposited behind
w/ wooden stakes/rope	$157	0.5 hr	0.5 hr	2005	
w/ earth anchors/rope (earth anchors reusable)	$200	0.5 hr	0 hr	2007	
Rock berm	$200	2 hrs	0 hr	2000?	Permit required, height to OHW; sediment fill in 100’ behind (Leech Lake)

EXCLOSURE (temporary)	**Cost/ 20 lin. ft.**	**Installation Time**	**Maintain. Time**	**First Installed**	**Effectiveness and Other Notes**
3’ high 1”x2” mesh fencing and posts	$55	1 hr	0.5 hr	2000	Remove prior to freeze-up, re-install yr 2?

UNIVERSITY OF MINNESOTA EXTENSION

Shoreline Erosion Control – PLANT MATERIALS

Plant Material	Cost	Installation Time	Maintain. Time	First Installed	Effectiveness and Other Notes
UPLAND AND WETLAND - values based upon 100 square feet - *DNR permit required below OHWL*					
Willow and red-osier dogwood cuttings (for live stakes & posts, live fascines, willow wattles, branch packing, brush mattress)	$0	1 hr	0 hr	2000	Harvest and install ASAP in early spring or late fall when plants are dormant. Keep cool, shaded, out of wind and damp until planted.
Native grass and flower seed	$1-3	0.25 hr	0.25 hr	2001	Use covercrop of oats or Canada wildrye
Bare root trees & shrubs (2 ft spacing)	$25	1 hr	0.5 hr	1999	Keep cool, shaded, out of wind and damp until planted. 50-90% survival; water first year
Plant plugs (1 ft spacing)	$100	1 hr	0.5 hr	1998	80-90% survival; water first year
Containerized plants (1 gal.; 3 ft spacing)	$100	1 hr	0.5 hr	1998	90-100% survival; water first year
EMERGENT AQUATIC – values based upon 20 linear feet - *DNR permit required below OHWL*					
Containerized plants - 1 gal 2 ft spacing	$50	0.25 hr	0 hr	1998	80-90% survival; use wave break at high energy sites
Pre-vegetated 11”x22” mat w/ wooden stakes; 4 ft spacing	$100	0.25 hr	0.25 hr	2002	0-90% survival; use wave break at high energy sites
In-lake emergent transplants 2 ft spacing	$0	1 hr	0 hr	1999	5-90% survival; use wave break at high energy sites

(Upland species for erosion control – site dependent)

Wetland species for erosion control:

Willows (sandbar)	*Salix* spp. (*S. exigua*)
Red-osier dogwood	*Cornus stolonifera*
Prairie cordgrass	*Spartina pectinata* (can be very aggressive)
Canada bluejoint grass	*Calamagrostis canadensis*
Sedges	*Carex lacustris, C. aquatilis, C. lasiocarpa* (*C. lanuginosa*), *C. atherodes*

Aquatic emergent species for erosion control:

River bulrush	*Bolboschoenus fluviatilis* (formerly *Scirpus fluviatilis*; can be very aggressive)
Burreeds (giant)	*Sparganium* spp. (*S. eurycarpum*)
Hard-/soft-stem bulrushes	*Schoenoplectus acutus/S. tabernaemontani* (formerly *Scirpus acutus/S. validus*)
Sedges	*Carex lacustris, C. aquatilis, C. lasiocarpa* (*C. lanuginosa*), *C. atherodes, C. rostrata, C. utriculata*

Shoreline Erosion Control Methods & Materials – WETLAND AND UPLAND ZONES

Note: Cost, installation time, and maintenance time are based upon ***trials of 20' in length or 100 sq ft***; costs may vary with distributor.

SLOW OR REDIRECT RUN-OFF	**Cost/ 20 lin ft**	**Installation Time**	**Maintain. Time**	**Install Date**	**Effectiveness and Other Notes**
Berm (soil, coco blanket, plants)	$10-30	1 hr	0.25 hr	2004	Divert run-off from slopes and sensitive areas
Water bar (various construction)	Various	Various	Various	2000	Divert water from roads and paths
Bio logs • coco • flax • straw	 $157 $212 ?	0.5 hr	0 hr	2004	Bio-terrace; slow water in swales; straw – 1 yr; flax and coco – 2+ yrs
Brush bundle	$9	1 hr	0 hr	2005	Bio-terrace; will not root
SOIL PROTECTION (surface)	**Cost/ 100 sq ft**	**Installation Time**	**Maintain. Time**	**Install Date**	**Effectiveness and Other Notes**
Herbaceous plants (or seed)	$1-100	0.25-1 hr	0.25 hr	1999	Water first year
Mulch • shredded wood • leaf or pine needles • straw	$0-25	0.25 hr	0.25 hr	1999	Use only on level to gently sloping sites; Shredded wood and pine needles – 2+ yrs.; leaf and straw - 1 yr
Coco blanket w/ cotton net	$18	0.5 hr	0 hr	2000	2-3 years; seeds will germinate and grow through
Futera blanket	$16	0.5 hr	0 hr	2005	Very delicate; good seed germination
Hydro-mulch*	$35	(installed)	0 hr	2005	Sow seed prior to mulching?
SOIL STRUCTURE ON SLOPE (deep)	**Cost/ 100 sq ft**	**Installation Time**	**Maintain. Time**	**Install Date**	**Effectiveness and Other Notes**
Deep-rooted woody and herbaceous plants (or seed)	$1-100	0.25-1 hr	0.5	1999	Water first year
Live stakes, live posts	$0-5	0.25	0 hr	2000	Install dormant plants in early spring or late fall
Live fascine, willow wattle	$45	1 hr	0 hr	2000	Bio-terrace; fascines root when installed in trench while dormant and covered with soil
Brush mattress	$150+	2 hrs	0 hr	2001	Effective in areas of high water level fluctuation
GULLIES					
Fill, plant, erosion blanket cover	Varies	Varies	Varies	2000	Redirect water at top of slope; for shallow gullies
Branch packing (100 sq ft)	$0	2 hrs	0 hr	?	Redirect water at top of slope; for narrow gullies

* Installed by contractors – installation included in cost (all other treatments installed by volunteers)

APPENDIX 3: RECOMMENDED PLANT SPECIES FOR USE IN LAKESHORE PROJECTS

Emergent Forbs		Normal Water Level		Water
Scientific Name	**Common Name**	**Duration**	**Max Depth**	Planting Depth
Acorus calamus	sweet flag	>10	20	<12
Alisma subcordatum	water plantain	>10	12	<12
Iris versicolor	northern blue flag	>10	12	<12
Sparganium eurycarpum	giant bur reed	>10	18	<12
Emergent Gramminoids		**Normal Water Level**		Water
Scientific Name	**Common Name**	**Duration**	**Max Depth**	Planting Depth
Scirpus americanus	three square rush	>10	24	<12
Scirpus acutus	hardstem bulrush	>10	36	<24
Scirpus atrovirens	dark green bulrush	>10	30	<12
Scirpus fluviatilis	river bulrush	>10	30	2
Scirpus validus	softstem bulrush	>10	12 to 48	6
Transitional Forbs		**Normal Water Level**		Water
Scientific Name	**Common Name**	**Duration**	**Max Depth**	Planting Depth
Asclepias incarnata	marsh milkweed		saturated	wet to saturated
Agastache foeniculum	blue giant hyssop		saturated	moist to saturated
Aster novae-angliae	new england aster		saturated	moist to saturated
Eupatorium maculatum	joe pye weed		saturated	moist to saturated
Physostegia virginiana	Obedient plant		saturated	moist to saturated
Verbena hastata	blue vervain		saturated	moist to saturated
Vernonian fasciculata	ironweed		saturated	moist to saturated
Veronicastrum virginicum	Culver's root		saturated	moist to saturated
Lobelia siphilitica	great blue lobelia		saturated	moist to saturated
Monarda fistulosa	wild bergamot		saturated	moist to saturated
Hibisicus militaris	rose mallow		saturated	moist to saturated
Scientific Name	**Common Name**	**Duration**	**Max Depth**	Planting Depth
Pycnanthemum virginianum	mountain mint		saturated	moist to saturated
Bidens cernua	nodding bur marigold		saturated	moist to saturated
Eupatoreum perfoliatum	boneset		saturated	moist to saturated
Eupatoreum purpureum	sweet joe-pye weed		saturated	moist to saturated

Gentiana andrewsii	bottle gentian		saturated	moist to saturated
Helenium autumnale	sneezeweed		saturated	moist to saturated
Liatris spicata	marsh blazing star		saturated	moist to saturated
Mimulus ringens	monkey flower		saturated	moist to saturated
Rudbeckia laciniata	wild goldenglow		saturated	moist to saturated
Boltonia asteroides	false aster		saturated	moist to saturated
Heliopsis helianthoides	False sunflower		saturated	moist to saturated
Lycopus americanus	Bugle weed		saturated	moist to saturated
Transitional Gramminoids		**Normal Water Level**		Water
Scientific Name	**Common Name**	**Duration**	**Max Depth**	Planting Depth
Calamagrostris candadensis	Canada bluejoint		moist to sat	moist to saturated
Carex bebbii	Bebb's sedge		moist	saturated
Carex bebbii	Bebb's sedge		moist	saturated
Carex comosa	bristly sedge		12	wet to 3" of water
Carex crinita	fringed sedge		6	wet to saturated
Carex hystericina	porcupine sedge		6	wet to saturated
Carex lacustris	lake sedge		6	wet to 3" of water
Carex lupulina	hop sedge			wet to saturated
Carex stipata	fox sedge		moist	moist to saturated
Carex stricta	tussock sedge		6	wet to 3" of water
Carex vulpinoidea	brown fox sedge		6	wet to saturated
Elymus riparius	riverbank rye		moist to sat	moist to saturated
Glyceria grandis	American manna grass		30	Wet to 12” of water to saturated
Glyceria striata	Fowl manna grass		30	Wet to 3 to 6” of water
Hierochloe odorata	Sweet grass			wet to 3" of water
Juncus balticus	Arctic rush		6	wet to 6"
Scirpus cyperinus	wool grass		3	wet to 3" of water
Spartina pectinata	cord grass		3	wet to 3" of water
Transitional Ferns		**Normal Water Level**		Water

Scientific Name	**Common Name**	**Duration**	**Max Depth**	Planting Depth
Osmunda regalis	royal fern		3	wet to 3" of water
Thelypteris palustris	marsh fern		saturated	wet to saturated
Transitional Forbs				
Scientific Name	**Common Name**			
Stachys palustris	Woundwort			
Mimulus ringens	monkey flower			
Aster umbellatus	Flat-topped aster			
Chelone glabra	Turtle head			
Eupatorium maculatum	Joe-pye weed			
Eupatorium perfoliatum	Boneset			
Helenium autmnale	Sneezeweed			
Liatris pycnostachya	Prairie Blazing Star			
Lobelia cardinalis	Cardinal Flower			
Lobelia siphilitica	Great blue lobelia			
Physotegia virginiana	Obdeiant plant			
Pycnanthemum verticillatum	Mountain mint			
Verbena hastata	Blue vervain			
Vernonia fasciculatum	Ironweed			
Asclepias incarnata	Swamp milkweed			
Boltonia asteroids	False aster			
Gentiana andrewsii	Bottle gentian			
Lasymachia	Winged loosestrife			
Rudbeckia hirta	Black-eye susan			
Zizia aurea	Golden alexanders			
Transitional Shrubs				
Scientific Name	**Common Name**			
Amorpha fruticosa	False indigo shrub			
Ilex verticillata	Winterberry			
Salix exidua	Sandbar willow			
Aronia melanocarpa	chokeberry			
Scientific Name	**Common Name**	**Duration**	**Max Depth**	Planting Depth
Cornus sericea	Red twigged dogwood			
Cephalanthus occidentalis	Buttonbush			
Cornum amomum	Silky dogwood			
Virburnum trilobum	Highbush cranberry			
Spirea alba	Meadowsweet			
Upland species				
Savanna Community				
Trees and Shrubs				
Quercus macrocarpa	Bur oak			
Q. alba	White oak			
Corylus Americana	American hazelnut			
Rosa arkansana	Prairie rose			
Symphoricarpos albus	Snowberry			

Coruns racemosa	Grey dogwood			
Rhus glabra	Smooth sumac			
Rhus typhina	Staghorn sumac			
Ground Layer				
Carex muhlenbergii	Sand-bracted sedge			
Andropogon gerardii	Big bluestem			
Scizachyrium scoparius	Little bluestem			
Sorghastrum nutans	Indian grass			
Koeleria macrantha	June grass			
Sprorobulus heterolepis	Prairie dropseed			
Elymus riparia	Riverbank rye			
Elymus hystrix	Bottlebrush grass			
Carex sprengelii	Sprengel's sedge			
Carex pensylvanica	Pennsylvania sedge			
Carex umbellata	Early oak sedge			
Carex bicknellii	Bicknell's sedge			
Pteridium aquillinum	Bracken fern			
Osmunda claytoniana	Interupted fern			
Osmunda cinnamomea	Cinnamon fern			
Adiantum	Madenhair fern			
Lycopodium spp.	Horsetails			
Dalea purpurea	Purple prairie clover			
Solidago nemoralis	Gray goldenrod			
Aster sericeus	Silky aster			
Aster ericoides	Heath aster			
Solidago rigida	Stiff goldenrod			
Anemone cylidrica	Long-headed thimbleweed			
Viola palmate	Bearded birdfoot violet			
Liatris aspera	Rough blazing star			
Pulsatilla patens	Pasque flower			
Helianthemum bicknellii	Hoary frostweed			
Scientific Name	**Common Name**	**Duration**	**Max Depth**	Planting Depth
Maianthemum [f. Smilacina] stellata	Starry false-Solomon's seal			
Comandra umbellata	Bastard toadflax			
Allium stellatum	Prairie wild onion			
Liatris punctata	Dotted blazing star			
Monarda punctata	Horsemint			
Lespedeza capitata	Round-headed bush clover			
Lupinus perrenis	Wild lupine			
Symphyotrichum [f. Aster] oblongifolium	Aromatic aster			
Physalis virginiana	Virginia ground cherry			
Coreopsis palmate	Stiff tickseed			
Zizia aptera	Heart-leaved Alexander's			

Monarda fistulosa	Wild bergamot			
Campanula rotundifolia	Harebell			
Solidago missouriensis	Missouri goldenrod			
Symphyotrichum oolentangiense [f. Aster oolentangiensis]	Skyblue aster			
Artemisia ludoviciana	White sage			
Verbena stricta	Hoary vervain			
Verbena stricta	Flowering spurge x			
Asclepias verticillata	Whorled milkweed			
Artemisia dracunculus	Tarragon			
Artemisia campestris	Tall wormwood			
Fragaria virginiana	Common strawberry			
Phlox pilosa	Prairie phlox			
Dalea candida	White prairie clover			
*Thalictrum dasycarpu)**	Tall meadow rue			
Pediomelum argophyllum	Silverleaf scurfpea			
Hedeoma hispida	Mock pennyroyal			
Penstemon grandiflorus	Large-flowered beard-tongue			
Galium boreale	Northern bedstraw			
Symphyotrichum laeve var. *laeve [f. Aster laevis]*	Smooth blue aster			
Ratibida pinnata	Gray-headed coneflower			
Helianthus occidentalis	Few-leaf sunflower			
Heliopsis helianthoides	Ox-eye			
Potentilla arguta	Tall cinquefoil			
Asclepias syriaca	Common milkweed			
Pediomelum esculentum	Prairie turnip			
Heuchera richardsonii	Alumroot			
Scientific Name	**Common Name**			
*Liatris pycnostachy)**	Prairie blazing star			
Pycnanthemum virginianum	Virginia mountain mint			
Lobelia spicata	Pale-spike lobelia			
Calylophus serrulatus	Toothed evening primrose			
Anemone canadensis	Canada anemone			
Pedicularis canadensis	Wood betony			
Liatris ligulistylis	Northern plains blazing star			
Desmodium canadense	Canada tick trefoil			
Lilium philadelphicum	Wood lily			
Scrophularia spp.	Figwort			
Rudbeckia hirta	Black-eye Susan			
Baptisia alba	White wild indigo			
Baptisia bracteata	Cream wild indigo			
Rudbeckia subuckthornomentosa	Sweet black-eye Susan			

Woodland communities				
Shrub layer				
Hammemelis virginiana	Witch hazel			
Virburnum rafenesquianum	Arrowwood			
Sambucus pubens	Red-berried elder			
Viburnum lentago	Nannyberry			
Viburnum trilobum	High bush cranberry			
Amelanchier spp	Serviceberry			
Ground Layer				
Carex pensylvanica	Pennsylvania sedge			
Carex blanda	Common wood sedge			
Elymus hystrix	Bottlebrush grass			
Carex sprengelii	Sprengel's sedge			
Bromus purgans	Hairy wood chess			
Elymus villosus	Silky wild rye			
Elymus virginiana	Virginia wild rye			
Bromus ciliate	Ciliated brome			
Allium burdickii	Narrow-leaf Wild leek			
Aquilegia Canadensis	Columbine			
Arisaema triphyllum	Jack-in-the-pulpit			
Aster sagittifolius	Arrow-leaved aster			
Aster macrophyllum	Large-leaved aster			
Blephilia hirsute	Hairy wood mint			
Scientific Name	**Common Name**			
Geranium maculatum	Wild geranium			
Mertensia virginica	Virginia bluebells			
Hepatica acutliata	Pointed Hepatica			
Hepatica americana	American Hepatica			
Trillium grandiflora	Large flowered Trillium			
Sanguinaria Canadensis	Blood root			
Hydrophyllum virginiana	Virginia waterleaf			
Uvularia grandifloris	Bell flower			
Polemonium reptans	Jacob's ladder			
Polygonatum biflorum	Solomon's seal			
Smilicina racemosa	False solomon's seal			
Solidago	Elm-leaved goldenrod			
Solidago flexicaulis	Zig-zag-goldenrod			
Thalictrum dioicum	Early meadow rue			
Lysimachia ciliata	Fringed loosestrife			
Actea rubra	Red baneberry			
Aralia racemosa	Spikenard			
Mitella diphylla	Bishop's cap			
Dicentra cucularia	Dutchman's breeches			
Euphorbia corollata	Flowering spurge			

Enemion biternatum	False rue anemone			
Rue anemone	Thalictrum thalictroides			
Anemone virginiana	Thimbleweed			

APPENDIX 4: SOIL UNIT DESCRIPTIONS

Map Unit Legend
Ramsey County, Minnesota (MN123)
Map Unit Symbol Map Unit Name Acres in AOI Percent of AOI
132B Hayden fine sandy loam, 2 to 6 percent slopes 26.6 1.2%
132C Hayden fine sandy loam, 6 to 12 percent slopes 124.6 5.6%
132D Hayden fine sandy loam, 12 to 25 percent slopes 56.2 2.5%
155C Chetek sandy loam, 6 to 12 percent slopes 5.2 0.2%
155D Chetek sandy loam, 12 to 25 percent slopes 2.7 0.1%
158B Zimmerman loamy fine sand, 0 to 6 percent slopes 253.7 11.5%
158C Zimmerman loamy fine sand, 6 to 12 percent slopes 42.5 1.9%
158D Zimmerman loamy fine sand, 12 to 25 percent slopes 30.2 1.4%
159B Anoka loamy fine sand, 3 to 9 percent slopes 28.0 1.3%
161 Isanti loamy fine sand, depressional 12.3 0.6%
162 Lino loamy fine sand 15.7 0.7%
169B Braham loamy fine sand, 1 to 6 percent slopes 57.6 2.6%
169C Braham loamy fine sand, 6 to 15 percent slopes 206.0 9.3%
170 Blomford loamy fine sand 27.8 1.3%
177C Gotham loamy sand, 6 to 12 percent slopes 16.0 0.7%
177D Gotham loamy sand, 12 to 20 percent slopes 35.3 1.6%
189 Auburndale silt loam 2.3 0.1%
225 Nessel fine sandy loam, 1 to 4 percent slopes 5.3 0.2%
266 Freer silt loam 1.0 0.0%
302B Rosholt sandy loam, 1 to 6 percent slopes 5.5 0.2%
325 Prebish loam 1.1 0.1%
342C Kingsley sandy loam, 6 to 12 percent slopes 37.4 1.7%
453B DeMontreville loamy fine sand, 2 to 6 percent slopes 18.0 0.8%
453C DeMontreville loamy fine sand, 6 to 12 percent slopes 1.6 0.1%
453D DeMontreville loamy fine sand, 12 to 25 percent slopes 26.8 1.2%
454C Mahtomedi loamy sand, 6 to 12 percent slopes 46.0 2.1%
454D Mahtomedi loamy sand, 12 to 25 percent slopes 74.5 3.4%
481 Kratka fine sandy loam 3.2 0.1%
540 Seelyeville muck 42.9 1.9%
541 Rifle muck 118.3 5.4%
543 Markey muck 12.0 0.5%
544 Cathro muck 1.7 0.1%
859B Urban land-Zimmerman complex, 1 to 8 percent slopes 46.9 2.1%
896C Mahtomedi-Kingsley complex, 3 to 12 percent slopes 22.3 1.0%
896D Mahtomedi-Kingsley complex, 12 to 25 percent slopes 43.7 2.0%
1027 Udorthents, wet substratum 1.9 0.1%
1029 Pits, gravel 8.4 0.4%
1033 Udifluvents 18.1 0.8%
1039 Urban land 7.4 0.3%
1055 Aquolls and histosols, ponded 10.2 0.5%
1813B Lino variant loamy fine sand, 2 to 6 percent slopes 44.0 2.0%
W Water 665.6 30.2%

Totals for Area of Interest 2,206.3 100.0%
Soil Map–Ramsey County, Minnesota Soil Map: Pleasant Lake

Natural Resources
Conservation Service
Web Soil Survey

Pleasant Lake Shoreline Evaluation, 2009

National Cooperative Soil Survey
8/13/2009

APPENDIX 5: DIAGRAMS OF TYPICAL LAKESHORE PRACTICES: ROCK VANES AND ROOT WADS

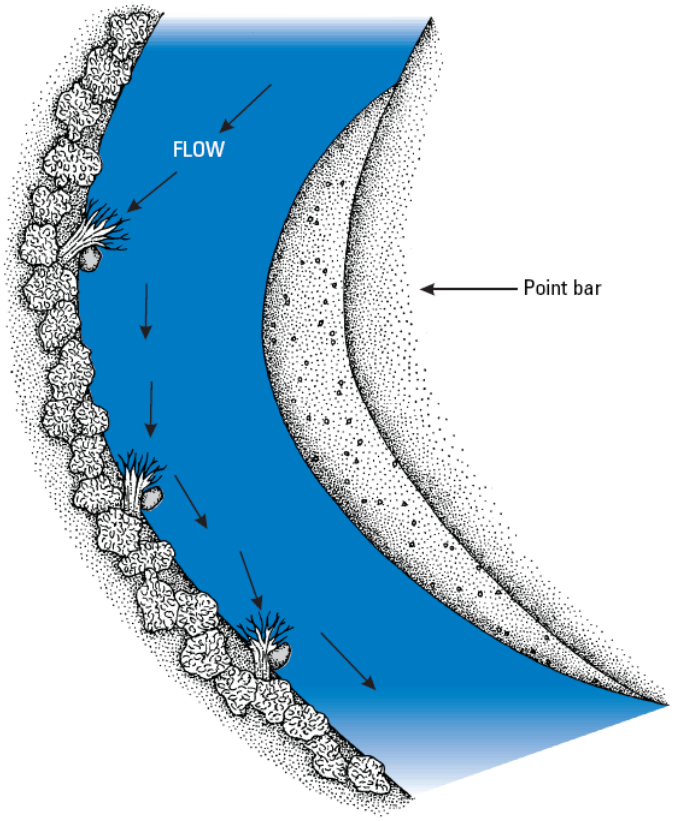
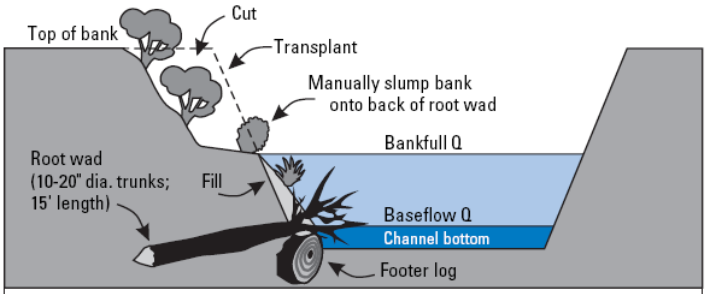


Figure 4. Root wads should be installed on the outside of the meander bend. They should be angled upstream to deflect the stream flow away from the bank.



Notes: 1) May need a boulder or log on top of root wad if bank height is low or non-cohesive soils.
2) Transplant mature trees on back of root wad and up bank.
3) Slope bank from 1.5:1 to 2:1.

Figure 5. Cross-section view of root wad design.

Figure 6. (a) Plan view, (b) cross-section, and (c) profile views of a rock vane.

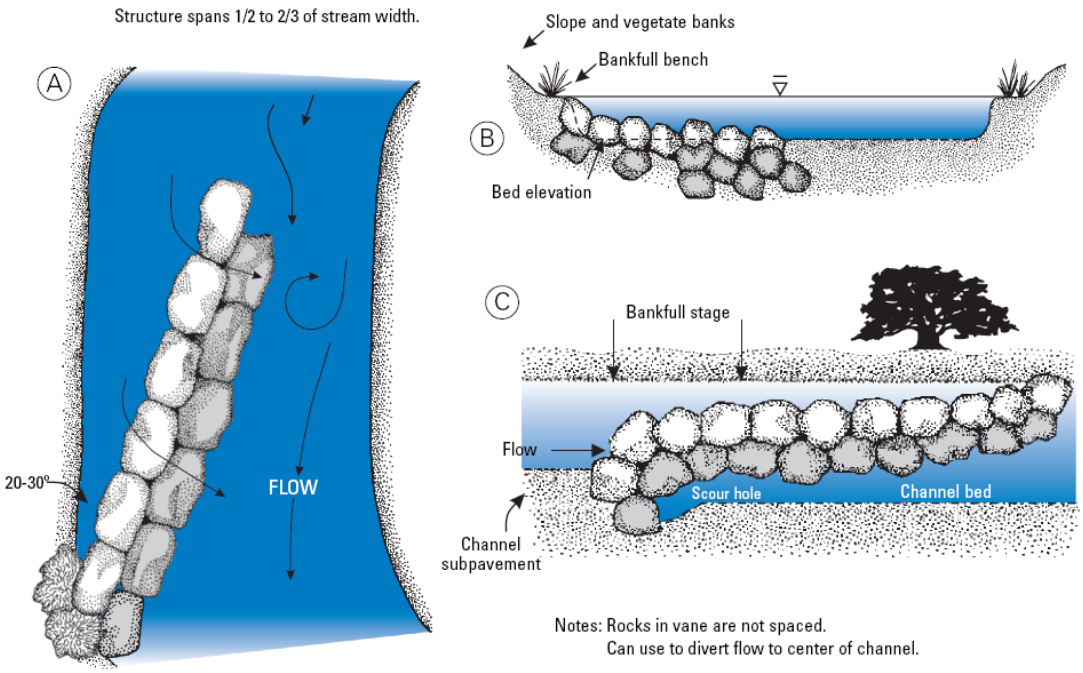


Figure 7. (a) Plan view, (b) cross-section, and (c) profile views of J-hook vane.

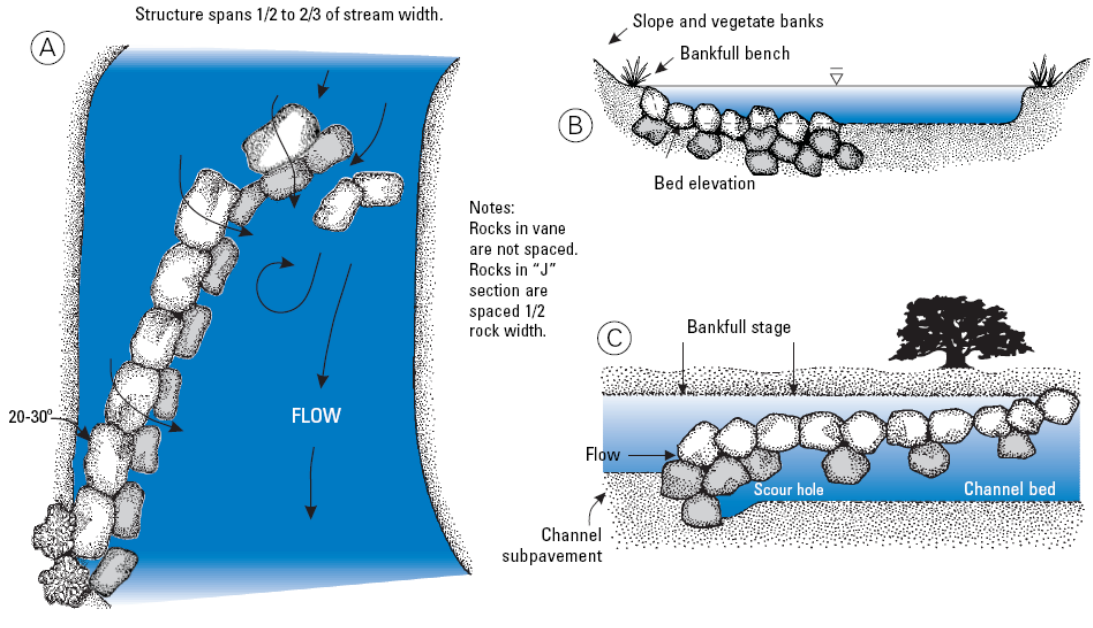
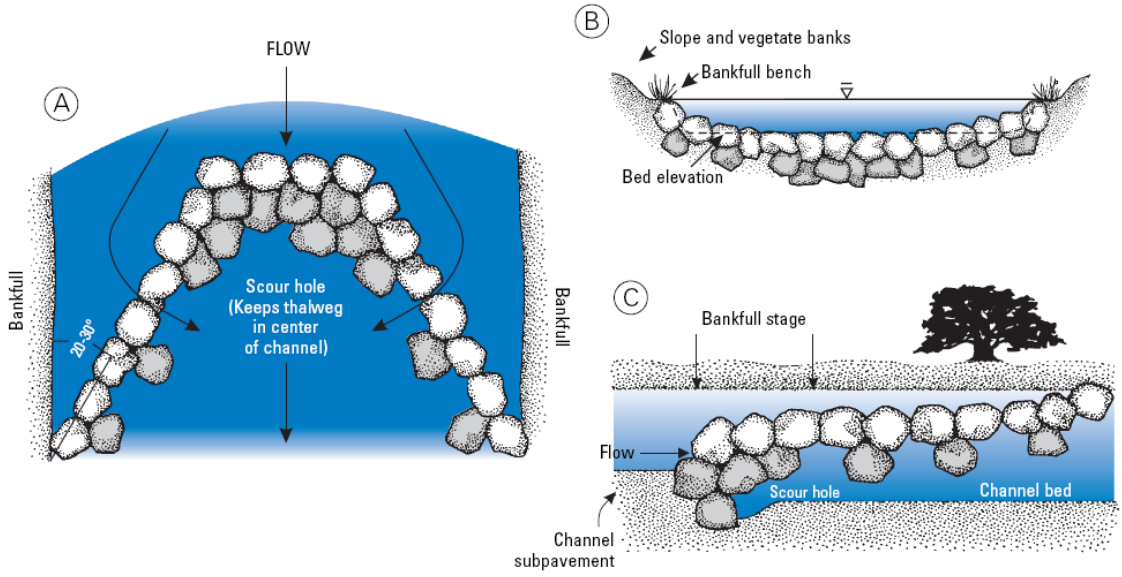


Figure 8. (a) Plan view, (b) cross-section, and (c) profile views of cross vane.



Note: There should be no gaps between the rocks in the cross vane.

References

Federal Interagency Stream Restoration Working Group. 1999. *Stream Corridor Restoration: Principles, Processes, and Practices.* Federal Interagency Stream Restoration Working Group. Washington, D.C.

Rosgen, D.L. 1998. *River Restoration and Natural Channel Design Course Handbook*. Wildland Hydrology. Pagosa Springs, CO.

Prepared by

William A. Harman
Extension Specialist, Biological and Agricultural Engineering

Rachel Smith
Extension Assistant, Biological and Agricultural Engineering

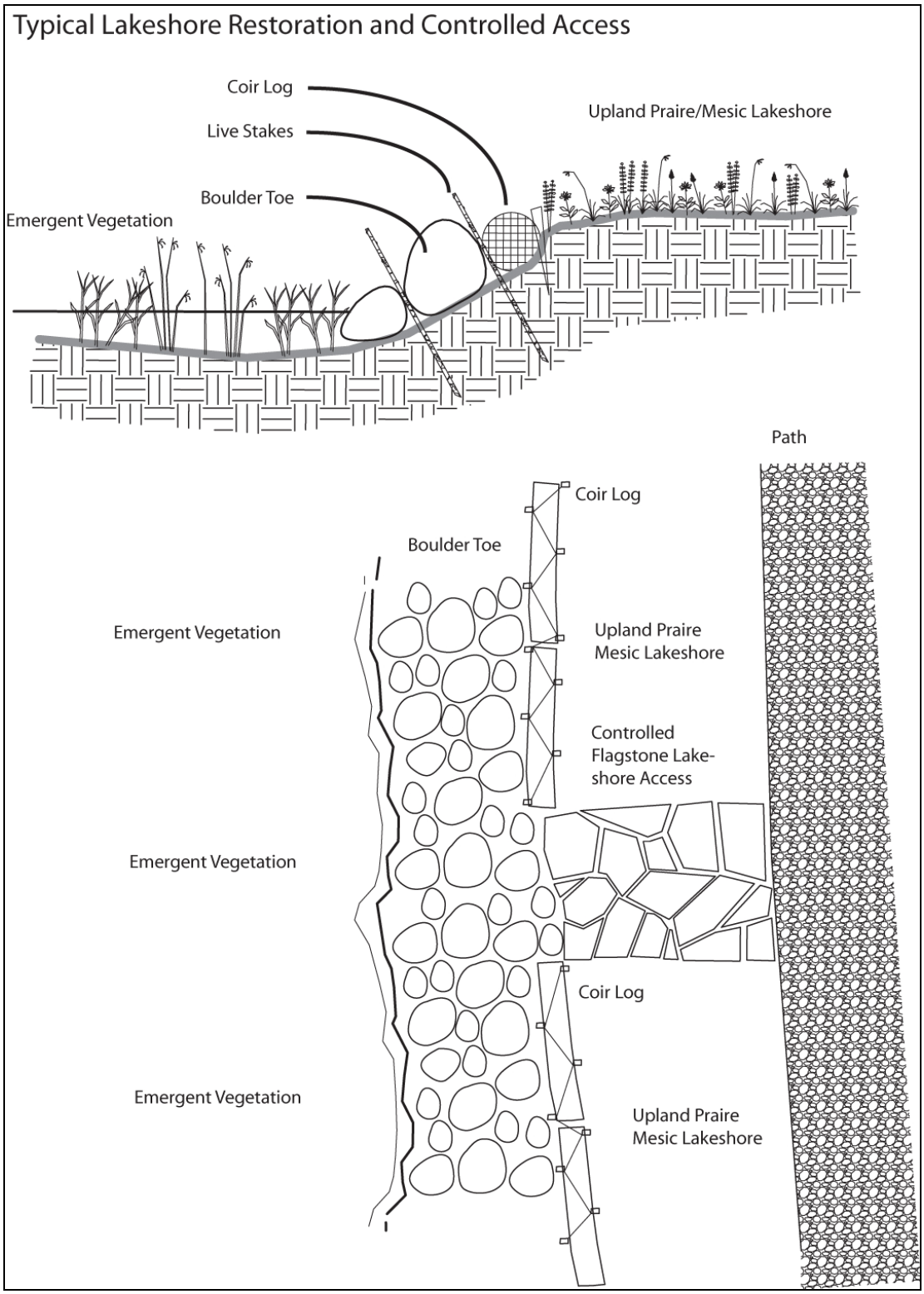
5,000 copies of this public document were printed at a cost of $xxx, or $.xx per copy.

Published by
NORTH CAROLINA COOPERATIVE EXTENSION SERVICE

6/00—5M—JMG/KEL
E00 39211

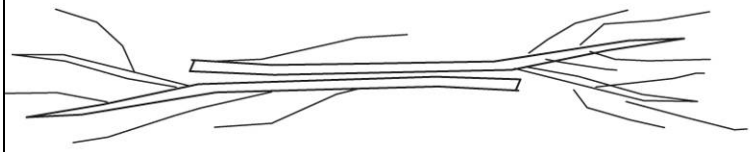
AG-590-4

APPENDIX 6: DRAWINGS OF TYPICAL PRACTICES AT PLEASANT LAKE



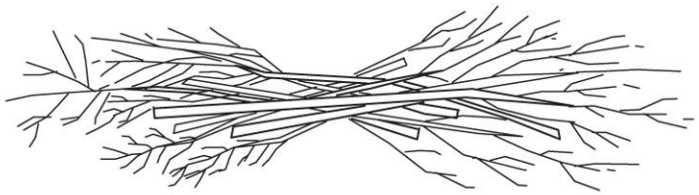
Buckthorn Brush Bundle Technique

Step 1.



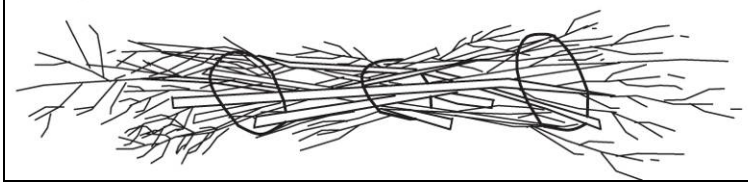
1. Assemble brush bundles by alternating butt ends with brush tops facing toward the outer edges. Before laying out first branch place a thick diameter rope ($\frac{1}{8}$" to $\frac{1}{4}$") underneath the staging area to help cinch the branches together for steps two and three below.

Step 2.



2. Keep stacking and assembling brush bundles until there is large enough bundle to cinch together. Use the cinch technique until the bundle is tight enough to add additional branches to the bundle. Cinch again as necessary.

Step 3.



3. Use the thicker diameter ropes to cinch the bundle into a tight two foot by ten foot brush bundle. After tightening with rope use an organic twine or equivalent diameter rope to reduce inter twig gaps and create a tightly formed wave break bundle 2-3 foot in diameter by 10-12 feet in length.

APPENDIX 7: SOME PLANT SPECIES ENCOUNTERED AT PLEASANT LAKE

(Red font indicates exotic species)

SUBMERGED/FLOATING-LEAVED VEGETATION

Scientific Name	Common Name
Spirogyra, Cladophora, and others	Filamentous algea
Elodea Canadensis	Canada waterweed
Potamogeton natans	Floating-leaf Pondweed
Potamogeton zosteriformis	Flat-stemmed pondweed
Potamogeton crispus	Curly-leaf pondweed
Myriopyllum exalbescens	Northern watermilfoil
Ceratophyllum demersum	Coontail
Lemna minor	Lesser duckweed
Nymphaea spp.	White water lily
Nuphar spp.	Spatterdock
Brasenia schreberi	Watershield

EMERGENT VEGETATION

Scientific Name	Common Name
Sagittaria latifolia	Broadleaved arrowhead
Sagittaria cuneata	Arum-leaved arrowhead
Rumex orbiculatus	Great water dock
Schoenoplectus fluviatilis	River bulrush
Schoenoplectus tabernaemontani	Softstem bulrush
Scirpus acutus	Hardstem bulrush
Schoenoplectus americanus	3-square bulrush
Carex lacustris	Lake sedge
Carex stricta	Tussock sedge
Typha angustifolia	Narrow-leaf cattail
Typha x glauca	Hybrid cattail
Scirpus atrovirens	Dark green bulrush
Eleocharis spp	Spike rush
Leersia oryzoides	Rice cut grass

TRANSITIONAL VEGETATION

Scientific Name	Common Name
Viburnum rafesquineanum	Nannyberry
Salix exidua	Sandbar willow
Salix nigra	Black willow
Salix bebbii	Bebb's willow
Carex scoparia	
Thalictrum dasycarpum	Tall meadow rue
Solidago flexicaulis	Zig-zag goldenrod
Rannunculus spp.	Buttercup
Aralia nudicaulis	Wild sarsaparilla
Populus deltoides	Eastern cottonwood
Fraxinus pensylvanica	Green ash
Acer saccharinum	Silver maple
Tilia americanum	American basswood
Calamagrostis canadensis	Canada blue joint
Onoclea sensibilis	Sensitive fern
Thalypteris palustris	Marsh fern
Rhus vernix	Poison sumac
Siam suave	
Impatiens capensis	Jewel weed

	Bugle weed
Iris versicolor	Blue flag iris
Salix bebbii	Bebb's willow
Eleocharis spp	Spike rush
Lythrum salicaria	Purple loosestrife
Iris pseudocorus	Yellow iris

UPLAND VEGETATION

Scientific Name	**Common Name**
TREES	
Quercus macrocarpa	Bur oak
Quercus rubra	Northern red oak
Quercus alba	White oak
Quercus ellipsoidalis	Pin oak
Betula papyrifera	Paper birch
Celtis occidentalis	Hackberry
Ostrya virginiana	Ironwood
Prunus serotina	Black cherry
Ulmus Americana	American elm
Juniperus virginiana	Eastern redcedar
Pinus strobus	White pine
Pinus resinosa	Red pine
Picea glauca	White spruce
SHRUBS	
Cornus sericea	Red osier dogwood
Amorpha fruticosa	False indigo shrub
Rhamnus cathartica	Common buckthorn
Frangula alnus	Glossy buckthorn
Syringa vulgare	Common lilac
Caragana spp	Siberian pea shrub
Viburnum lentago	Nannyberry
Virurnum triloba	Highbush cranberry
Viburnum rafenesquianum	Arrow wood
Prunus virginiana	Chokecherry
Sambucus pubens	Red elderberry
Sambucus canadensis	Black elderberry
Aronia melanocarpa	Chokeberry
Corylus americana	American hazelnut
Cornus racemosa	Grey dogwood
Euonymus spp	Burning bush
Berberis thunburgii	Barberry
Amelanchier spp	Serviceberry
Rhus glabra	Smooth sumac
Rhus typhina	Staghorn sumac
Rubus spp	Black raspberry
Salix discolor	Pussywillow
Salix exidua	Sandbar willow

GRAMANOIDS AND FORBS

Scientific Name	**Common Name**
Tradescantia spp	Spiderwort
Poa pratensis	Kentucky blue grass
Sonchus spp	Sow thistle
Toxicodendron radicans	Poison ivy
Thalictrum dasycaropum	Tall meadow rue

Anemone cylidrica	Thimbleweed
Aralia nudicaulis	Wild sarsaparilla
Ranunculus spp	Wild buttercup
Solidago flexicaulis	Zig-zag goldenrod
Cyperus esculentus	Yellow nut sedge
Verbena hastate	Blue vervain
Eupatorium maculatum	Joe pye weed
Eupatroium perfoliatum	Boneset
Asclepias incarnate	Marsh milkweed
Laportea Canadensis	Wood nettle
Bromus inermis	Smooth brome
Urtica dioica	Stinging nettle
	Dandylion
	Lions beard
	Lamb's quarters
Polygynum spp	Smart weed

APPENDIX 8: PLEASANT LAKE SHORELINE EVALUATION PHOTO LOG

Day 1	
Photo #	**Description**
1	Canoe storage area
2	Canoe storage area
3	Shoreline canoe storage area and ice ridge
4	Shoreline canoe storage area and ice ridge
5	Swimming beach
6	Swimming beach
7	West of swimming beach
8	West of swimming beach
9	Shoreline restoration area west of swimming beach
10	Shoreline restoration area west of swimming beach
11	Shoreline restoration area west of swimming beach
12	Broken steps
13	Broken steps
14	Falling tree at shoreline
15	Black willow root wad
16	Black willow root wad
17	Degraded shoreline
18	Cottonwood eroding
19	Cottonwood eroding
20	Erosion at shoreline with fallen tree
21	Bridge erosion: rip rap
22	Erosion behind willow. Unauthorized access point
23	Erosion behind willow. Unauthorized access point
24	Erosion near bridge
25	Fallen tree, causing blow out erosion by bridge
26	Fallen tree, causing blow out erosion by bridge
27	Steep bank with erosion
28	Basswood with exposed roots
29	Some shoreline erosion
30	Floating snag that should lessen erosion
31	Shoreline
32	Vegetation removed causing erosion
33	Vegetation removed causing erosion
34	Start of Mary Hill Park
35	Yellow iris by dock
36	Yellow iris by dock
37	Gully erosion on steep slope
38	View of shoreline
39	Eroding bank and slope
40	West end of Mary Hill Park
41	Large concrete slabs once used for erosion control
42	Site of beginning of "Tract X" after Mary Hill Canal
43	Mary Hill Park canal
Day 1	

Photo #	Description
44	Old steps
45	Island Peninsula from west side
46	Island Peninsula from west side
47	Eroding shoreline
48	Island Peninsula from west side
49	Erosion caused by unauthorized access to lake; very close to Island Road
50	Over clearing of shoreline
51	Over clearing of shoreline
52	Black willow red root hairs on root wad
53	Black willow red root hairs on root wad
54	Black willow red root hairs on root wad
55	Bad erosion of bank
56	Bad erosion of bank
Day 2	
Photo #	**Description**
1	forested buffer--good
2	Some cattails in bay. Shoreline erosion encroaching on trail
3	Some cattails in bay. Shoreline erosion encroaching on trail
4	Some cattails in bay. Shoreline erosion encroaching on trail
5	Some cattails in bay. Shoreline erosion encroaching on trail
6	Some cattails in bay. Shoreline erosion encroaching on trail
7	Narrow buffer to trail
8	Narrow buffer to trail
9	New lot site. Steep upland slope on either side of trail
10	small clearing of buffer
11	Dock
12	Narrow buffer to trail
13	Leaning ash trees
14	Rushes established--good
15	Point of Island--over clearing
16	view of shoreline
17	Rushes established--good
18	erosion on bank
19	Good example of downed tree and bulrush establishment combined
20	Nice steps
21	Nice steps
22	erosion very close to trail (runner on trail)
23	erosion very close to trail
24	erosion very close to trail
25	erosion very close to trail
26	erosion very close to trail
27	Steep slope needs replanting
28	erosion very close to trail
29	erosion very close to trail
Day 2	

Photo #	Description
30	erosion very close to trail
31	Blue flag iris-good
32	Large boulders on shallow lakebed
33	erosion very close to trail
34	erosion very close to trail
35	erosion very close to trail
36	Sagittaria in bay--good
37	erosion very close to trail and over cleared slope
38	Good start at emergent vegetation establishment, but needs more transitional and upland buffer
39	Good start at emergent vegetation establishment, but needs more transitional and upland buffer
40	Good start at emergent vegetation establishment, but needs more transitional and upland buffer
41	Good start at emergent vegetation establishment, but needs more transitional and upland buffer
42	Good start at emergent vegetation establishment, but needs more transitional and upland buffer
43	Good start at emergent vegetation establishment, but needs more transitional and upland buffer
44	Good start at emergent vegetation establishment, but needs more transitional and upland buffer
45	Good start at emergent vegetation establishment, but needs more transitional and upland buffer
46	Good tree root shelf for fish habitat
47	Nice bulrushes
48	Nice example of downed log protecting vegetation on shoreline. Diverse planting.
49	Eroding bank
50	Over cleared steep slope. Needs follow-up plantings.
51	nice river bulrushes
52	Leaning tree and lack of vegetation on buffer and slope
53	Leaning tree and lack of vegetation on buffer and slope
54	Leaning tree and lack of vegetation on buffer and slope
55	Some emergent vegetation, but more are needed.
56	Blue flag iris in marsh
57	Blue flag iris in marsh
58	Carex comosa
59	River bulrush and other marsh vegetation
60	Carex
61	blue flag
62	marsh shoreline
63	marsh shoreline. Carp jumping in lake.
64	yellow iris
65	Diverse flora. Marsh fern.
66	Diverse flora.
67	Sitting bench on marsh shoreline
68	Cleared vegetation on marsh shoreline

69	Transition from marsh to mineral shore
70	Transition from marsh to mineral shore
71	Degraded shoreline--no need for retaining wall if use bioengineering techniques.
72	Undercutting of shoreline bank
73	Undercutting of shoreline bank
74	Dying ash tree on shoreline
75	Eroding bank due to lack of emergent vegetation
76	Bank holding due to buffer of emergent vegetation
77	Both sides of dock, one holding, one not due to emergent vegetation
78	beginning of trail on Island peninsula
79	Erosion despite boulder--need vegetation to stabilize
80	Nice steps
81	buckthorn clearing without treating stumps--they resprout
82	Buckthorn clearing without replanting native plants
83	Erosion very close to trail
84	erosion close to trail on point of island
85	shallow lakebed conducive to emergent plant establishment
86	erosion very near trail
87	erosion very near trail
88	Over cleared steep slope. Needs follow-up plantings.
89	Good start at emergent vegetation establishment, but needs more transitional and upland buffer
90	goose droppings. Geese are discouraged when the buffer is dense and tall
91	Over cleared steep slope. Needs follow-up plantings.
92	Over cleared steep slope. Needs follow-up plantings.
93	Over cleared steep slope. Needs follow-up plantings.
Day 3	
Photo #	**Description**
1	Leaning tree. OK for fish habitat
2	Leaning tree. OK for fish habitat
3	Pipe draining directly into lake--not good
4	combination of factors leads to shoreline recession
5	erosion close to trail
6	great stand of river bulrush
7	dock at Charlie Lake inlet
8	boat launch at Charlie Lk inlet
9	erosion at corner of boat ramp
10	erosion at point by Charlie lk bridge and canal inlet
11	erosion at point by Charlie lk bridge and canal inlet
12	erosion at point by Charlie lk bridge and canal inlet
13	erosion at point by Charlie lk bridge and canal inlet
14	Erosion south of bridge, getting very close to trail
15	Erosion south of bridge, getting very close to trail
16	Erosion south of bridge, getting very close to trail
Day 3	

Photo #	Description
17	view of shoreline
18	shallow bed conducive to emergent vegetation establishment
19	shallow bed conducive to emergent vegetation establishment
20	shallow bed conducive to emergent vegetation establishment
21	Blow out due to runoff
22	white water lily in blue water lagoon
23	white water lily in blue water lagoon
24	white water lily in blue water lagoon
25	erosion of bank near sitting bench from over clearing
26	erosion of bank near sitting bench from over clearing
27	bridge at Charlie Lake inlet canal
28	bridge at Charlie Lake inlet canal
29	bridge at Charlie Lake inlet canal
30	bridge at Charlie Lake inlet canal
31	Charlie lake inlet canal
32	bank erosion at bridge and point
33	bank erosion at bridge and point
34	bank erosion at bridge and point
35	bank erosion at bridge and point
36	leaning trees
37	stumps providing some protection to shoreline
38	stumps providing some protection to shoreline
39	shallow bed conducive to emergent vegetation establishment
40	bank erosion
41	bank erosion
42	bank erosion
43	bridge
44	sand bar willow on north bank of bridge
45	boat launch at Charlie Lk inlet
46	approach to boat launch
47	eroding dock area
48	boat launch interface with water
49	boat launch interface with water: blacktop breaking up
50	sand bar willow
51	poison ivy
52	approach to boat launch
53	approach to bridge
54	parking lot by bridge
55	access to canal
56	access to canal
57	access to canal
58	large mowed turf area next to boat launch approach
59	large mowed turf area next to boat launch approach
60	river bulrush in emergent zone
61	just north of boat launch area
62	drain pipe discharging directly into lake
Day 3	

Photo #	Description
63	large mowed turf zone next to trail on private property, north of boat launch site
64	large mowed turf zone next to trail on private property, north of boat launch site
65	over cleared steep slope causing erosion next to trail
66	birch tree topped for view of lake--not recommended
Day 4	
Photo #	**Description**
1	Typical shoreline scouring
2	16 Evergreen Rd restoration, Year 2
3	16 Evergreen Rd restoration, Year 2
4	16 Evergreen Rd restoration, Year 2
5	16 Evergreen Rd restoration, Year 2
6	close-up
7	16 Evergreen Rd restoration, Year 2
8	16 Evergreen Rd restoration, Year 2
9	close-up
10	close-up
11	16 Evergreen Rd restoration, Year 2
12	16 Evergreen Rd restoration, Year 2
13	Shoreline just south of 16 Evergreen. Bank receding close to trail
14	Shoreline just south of 16 Evergreen. Bank receding close to trail
15	Shoreline just south of 16 Evergreen. Bank receding close to trail
16	Shoreline just south of 16 Evergreen. Bank receding close to trail
17	Shoreline just south of 16 Evergreen. Bank receding close to trail
18	Shoreline just south of 16 Evergreen. Bank receding close to trail
19	Shoreline just south of 16 Evergreen. Bank receding close to trail
20	shoreline
21	Shoreline just south of 16 Evergreen. Bank receding close to trail
22	close-up
23	black willow is holding bank here, otherwise it would be receding like the rest of it
24	sheer face of bank due to active erosion
25	erosion near trail. Need to solidify log and vegetation establishment
26	Active sloughing of bank. Excessive mowed turf--no buffer.
27	Active sloughing of bank. Excessive mowed turf--no buffer.
28	Active sloughing of bank. Excessive mowed turf--no buffer.
29	Buffer intact on right side of photo: erosion not a problem. Buffer compromised on left side of photo: erosion is active.
30	Segment of shoreline buffer has been cleared/compromised: erosion has started, trees are starting to lean.
31	Hard to see, but bank is scoured and eroding. Covered with mostly shallow-rooted exotics.
32	Silver maple roots creating shelf: good fish habitat. Note buckthorn in shrub layer.
Day 4	

Photo #	Description
33	Same silver maple. Shows that if it were to fall, it would rip out most of the bank here. Must strike balance between benefits of tree on shoreline versus costs if it were to fall.
34	Removing large trees that are prone to tipping is a good idea, but should be followed up with some bank re-shaping and much native herbaceous and shrub planting in the buffer zone, which have not been done. Roots of trees still holding bank, but bank is already sloughing away into the lake. Large expanse of mowed turf in upland buffer exacerbating the situation.
35	close-up
36	Buffer has been cleared of most vegetation except a couple of large trees which are starting to lean.
37	Nice rain garden in transitional and upland slope, but bank and emergent vegetation zone has been cleared of vegetation, and is great need of being restored. Bank is still eroding despite the upland improvements. Shows that both emergent and transitional/upland restoration needs to be done for ultimate stabilization success.
38	ditto
39	ditto
40	Rain garden overflow drain pipe. Need to review whether this pipe needs to be here. Generally pipes that drain directly into the lake should be discouraged. This one is very visible and setting the wrong example for the rest of the lake. Recommend removal.
41	This drain pipe is less obtrusive, which is better. If it only conducts stormwater overflow from rain garden, then it is serving a legitimate purpose. Recommend placing rock and heavy-duty structures at outlet spill point.
42	same as 36
43	same as 36
44	Boat launch of pump house. Needs native plantings and some stabilization.
45	Black willow root wad exists on west side of ramp, which is holding the bank here.
46	Evidence of a higher water level (dead branches of trees).
47	Buffer clearing has led to erosion around roots of trees on shoreline.
48	Model shoreline. Very vegetated. Cleared only a little around the deck. Trees left intact which gives structure. Shrubs are along the bank. Upland gardens, about 25' off the trail. Landscape trees and perennial beds on slope leading down to water. Quite refreshing to see. Weed whacking/mowing a little, but not to excess.
49	Excessive clearing of steep slope. Bare soil is exposed, which is very prone to eroding.
50	High density of willow stems on shoreline. Good example of how willow will look once established and how it can quickly stabilize a lakeshore.
51	High density of willow stems on shoreline. Good example of how willow will look once established and how it can quickly stabilize a lakeshore.
52	Shoreline
53	Forested shoreline showing existing rocks on toe.

54	Excessive clearing for beach area. Large expanse of mowed turf adjacent to shoreline exacerbates the situation.
55	close-up
56	Exposed bare soil on steep slope leading to shoreline. Erosion prone area that needs to be replanted.
Days 5 & 6	
Photo #	**Description**
1	Michelle in canoe
2	Rocky shoreline
3	Shoreline receding despite rocks on toe. Native vegetation in buffer zone holds fine soil particles.
4	Hybrid cattails are not recommended to be used in the emergent zone since they are non-native and they form patches of thick, impenetrable monocultures which tend to drive biodiversity down.
5	Sheer bank face actively eroding.
6	Shrubs starting to grow in buffer zone. Recommend allowing native shrubs to colonize the bank and buffer zone.
7	Mix of native and non-native vegetation in the buffer zone. Reed canary grass is the dominant grass here--it is exotic and very aggressive along shorelines and wetland margins. A good replacement for RCG is the native Canada blue-joint grass (*Calamagrostis canadensis*).
8	Rocks in the toe of slope and some vegetation on the bank, but none in the emergent zone. Erosion is slowed, but still active on the bank. Recommend re-establish native vegetation in the emergent zone to halt erosion of the bank.
9	Steep upland slope cleared but not replanted with deep-rooted native shrubs and/or herbaceous plants, which allows soil to be easily eroded.
10	Complete clearing of buffer and mowing of bank increases runoff onto shoreline which accelerates erosion of the bank.
11	High energy, high bank situation requires heavy duty stabilization solutions.
12	Black willow holding toe zone.
13	Lots of buckthorn on the bank results in soil erosion.
14	Michelle preparing for the day's work.
15	Illustrates how tall some native vegetation can get. This Joe-Pye Weed towered over Michelle's head, reaching 6 to 7 feet tall. Tall, dense native vegetation is a particularly effective shoreline stabilizer, as well as being aesthetically pleasing.
16	Recommend continuing the rain garden planting all the way across the slope for maximum effectiveness.
17	Erosion undercutting the bank closes to the trail.
18	Erosion only 2 to 3 feet from trail.
19	Black willow holding on to soil on the shoreline, in spite of surrounding vegetation clearing.
20	Black willow holding on to soil on the shoreline, in spite of surrounding vegetation clearing.
21	Erosion on cleared shoreline
Days 5 & 6	

Photo #	Description
22	Erosion 10 to 15 feet from trail.
23	Bank actively sloughing into lake very near trail. Notice how points exhibit slowed erosion due to the presence of tree stumps that act to buffet waves and hold on to fine soil particles. Eventually even these structures will succumb to the erosive force of waves and water runoff.
24	Someone has been mowing or weed whacking the native emergent and transitional vegetation on this shoreline. Recommend leaving native vegetation alone.
25	Someone has been mowing or weed whacking the native emergent and transitional vegetation on this shoreline. Recommend leaving native vegetation alone.
26	Huge expanse of mowed turf upslope from shoreline. Promotes accelerated erosion of shoreline.
27	Eroding bank on cleared shoreline.
28	Eroding bank on cleared shoreline.
29	Huge expanse of mowed turf upslope from shoreline. Promotes accelerated erosion of shoreline.
30	Someone has been mowing or weed whacking the native emergent and transitional vegetation on this shoreline. Recommend leaving native vegetation alone.
31	Erosion slowing and shoreline starting to recover due to emergent vegetation.
32	Erosion slowing and shoreline starting to recover due to emergent vegetation.
33	Eroding bank on cleared shoreline.
34	Bare soil that can erode.
35	Bare soil that can erode.
36	Shoreline on south shore. Buffer intact and little erosion present. Ice heave formation in transitional zone.
37	Boat launch ramp at Pump House.
38	Nice attempt at buffer planting. Consider using native perennials instead of annuals and beware of invasives. Perennial cultivars may be OK if they are not invasive.
39	Large expanse of mowed turf in upland slope. Not recommended.
40	Large expanse of mowed turf in upland slope. Not recommended.
41	Interesting rain garden. Large wood-chipped garden at base of hill with fabric and 3 inches of mulch. Mostly non-natives, but nice looking and effective at controlling stormwater. Preferable to mowed turf.
42	ditto
43	ditto
44	Ice ridge/heave on buffer zone of east shore.
45	Ice ridge/heave on buffer zone of east shore.
46	Illustrates how vegetation is sparse under canopy of dense buckthorn thicket. Bare soil is exposed which increases erosion.
47	View of buffer clearings across lake from Golf Course sitting bench.
48	Culvert at beginning of canal.
49	"The Ruins"
Days 5 & 6	

Photo #	Description
50	Old path where erosion had started. Low priority.
51	Cleared shoreline eroding.
52	Pond across trail.
53	Clearing of vegetation and mowed turf in entire buffer zone.
54	Pond across trail.
55	Clearing of vegetation and mowed turf in entire buffer zone.
56	Clearing of vegetation and mowed turf in entire buffer zone.
57	Given the right mix of shrubs and herbaceous plants, shorelines can be successfully stabilized.
58	Erosion close to trail
59	Erosion close to trail
60	Erosion close to trail
61	Erosion close to trail
62	Erosion close to trail
63	Ice ridge/heave on buffer zone of east shore.
64	Clearing of steep slope promotes erosion.
65	Area near large culvert would benefit from native vegetation planting.
66	Area near large culvert would benefit from native vegetation planting.
67	Drainage pipe causing erosion to site.
68	Clearing of vegetation and mowed turf in entire buffer zone.
69	Another pond across from trail.
70	Another pond across from trail.
71	Trail being threatened on both sides due to lack of vegetated buffer.
72	Culver with lack of vegetation.
73	Rocks help, but adding vegetation would tie it all together.
74	Erosion in spite of rocks.
75	Example of nice, healthy buffer of diverse native emergent and transitional plants (river bulrush, broad leaved arrowhead, pickerel plant, native cattails, tussock sedge, etc.).
76	Other side from 75, shows eroding, mowed turf pond edge.
77	Close up of sheer eroding bank face of lakeshore. Note the poison ivy.
78	Three-square bulrush in the transitional zone holding on to the shoreline.
79	Ice ridge/heave present on this cleared shoreline. (The tall plant in foreground is common mullein (*Verbascum thapsis).*
80	Unidentified species of Carex on open beachy area on east shore.
81	Close up of ice ridge/heave.
82	Close up of ice ridge/heave. False indigo shrubs (*Amorpha fruticosa)* have started to colonize this ridge.
83	Great example of how emergent vegetation can hold the shoreline. One patch of bulrush appears to protrude into the lake because it has slowed the erosion of the shoreline since it acts to deflect or baffle the waves.
84	Ice ridge on "beach" area.
85	Emergents starting to get a toe hold on shoreline.
86	Native spiderwort (*Tradescantia spp.)* plant.
87	More spiderwort without blossom.
Days 5 & 6	
Photo #	**Description**
88	Unidentified species of Carex on open beach area on east shore.

89	Unidentified species of Carex on open beach area on east shore. Notice the field bind weed in the left of the photo--a very aggressive exotic vine that can choke out its host plants.
90	Great example of how emergent vegetation can hold the shoreline. One patch of bulrush appears to protrude into the lake because it has slowed the erosion of the shoreline since it acts to deflect or baffle the waves.
91	Close up of three-square bulrush.
92	Sterile spurge, an exotic plant.
93	Canoe storage area.
94	Boat launch ramp near Swimming Beach. Notice formation of ruts.
95	Boat launch ramp near Swimming Beach.
96	Looking west from boat ramp towards Swimming Beach. More canoes stored along shoreline.
97	Ice ridge near swimming beach.
98	Swimming beach.
99	Swimming beach.
100	Erosion of shoreline just west of swimming beach.
101	Great example of emergent vegetation along the edge of canal shoreline just interior to trail.
102	Great example of emergent vegetation along the edge of canal shoreline just interior to trail.
103	Great example of emergent vegetation along the edge of canal shoreline just interior to trail.
104	Great example of emergent vegetation along the edge of canal shoreline just interior to trail.

Place CD/DVD Here

Great River Greening

35 W Water St #201
Saint Paul MN 55107

www.greatrivergreening.org