Appendix D

Restoration Plans for Dredge Locations
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Aquatic Plant Restoration Methodology for Nagawicka Lake Restoration Project

Introduction

Wisconsin's greatest natural resource is its lakes, rivers, and wetlands. These features of the landscape are what drives much of the tourism and recreation in the state. Protecting and enhancing these waterbodies is a responsibility that is shared by all. Ideally, Wisconsin's lakes would not have been impacted (and thus degraded) by man though the promotion of agriculture, deforestation, and urbanization. Unfortunately, these impacts have caused degradation to many lakes in the state including Lake Nagawicka. The challenge of restoring sediment laden areas of the lake to better provide safe navigation and optimum aquatic habitat is not one that is taken lightly. The following plan is the basis for the aquatic restoration work that the City of Delafield and the Nagawicka Lake Welfare Committee plan to undertake as part of the the comprehensive Lake Restoration Project.

Once the dredging is completed, the focus of the Lake Restoration Project turns to regaining healthy, diverse native plant communities in the disturbed areas. There are many factors to consider in determining how best to do undertake such a task. Aquatic plant restoration is difficult under the best conditions. Emergent plant restoration is becoming more common with many conservation groups in southern Wisconsin having much success. Submergent species restoration is a more difficult task. The following factors are critical in the success of aquatic plant restoration:

*Different age of the sediments relating to current sediment depth.
*Sediments vary greatly by location.
*Disturbance prone species have an elevated chance of coming back first.
*Coontail, elodea come back in high sediment prone areas.
*Replanting of aquatic species has a high mortality rate.
*Consider a multiprong approach.
*Consider a 5 year implimentation plan addressing EWM regrowth.
*Consider an early spring application of 2,4D (prior to emergence of natives) application to help control reinfestation of EWM.
*Success is known to be greater with emergent species.
*Of the submergents, certain species are known to be tougher than others – Sago pondweed is a tough and tolerant species; the Illinois pondweed along with many of the other broadleaf pondweeds are not hardy and show little success.
*Predation by turtles, carp, muskrats, etc. is to be expected.
*Survival rates jump dramatically with the use of exclosures.
*The most successful exclosures are lightweight mesh with small openings to limit small fish, reptile, etc. migration through. Chicken wire staked in place has worked well in past restoration projects.

The above comments/factors were taken from conversations with Russ Hefty, Conservation Resource Supervisor for the City of Madison (a local expert in aquatic restoration work) and Susan Graham, Water Resources Management Specialist, WIDNR.

In creating specific restoration plans for each dredge area the following factors guided planning.

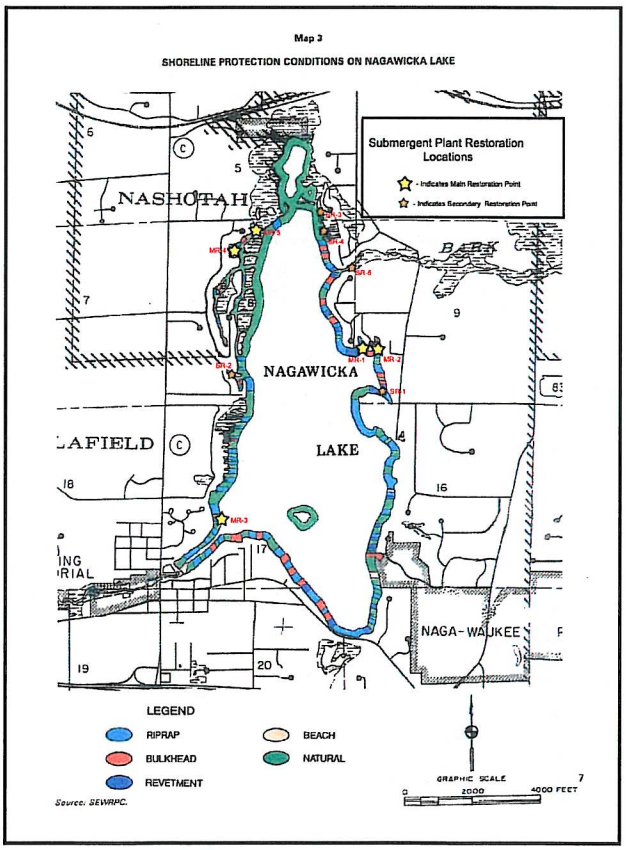
- Difficulty reestablishing native submergent plant communities
    - Using exclosures vs. not using exclosures
- Likelihood of natural regeneration from existing tubers/seedbank
- Quality of habitat in area prior to dredging/proximity to sensitive areas
- Need for ensuring ongoing nearshore sediment stability
- Size of disturbance in a given area
- Use of dredged area (narrow thoroughfare vs. inlet/lake fringe)
- Need for immediate EWM control as well as ongoing monitoring and treatment
- Costs for monitoring/maintenance, plant material, labor

Submergent Plantings

Determining Areas to be Replanted

The objective of the lake restoration work varies from location to location around the lake. In determining the areas in need of aquatic plant restoration (vs. areas to be left to natural regeneration) there are a few main ecological factors to consider:

- Areas with healthy, diverse native aquatic plant communities
    - Most important to revegetate with natives/limit infestation by exotics
- Larger dimensional areas more heavily disturbed
    - Larger tracts with minimal likelihood of natural plant regeneration
- Areas of high quality habitat/proximity to sensitive areas where the use of exclosures are warranted
    - Areas of known importance to the lake fishery
- Existing water depths prior to sediment removal
    - Shallower water depths may indicated older sediment with an older, less viable seedbank



The areas to be restored with submergent species will be limited in success by their water depth, proximity to boat traffic, predation (by reptiles, muskrats, geese, etc.), difficulty in planting, possible competition by invasive species, among other factors. To combat these impediments a simple planting plan has been devised. Five main restoration planting areas are to be reestablished with a variety of native submergent species. The planting will be at a

density of 1 plant/propagule per 3 sq. ft. These areas are as follows (MR meaning Main Restoration):

MR-1 (Zastrow's Bay) = 60'x100'=6,000 sq. ft	2,000 plants	
MR-2 (Zastrow's Bay) = 60'x150' = 9,000 sq. ft	3,000 plants	
MR-3 (S of NW Channels) = 5 areas x (30'x100') = 15,000 sq. ft.	5,000 plants	$5,000 exclosures
MR-4 (Inlet 2nd from top of NW Channels) = 30'x 300'= 9,000 sq. ft.	3,000 plants	$10,000 w. propagules
MR-5 (Inlet 1st from top of NW Channels) = 70'x100' = 7,000 sq. ft.	2,300 plants	$10,000 labor
15,300 total weighted propagules		$25,000 Exclosure Planting Costs

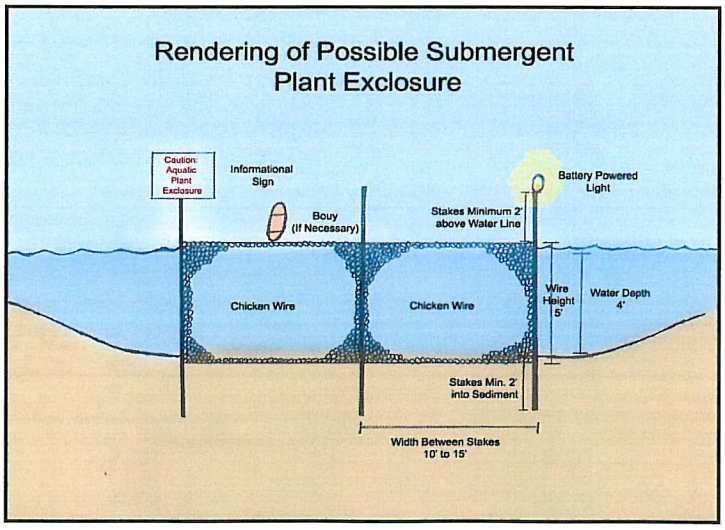
Five additional areas are to be planted with 500 weighted propagules but no exclosures are to be used. These areas are narrow, high traffic channels where the use of exclosures is not practical. These areas are very much test plots to see success rates. If this method using the protective bag does prove successful on its own, it can be expanded to areas where, by the 2nd year, little to no natural recovery has occurred. These areas have been identified as follows by their current depth of sediment (anticipated older sediments). These areas are as follows (SR meaning sub-restoration):

SR1 (S. Lobe Zastrow's Bay) = 50'x30' = 1,500 sq. ft.	500 plants
SR2 (Inlet S. of NW Channels) = 30'x 50' =1,500 sq. ft.	500 plants
SR3 (Channel 2nd from top in NE Channels) = 15'x100'= 1,500 sq. ft.	500 plants
SR4 (Channel 2nd from top in NE Channels) = 15'x100'= 1,500 sq. ft.	500 plants
SR5 (Bark R. Inlet) = 15'x100'= 1,500 sq. ft.	500 plants

2,500 total weighted propagules = $1,600

Total Submergent Plant Restoration Costs = $26,600

Each of these areas will be planted by boat using weighted propagules. All propagules will be placed in a biodegradable bag with washed gravel which will provide the weight. The substrate in each of the areas where the weighted propagules are to be placed will be still be comprised of soft sediment after dredging occurs. This sediment will be conducive to the intake of the weighted bags. Testing of this method will be necessary to determine how much weight is needed to provide adequate depth into the sediment for optimum planting success. In using this method, the predation of the propagules by wildlife will be greatly reduced as well as labor costs. This methodology is further explained in later pages of this section. Each restoration area will be entirely surrounded by an exclosure. One suggested method is to use chicken wire, wooden stakes, bouys, and flagging. A general consensus of professionals attempting such restoration work is that the exclosures greatly increase propagule success.



Possible layout for submergent plant exclosure

Emergent Plantings

Determining Areas to be Replanted

The objective of the lake restoration work varies from location to location around the lake. In determining the areas in need of or greatly enhanced by emergent plant additions (vs. areas minimally impacted or likely to regenerate these natives on their own) there are a few main ecological factors to consider:

<u>Assuming the soft sediment nearshore 'no touch' buffer of 5'</u>

- Dredge proximity to unvegetated nearshore sediments
    - Highly erodeable sediments
- Dredge proximity to natural shoreline areas (vs. developed shoreline areas)
    - Higher quality habitat areas due to less disturbance
- Dredge proximity to developed shoreline areas
    - Areas along lot lines are less disturbed areas

One of the keys to making the sediment removal last as long as possible is to ensure the stability of the remaining sediment adjacent to the dredged areas. The water depths along the 5' 'no touch' shoreline buffer range between several inches to around 3 feet. Emergent species such as wild iris, softstem bulrush, pickerelweed, arrowhead, and river bulrush grow in water depth of this range and a few of these species into even deeper water. The goal for the restoration of these plants would be to reinforce the edges of the dredge prisims where most needed. Since many of the species selected for restoration in these areas grow in depths greater than the existing depths, plants can be alternated along the top undisturbed sediment and heading down the 4:1 prism slope. This methodology would allow for more stability of sediment heading down the dredge slope while maximizing the use of the (generally) more successful emergent species. The sediments further down the slope in the deeper water depths would be allowed to regenerate naturally. These areas are primarily vegetated with submergent species which is what is expected would recover. The deeper water as well as boat traffic, especially in the channel areas, would limit excessive growth/migration of the emergents into navigation areas.

There is roughly 36,000' linear feet of shoreline adjacent to the dredge areas. Of this 36,000', approximately 12,000' are adjacent to natural shoreline areas. The other 24,000' are adjacent to developed lots. The emergent plantings will be targeted along all the shoreline areas impacted by the dredging. In the natural shoreline areas, 1 plant will be placed each foot along the edge of the dredge prism. The planting will be done in an alternating pattern; 1 plant in the undredged 'no-touch' zone, the next plant will be placed just down the slope of the dredge prism. In the developed lot areas, one plant will be placed each foot only along side lot areas (assume each lot gets a 45% linear foot access corridor with no planting done in that area). For example, if a landowner owns a 100' lot in the NW channels, 55 plants will be added along their frontage. The 55 plants will be divided along each side of the lot. This will leave 45' not replanted to be used for piers, navigation access, etc. Areas already vegetated will be left alone and the plants allocated for those areas will be distributed to other locations where needed.

12,000 plants for natural shoreline areas
13,000 plants for developed shoreline areas

26,000 emergent plants total

$21,000 plant costs
$20,000 labor costs

Total Emergent Plant Restoration Costs = $41,000

Eradication of Eurasian Water Milfoil and Monitoring/Maintenance of EWM & Revegetation Success

EWM (and other exotics) Plan

Much of the success of the vegetation restoration portion of the project hinges on the elimination and monitoring of EWM. EWM has been identified in each of the areas where replanting is to occur. The plan is broken down into a five year eradication, monitoring, and maintenance plan. The monitoring of the EWM will double as the monitoring of the overall revegetation success. The plan is as follows:

1st year after dredging: Approximate Cost = $15,000

Spring - Pre-emergence application of 2,4D in all dredge locations.
Late June – Initial monitoring trip through all dredge areas noting EWM infestations & revegetation success.
Early July – "EWM Hunting Day" – LWC members & other volunteers carefully pull known EWM colonies.
Early August – Secondary monitoring trip through all dredge areas noting EWM infestations & revegetation success.

2nd year after dredging: Approximate Cost = $12,000

Spring - Pre-emergence application of 2,4D in all dredge locations.
Late June – Preliminary monitoring trip through all dredge areas noting EWM infestations & revegetation success.
Early July – "EWM Hunting Day" – LWC members & other volunteers carefully pull known EWM colonies.
Early August – Secondary monitoring trip through all dredge areas noting EWM infestations & revegetation success.

3rd year after dredging: Approximate Cost = $10,000

Spring - Pre-emergence application of 2,4D in known infestation areas only.
Late June – Preliminary monitoring trip through all dredge areas noting EWM infestations & revegetation success.
Early July – Aquatic revegetation where identified in June as needing additional plantings.

Early July – "EWM Hunting Day" – LWC members & other volunteers carefully pull known EWM colonies.
Early August – Secondary monitoring trip through all dredge areas noting EWM infestations & revegetation success.

4th year after dredging: Approximate Cost = $10,000

Spring - Pre-emergence application of 2,4D in known infestation areas only.
Late June – Preliminary monitoring trip through all dredge areas noting EWM infestations & revegetation success.
Early July – Aquatic revegetation where identified in June as needing additional plantings.
Early July – "EWM Hunting Day" – LWC members & other volunteers carefully pull known EWM colonies.
Early August – Secondary monitoring trip through all dredge areas noting EWM infestations & revegetation success.

5th year after dredging: Approximate Cost = $10,000

Spring - Pre-emergence application of 2,4D in known infestation areas only.
Late June – Preliminary monitoring trip through all dredge areas noting EWM infestations & revegetation success.
Early July – Aquatic revegetation where identified in June as needing additional plantings. Final year of replanting.
Early July – "EWM Hunting Day" – LWC members & other volunteers carefully pull known EWM colonies.
Early August – Secondary monitoring trip through all dredge areas noting EWM infestations & revegetation success.

Total Aquatic Planting Restoration Costs = $67,600
Aquatic Plant Appreciation Information & Education Program Costs = $3,000
EWM Eradication, along with overall Monitoring & Maintenance Costs = $57,000

Total Aquatic Restoration, Monitoring, & Maintenance Costs = $127,600

Submergent Planting Infomation

Approach

To overcome impediments to natural establishment such as dredge depth, competition with invasive species, as well as human impact, an approach has been developed for establishing "founder colonies." Founder colonies are small colonies of aquatic plants established in strategic locations within the restoration areas. Successful establishment of founder colonies relies on planting of robust propagules (such as mature transplants) into protected sites (Smart et al. 1996; Smart, Dick, and Doyle 1998). Protection of these areas may include temporary limitations on boat traffic in newly restored areas, temporary fencing/marking of planting zones, etc. Much of the following information comes (nearly) verbatim from the publication Propagation and Establishment of Aquatic Plants: A Handbook for Ecosystem Restoration Projects, R. Michael Smart, Gary O. Dick, US Army Corps of Engineers Technical Report A-99-4 February 1999 and its update from March 2005.

Sediment substrate

Submersed aquatic plants will grow in a variety of substrate types, ranging from pure sand to heavy clays. However, for optimum production a fine textured substrate with a low to moderate organic content (10 to 20 percent) is ideal for most species of submersed aquatic plants. Sandy substrates are unsuitable because they are generally infertile and added nutrients may diffuse into the water column, causing algal problems. Highly organic substrates can be inhibitory to plant growth (Barko and Smart 1983, 1986).

Propagule Types

Many commercial plant suppliers sell aquatic plant propagules. Availability is often seasonal. Stem fragments, daughter plants, root crowns, tubers or winter buds, and even seeds (usually dependent upon species) may be used as starter materials for aquatic plant cultures. After a culture of a particular species is established, it can be used as a source for the next generation of cultivation. This prevents excessive damage that might be inflicted on donor populations if repetitive annual collections were required.

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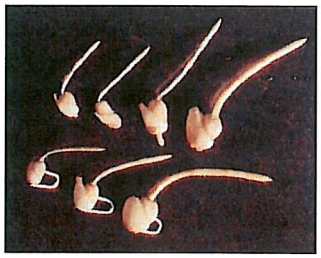
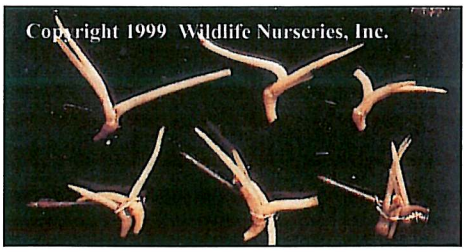


Sago pond weed tubers. Weighted tubers shown on bottom row.

Stem fragments

Many aquatic plant species spread vegetatively from stem fragments. These species have apical meristems at the terminal ends of the shoots. Select stem tips and cut to a length of 15 to 20 cm. When selecting material, remember that the greater the density of leaves along the stem, the better, as most nodes can produce roots as well as leaves and branches. Plant the apical cutting about 8 to 10 cm deep in the potting medium. For faster development, several cuttings could be planted per pot. Established plants readily regenerate new meristematic tissues after cutting, so once the culture is actively growing, additional cuttings can be taken.



Wild celery winter buds. Weighted buds shown on bottom row.

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Dormant perennating plants

Many aquatic plants perennate by producing tubers or winter buds that survive winter or dry periods in a dormant state. The use of tubers or winter buds is an excellent way to start a culture. Dormant propagules can be collected, held in a dormant state by refrigeration (for up to 6 weeks), and then planted when desired. Tubers are buoyant and should be planted about 5 cm deep and covered completely with substrate.

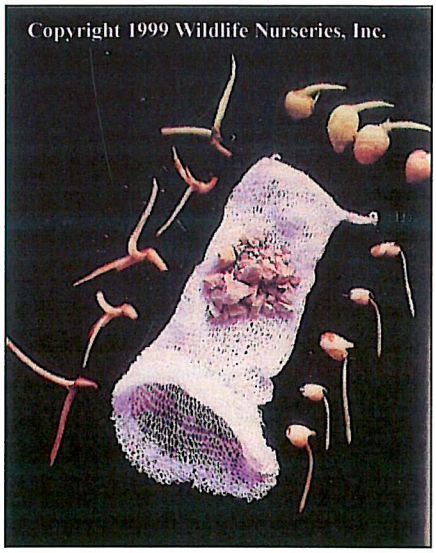
Implementation

Site Recommendations

Sites should be selected based upon several criteria. Choose well-protected (from winds and wave action), shallow (<2-m depths) coves—preferably with gradual slopes—for establishment of aquatic plants. A fine-textured substrate is preferred and generally indicates a favorable, low-energy environment. Other than as an indicator of physical conditions, sediment texture does not seem to be critical to successful short-term establishment, and similar results have occurred on sandy to muddy substrates. The major consideration is that plant roots must be able to penetrate the sediment to a depth of at least 15 cm in order to anchor the plant. Wooded shorelines can be a problem due to excessive shading, which greatly reduces the light available to submersed aquatic plants.

Planting Depth

The two greatest abiotic influences on aquatic establishment are water-level fluctuations and high turbidity. Because submersed aquatic plants require light to establish, plant in shallow depths—particularly if the water is turbid. Water levels of most reservoirs are influenced by both natural (seasonal or climatic) events and operations (storage or release of floodwaters or water supplies, power generation, etc.), both of which are generally beyond one's control. For planning purposes, historic water-level fluctuations are reviewed to estimate expected levels during early establishment. Based on expected water levels and knowledge of the biology of the plant species, an appropriate depth or depth range is assigned for each species. In general, submersed plants will establish best at depths of 0.5 to 1.0 m, floating-leaved plants from 25 to 75 cm, and emergent plants from 0 to 25 cm. The use of mature transplants, with well-developed shoots and/or leaves, is mandatory in turbid waters. Introducing a 75-cm-tall plant into 50 to 75 cm of water ensures that at least some photosynthetic surfaces will receive adequate light.



Sago pond weed tubers. Note weighted tubers bottom row.

Using Weighted Propagules

Deeper water areas that cannot be easily planted by hand can be revegetated through the use of weighted propagules. This can be done using nails, staples, etc. driven through the plant material and dropped or aimed into the substrate. Planting bags are another option. Propagules are placed into a quickly biodegradable woven mesh bag, weighted with gravel, and tied at the top. These bags keep the planting material from being eaten by muskrats or geese while the plants grow out of the bag. **Due to the amount of metal that the nails, staples, etc. would add to the lake along with the lack of protection against predation, the weighted bag method will be used for the Lake Nagawicka Lake Restoration Project.** This information regarding weighted propagule plantings comes primarily from the planting guide What Brings Them In? by Jim Lemberger, Wildlife Nurseries, Inc., third printing - 1999.

Species Selection

Plant species should be selected based upon several criteria. Overall, using only native plant species is suggested, as these tend not to reach weedy proportions, reducing the need for future intensive management. Establishing as great a species diversity as possible is also suggested. These criteria include water level tolerance, ability to thrive, and for the goals of the Nagawicka Lake Project, fisheries habitat and silt stabilization are critical as well.

Timing

Timing and site selection can be as critical as species selection. Planting should occur prior to or during periods of active growth to ensure establishment during that growing season. Unlike seeds or less robust propagules, mature transplants can be planted over a relatively long period of time. Depending on location, this may range from midspring to late summer. In reservoirs that

experience spring floods, planting should be delayed until water levels drop to their normal summer levels. In general, plants should be planted as early as practicable. Establishment of a viable population from mature transplants is possible in late summer, but late planting reduces the length of growing season remaining and decreases the likelihood of success.

Factors Impacting Restoration Success

Weeds

As with any culture or crop, nuisance weeds or pests may cause problems. Pond sediments often contain seeds and spores of aquatic species that might interfere with success of the restored, desired species. In Nagawicka Lake this may be seen to some degree with Eurasian water milfoil and curly leaf pondweed which are known to exist in many of the restoration areas.

Algae

Excessive algal growth is always a concern with cultures of submersed aquatic plants. High concentrations of nutrients (especially phosphorus and nitrogen) in the water column will generally support excessive algal growth. Algae, whether growing in the water, on the water surface, or on the plants themselves, cause problems by reducing the growth of desired plants. Algae compete with macrophytes for light, nutrients, and inorganic carbon, and, because they are capable of rapid growth, they can quickly grow to problem levels.

Grazing pests

Herbivore damage may become a problem in some situations. Pond and inlake plant cultures may need protection from turtles, carp, waterfowl, muskrats, and some invertebrates.

Propagation and Establishment of Aquatic Plants: A Handbook for Ecosystem Restoration Projects, R. Michael Smart, Gary O. Dick, US Army Corps of Engineers Technical Report A-99-4 February 1999.

Community Outreach Plan to Ensure Peaceful Co-existence with Native Aquatic Vegetation

To ensure the success of the Nagawicka Lake Restoration Project, it is necessary to work with not only the shoreline landowners around the lake, but the Delafield/Nashotah communities as a whole. Most lake enthusiasts care deeply about the quality of the lake they enjoy. Few understand the relationships between soil, water, and vegetation in the watershed. It is critical to the success of the dredging project to increase this understanding. In additon, the misconceptions of most people regarding aquatic vegetation, their benefits, and problems must be addressed to ensure no tampering occurs with the plantings.

The following tasks will be completed to promote community-wide appreciation of native aquatic plant communities in Lake Nagawicka.

*Spring workshops

*Highlight at annual meetings

*Run info ads on closed circuit TV channel

*Direct mailings to landowners

*Articles in local newspaper

*City adopt ordinance fining anyone caught tampering with restored vegetation

The focus of the above tasks will be to educate landowners on the importance of their own shoreline (& the barrier islands) stability for the purpose of keeping soil in place and out of the lake. Along this same vein, landowners will be introduced to the concepts related to overland runoff & the damage it can cause. The I&E program will center on the belief that everyone must do their own part to protect the lake.

Value of aquatic plants

Aquatic plants are a natural part of most lake communities and provide many benefits to fish, wildlife, and people. In lakes, life depends--directly or indirectly--on water plants. They are the primary producers in the aquatic food chain, converting the basic chemical nutrients in the water and soil into plant matter, which becomes food for all other life.

Aquatic plants serve many important functions:

Provide fish food
More food for fish is produced in areas of aquatic vegetation than in areas where there are no plants. Insect larvae, snails, and freshwater shrimp thrive in plant beds. Sunfish--Minnesota's most sought-after game fish--eat aquatic plants in addition to aquatic insects and crustaceans.

Offer fish shelter
Plants provide shelter for young fish. Because bass, sunfish, and yellow perch usually nest in areas where vegetation is growing, certain areas of lakes are protected and posted by the DNR as fish spawning areas during spring and early summer. Northern pike use aquatic plants, too, by spawning in marshy and flooded areas in early spring.

Improve water clarity and quality
Certain water plants, like bulrushes, can absorb and break down polluting chemicals. Nutrients used by aquatic plants for growth are not available to algae. This reduces algae abundance improving water clarity. Aquatic plants also maintain water clarity by preventing the re-suspension of bottom sediments. Algae, which thrive on dissolved nutrients, can become a nuisance when too many submerged water plants are destroyed.

Protect shorelines and lake bottoms
Aquatic plants, especially rushes and cattails, dampen the force of waves and help prevent shoreline erosion. Submerged aquatic plants also weaken wave action and help stabilize bottom sediment.

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

Improve aesthetics
The visual appeal of a lakeshore often includes aquatic plants, which are a natural, critical part of a lake community. Plants such as water lilies, arrowhead, and pickerelweed have flowers or leaves that many people enjoy.

Provide economic value
As a natural component of lakes, aquatic plants support the economic value of all lake activities. Minnesota has a huge tourism industry centered on lakes and the recreation they support. Residents and tourists spend more than $1.5 billion each year to hunt, fish, camp, and watch wildlife on and around the state's lakes. The wild rice harvesting industry alone is worth at least $2 million to Minnesota's economy.

Factors influencing aquatic plant abundance

If you have visited lakes across Minnesota, you have probably noticed that some are loaded with plants while others have hardly any. The primary factors that influence the growth of aquatic plants are water depth, bottom type, and water clarity. These factors vary from lake to lake, and are themselves influenced by what is happening in their watershed--the surrounding land that contributes water (from rainfall, snowmelt, or groundwater) to the lake. Here are some aspects of watersheds that influence aquatic plant growth:

The "age" of the lake
Lakes undergo a natural aging process by which, over thousands of years, they slowly fill up with sediment. This sediment is primarily decayed plant and animal matter and eroded soil that has washed in from the surrounding land. The sediment also contains nutrients such as nitrogen and phosphorous. As the sediment builds up, the lake gets shallower, the bottom sediments become more fertile, and conditions in the lake become more favorable for aquatic plant growth.

Nutrients
Like their land-based cousins, aquatic plants need sunlight, water, carbon dioxide, and nutrients-including phosphorous, nitrogen, potassium, and calcium-to grow. The watershed is the primary source of nutrients. Northern Minnesota lakes typically have few aquatic plants because the watershed is low in phosphorous and nitrogen. In central and southern Minnesota, where the soils are naturally more fertile, more nitrogen and phosphorous enter lakes from the watershed, so these nutrient-rich lakes tend to have more aquatic plants and algae.

Weather
During periods of heavy rainfall, increased runoff brings more nutrients into a lake. These additional nutrients may be released from flooded soils or carried into the lake on silt or clay particles. Excess nutrients often boost plant growth, particularly algae or free-floating aquatic plants. If rainfall and water levels are normal, nutrient levels and plant growth tend to remain stable. Conversely, frequent low water levels can promote plant growth, particularly that of rooted plants, by expanding the shallow-water areas available for growth.

Human Activities
Intense cultivation or land development near a lake can also increase the amount of aquatic plants by increasing the amount of nutrients flowing from the watershed into the water. Nutrient-laden discharges from sewage treatment plants, livestock feedlots, and leaky septic systems

promote heavy growth of aquatic plants. Development within a watershed also speeds up the aging process of a lake. The construction of roads and houses removes vegetation that would normally protect soils, leading to more soil erosion. The addition of houses, paved driveways, and other hard surfaces adds to the amount of nutrient-rich runoff that flows into lakes and streams. For all of these reasons, lakes and ponds that did not support a dense growth of aquatic plants in their natural state may show increased growth because of human activities.

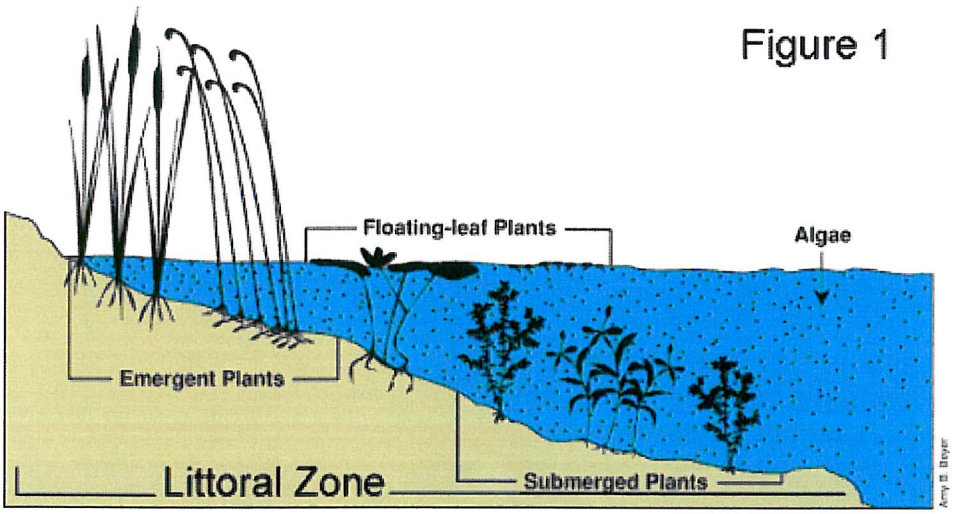
Where aquatic plants grow

Within a lake or pond, aquatic plants grow in an area known as the littoral zone--the shallow transition zone between dry land and the open water area of the lake. In Minnesota waters, the littoral zone extends from the shore to a depth of about 15 feet, depending on water clarity. The littoral zone is highly productive. The shallow water, abundant light, and nutrient-rich sediment provide ideal conditions for plant growth. Aquatic plants, in turn, provide food and habitat for many animals such as fish, frogs, birds, muskrats, turtles, insects, and snails. Protecting the littoral zone is important for the health of many of a lake's fish and other animal populations.

Aquatic plants are grouped into four major categories:

1. **Algae** have no true roots, stems, or leaves and range in size from tiny, one-celled organisms to large, multi-celled plant-like organisms, such as chara. Plankton algae, which consist of free-floating microscopic plants, grow throughout both the littoral zone and the well-lit surface waters of an entire lake. Other forms of algae, including stringy filamentous types, are common only in the littoral area.
2. **Submerged plants** have stems and leaves that grow entirely underwater, although some may also have floating leaves. Flowers and seeds on short stems that extend above the water may also be present. Submerged plants grow from near shore to the deepest part of the littoral zone (see Figure 1, below) and display a wide range of plant shapes. Depending on the species, they may form a low-growing "meadow" near the lake bottom, grow with lots of open space between plant stems, or form dense stands or surface mats.
3. **Floating-leaf plants** are often rooted in the lake bottom, but their leaves and flowers float on the water surface. Water lilies are a well-known example. Floating leaf plants typically grow in protected areas where there is little wave action.
4. **Emergent plants** are rooted in the lake bottom, but their leaves and stems extend out of the water. Cattails, bulrushes, and other emergent plants typically grow in wetlands and along the shore, where the water is less than 4 feet deep.

As Figure 1 illustrates, each of the four types of aquatic plants favors a certain water depth. Typically, however, the growth areas are not sharply divided. Expect to see overlap in growth--submerged plants, for example, interspersed among floating-leaf varieties.



The width of the littoral zone will vary within a lake and among lakes. In places where the slope of the lake bottom is steep, the littoral area may be narrow, extending several feet from the shoreline. In contrast, if the lake is shallow and the bottom slopes gradually, the littoral area may extend hundreds of feet into the lake or may even cover it entirely.

Cloudy or stained water, which limits light penetration, may restrict plant growth. In lakes where water clarity is low all summer, aquatic plants will not grow throughout the littoral zone but will be restricted to shallow areas near shore.

Other physical factors also influence the distribution of plants within a lake or pond. For example, aquatic plants generally thrive in shallow, calm water protected from heavy wind, wave, or ice action. However, if the littoral area is exposed to the frequent pounding of waves, plants may be scarce. In a windy location, the bottom may be sand, gravel, or large boulders--none of which provides a good place for plants to take root. In areas where a stream or river enters a lake, plant growth can be variable. Nutrients carried by the stream may enrich the sediments and promote plant growth, or suspended sediments may cloud the water and inhibit growth.

In summary: Where aquatic plants grow and how abundant they are may vary greatly from lake to lake, and even within a lake itself. Before making decisions that could affect the shoreline, examine the distribution and composition of the plant community in any lake.

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Species to be planted in restoration areas

Emergent Species

Blue Flag Iris *(Iris versicolor)*

Common names: Wild iris; northern blue flag.

Location: Found in wetlands, stream banks and shallow water (less than 1 m deep) of ponds and lakes.

Description: The leaves and flower stalks emerge from a stout rhizome that is very shallow and sometimes exposed above the sediment. The sword-like leaves grow in flattened, fan-like clusters. The flower stalks are taller than the leaves, creating the 'flag' appearance.

Importance of plant: Frequently grazed by muskrats and provides food for a variety of waterfowl including canvasback, gadwall, goldeneye and redhead. Also provides good cover for wildlife and waterfowl.

Management strategy: The white water lily has much value for waterfowl and wildlife habitat and as a decorative nearshore plant. Water depth will limit the spread of the plant as it is found in water less than 1 m in depth. Once established, the iris's thick tubers make hand-pulling or cutting difficult. Adjacent property owners most likely will enjoy the added beauty this plant provides.

Softstem Bulrush *(Sciripus validus)*

Common names: Bulrush, reeds.

Location: Grows rooted in mucky or silty bottoms in water less than 2 meters deep.

Description: Identifiable by its tall, flexible stems that emerge from a shallow rhizome. The cylindrical, bluish-green stems are spongy when pressed between fingers. .

Importance of plant: Provides excellent habitat for invertebrates and shelter for young fish. The nutlets are consumed by a wide variety of waterfowl, marsh birds, and upland birds while the stalks provide nesting material and cover.

Management strategy: Softstem bulrush has much value as fish habitat and as sediment stabilization. The roots of the bulrush are prolific and dense. Boat traffic and predation by waterfowl and muskrats will limit the spread of the plant by opening and maintain a path through stands. An attractive plant, stands tend to be relatively easy to see through; an attribute that many adjacent landowners may appreciate (versus dense stands such as cattails).

Pickeralweed *(Pontederia cordata)*

Common names: Heartweed.

Location: Grows in a variety of sediments in water depths ranging from 3 inches to 2 meters deep.

Description: Lavender to blue shade flower spike above glossy, heart-shaped leaves that emerge from a robust, sprawling, air-filled stalks. Each blossom has a tubular portion that contains the nectar and flared lobes. Occasionally plants with white blossoms have been found.

Importance of plant: The flowering stalk is a haven for many insects – some seeking nectar and other a spot to rest. The seeds are consumed by waterfowl as well as muskrats. Networks of rhizomes and leaves also offer shade and shelter for fish. Beds of pickerelweed can be important shoreline stabilizers and help dampen wave action.

Management strategy: Pickeralweed has great value as a shoreline sediment stabilizer and as a decorative plant. Boat traffic will limit the spread of the plant by opening and maintain a path through stands. The beauty of the pickerelweed plant and its preference for nearshore areas will gain appreciation from adjacent landowners.

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Floating Leaf Species

White Water Lily *(Nymphaea odorata)*

Common names: Lily pad; fragrant water lily.

Location: Grows rooted in mucky or silty bottoms up to 5 feet deep.

Description: White flower with rows of petals surrounding a yellow center; rooted on the bottom and floating on the water surface or extending slightly above it; surrounded by round, floating leaves that are green-colored and 6 to 12 inches in diameter; plant stem is mostly below water surface.

Importance of plant: Provides excellent habitat for largemouth bass and sunfish; seeds are eaten by waterfowl; highly decorative----often planted in water gardens.

Management strategy: The white water lily has much value as fish habitat and as a decorative plant. Boat traffic will limit the spread of the plant by opening and maintain a path through stands, however herbicide can also provide effective control. The lily's thick tubers make hand-pulling or cutting difficult.

Submergent Species

Broad-leaf Pondweeds *(Potamogeton spp.)*

Common names: Large-leaf pondweed, claspingleaf (Richardson) pondweed, floating-leaf pondweed, whitestem pondweed, broad-leaf cabbage, musky cabbage, bass weed.

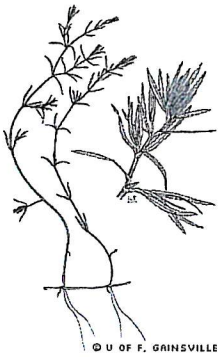
Location: Found in lakes and streams, growing in depths up to 20 feet; often grow near drop-offs.

Description: Leaves 2 to 8 inches long; large-leaf and claspingleaf pondweeds grow below the water surface, except for the flowering stalk; floating-leaf pondweed grows below the water surface, except for their flowering stalk and large, floating leaves; all species have thin and delicate submerged leaves, tough stems that are firmly rooted, and a stiff appearance when out of the water.

Importance of plants: Broad-leaf pondweeds provide excellent habitat for panfish, largemouth bass, muskellunge, and northern pike; bluegills nest near these plants and eat insects and other small animals found on the leaves; walleyes use these pondweeds for cover.

Management strategy: These plants are important fish habitat. These plants are also highly resistant to chemical control.

Bushy Pondweeds and Naiads *(Najas spp.)*



Common names: Bushy naiad,(pronounced NAY-ads) water naiad, brittle naiad, slender naiad, spiny leaf naiad.

Location: Clear water at depths of up to 20 feet.

Description: Grow entirely below water surface; have long, waving stems in deep water and are dense and bushy in shallow water. These are annual plants which must start from seed each year.

Importance of plants: Entire plants are eaten by waterfowl, especially mallards; provide cover for young largemouth bass, northern pike, small bluegills and perch.

Management strategy: Bushy pondweed has become more common in recent years; it can grow abundantly in some areas and cause problems. When control is necessary, aquatic herbicides can be effective.

Narrow-leaf Pondweeds *(Potamogeton zosteriformes, Potamogeton foliosus, Potamogeton pectinatus)*

Common names: Flat-stemmed, leafy, and sago pondweeds.

Location: Grow below water surface; are firmly rooted; have branched, slender stems; have grasslike, narrow leaves; may have flowers or seeds extending above water surface; are limp when out of the water.

Importance of plants: Provide some cover for bluegills, perch, northern pike, and muskellunge, though these fish prefer broad-leaf pondweeds; good cover for walleye; provide food for waterfowl; support aquatic insects and many other small animals that fish and ducklings eat. Swans, geese, and diving ducks such as canvasbacks favor the tubers and seeds of sago pondweed.

Management strategy: Aquatic herbicides can be an effective control method if stands grow to be a nuisance.

Wild Celery *(Vallisneria americana)*

Common names: Water celery, eelgrass, tapegrass.

Location: Lakes in depths up to 15 feet and streams; prefers semi-hard bottom such as sand covered with a thin layer of muck.

Description: Leaves are ribbon-like, dark-green, and grow below the water surface; rooted in mud; in late summer, produces a small, whitish-yellow flower, supported by a coiled stalk; often grows in beds amid pondweeds and other submerged plants.

Hints to identify: Unbranched leaves extending from the lake bottom to the water surface; flowers (and occasionally some leaves) float on the surface; leaves are attached to a horizontal central stem right above lake bottom.

Importance of plant: Provides shade and shelter for bluegills, young perch, and largemouth bass; choice food of waterfowl, particularly diving ducks; attracts muskrats, marsh birds, and shore birds.

Management strategy: See DNR regulations. Because wild celery is an excellent wildlife food, it is usually best left alone. Abundant growth during July and August in shallow water may interfere with recreation. Herbicides don't work well to control this plant. Hand-pulling or raking sometimes works, though floating, uprooted plants often re-establish themselves in shallow water.

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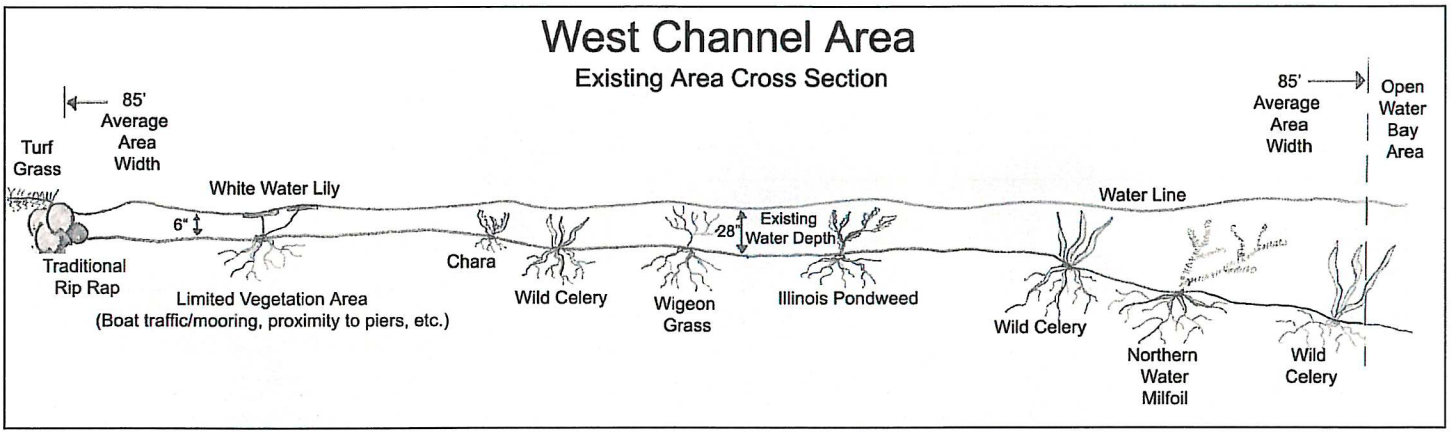
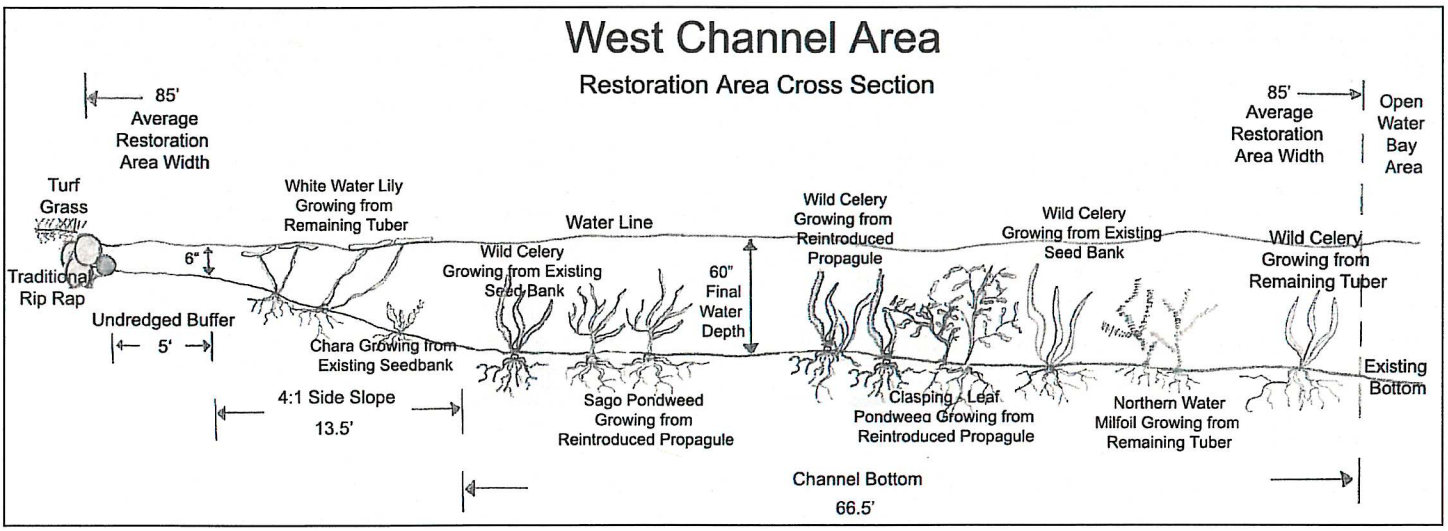
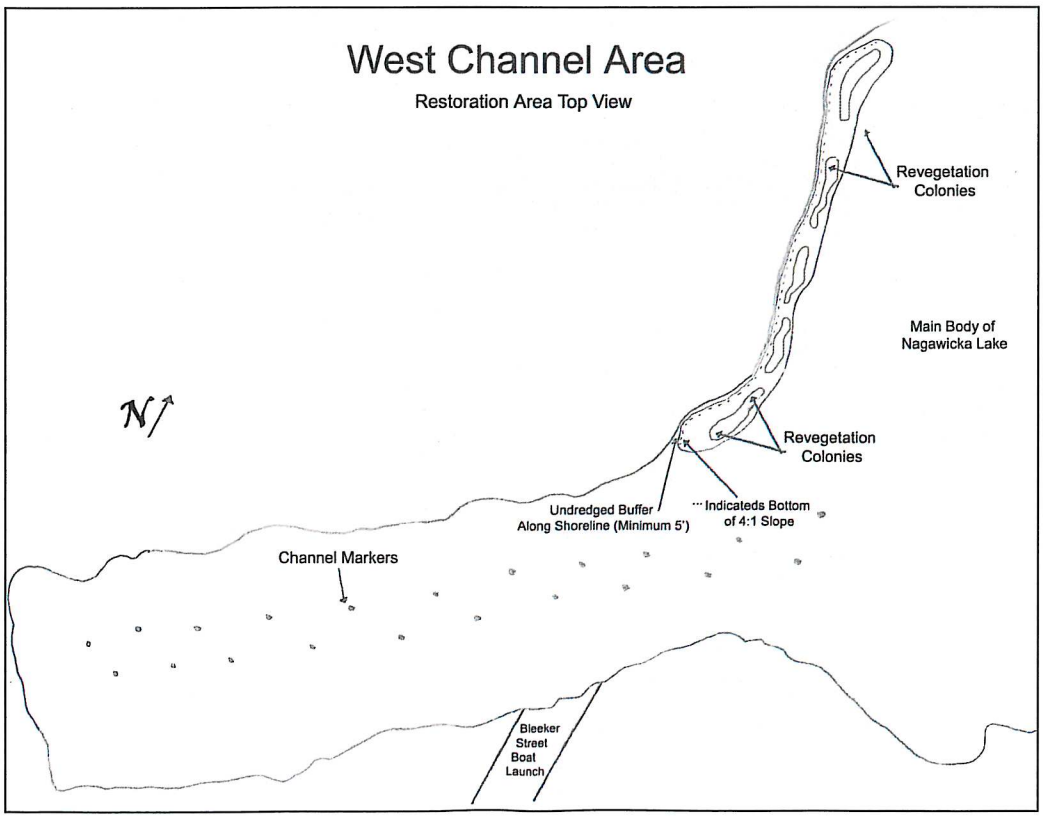
Restoration Plans for West Channel Area







Restoration Methodology for West Channel Area

Description of Restoration Area

The shoreline area just south of the west channels is also a developed residential area. Very shallow water depths are seen within and just waterward of the pierhead line along most of the shoreline in this area. Continued accumulation of organic matter (cut aquatic vegetation, duckweed, leaf litter, etc.) has lessened the water depths of this area.

Adjacent areas with deeper water levels support a diverse, healthy, stable aquatic plant community. Species found in all three areas include water celery, clasping-leaf pondweed, sago pondweed, whorled and northern milfoil, along with a variety of others.

Revegetation Plan

The revegetation focus for this area is to stabilize the newly dredged areas while blending with the healthy communities in the adjacent bay. The stabilization of the newly dredged areas is not only to hold exposed sediments in place, but also to return native vegetation to the areas before exotic species such as Eurasian Water Milfoil or curly-leaf pondweed have a chance to take hold. Dredging in these areas will follow the basic project protocol of 4:1 side slopes to a 5' water depth. Areas along water's edge will have a minimum 5' undredged buffer allowing for stability of shoreline vegetation and sediment. These areas have variable water depths along the edge of the dredge prism and may be limited to deeper water emergents. Nearly all of the land adjacent to the dredged area here is developed. Emergents will be placed at a density of 1 plant per linear ft. in clusters along lot line areas. Final dredge depths are not expected to reach natural bottom which will allow for the primary use of weighted propagules for the restoration plantings.

Revegetation Species List

Main Species
water celery
sago pondweed
clasping–leaf pondweed
slender naiad

Shallow Water Emergent Species (inches to 1.5' water depth)
blue flag iris
common arrowhead
river bulrush
burreed

Deep Water Emergent Species (1.5' to 3' water depth)
softstem bulrush
pickeralweed
slender arrowhead

Estimated Planting Needs

West Channel Area – MR – 3
*All planting will be done by boat to minimize migration of sediment into dredged areas
*Five oval shaped submergent plant colonies will be restored along the lot lines of the 7 properties in this area 5x(30'x100')= 15,000 sq. ft.
*5,000 submergent plants (weighted propagules) utilized
*Planting density 1 plant per 3 sq. ft.
*Five exclosures will be utilized in this area
*Approximately 1,500 emergent plants utilized along shorelines in this area
*Due to varying water depths along the top of the dredge prism, a mix of shallow and deeper water emergents will be utilized in the nearshore area clustered along property lines
*The exclosure will be erected a minimum of 10' from any piers
*The exclosure will only be utilized for one growing season

Monitoring and Maintenance Plan

*No mechanical harvesting in dredged areas for a minimum of 5 years.

*Beginning the first spring after sediment removal, the area will be treated for Eurasian Water Milfoil with 2,4D prior to native plant emergence. Successive year's spraying will be determined each August during the second seasonal monitoring/evaluation site visit of the vegetation restoration.

*Monitoring of native emergent & submergent success to be done in June and early August each year.

*Any necessary replanting is to be done in July beginning in the 3rd year after dredging. Evaluation of any new replanting is to be completed during the August site visit/evaluation.

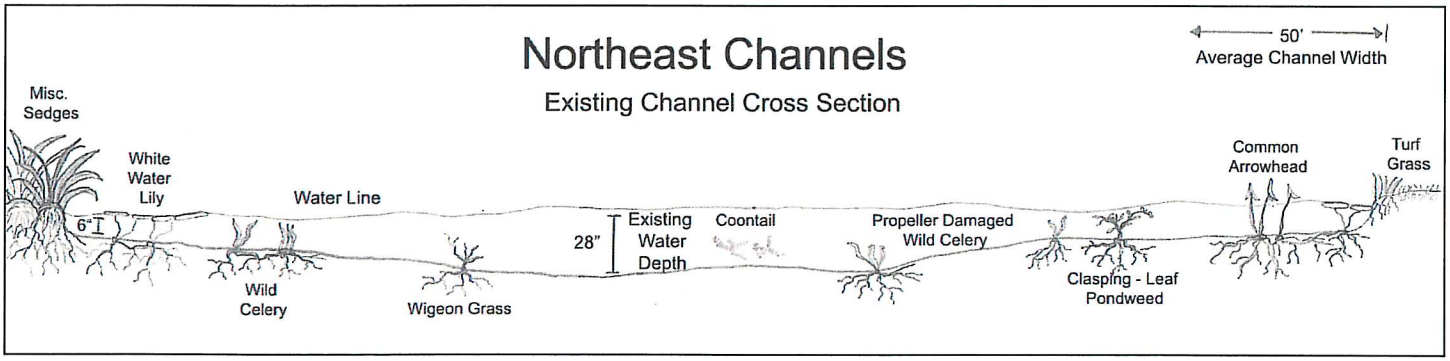
*The following performance standards are to be documented on each site visit/evaluation

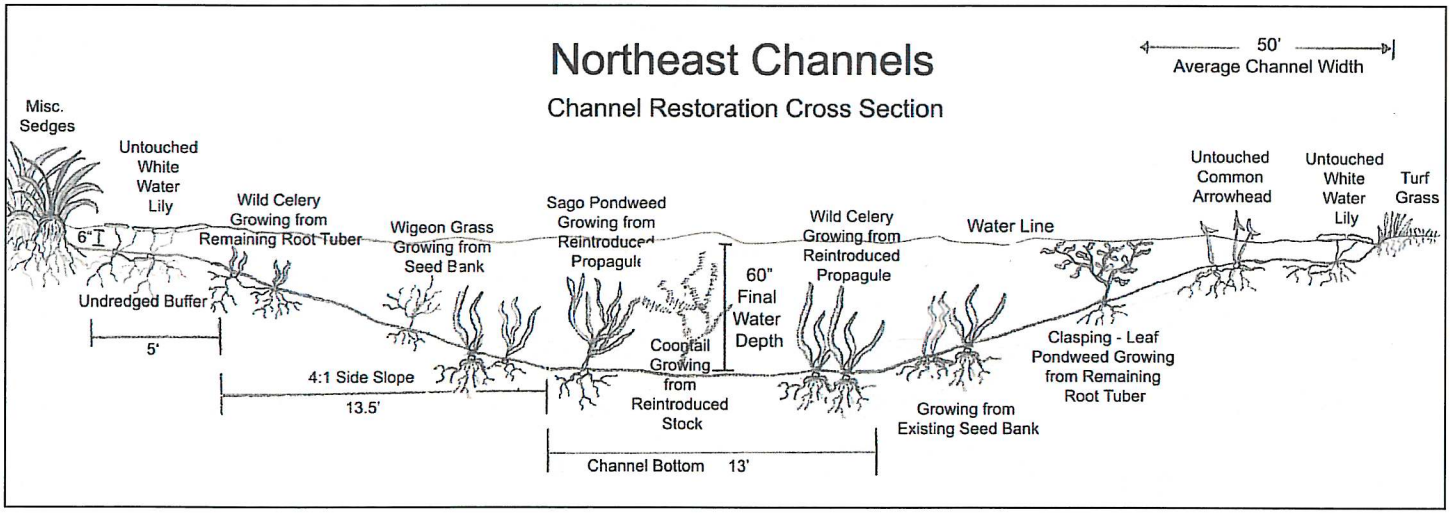
<u>Submergent Standards</u>
% of the dredged area covered in native vegetation
% dredged area submergent regrowth native species
% known restored species
% damaged by animal or boat traffic
Water depths in health stand areas

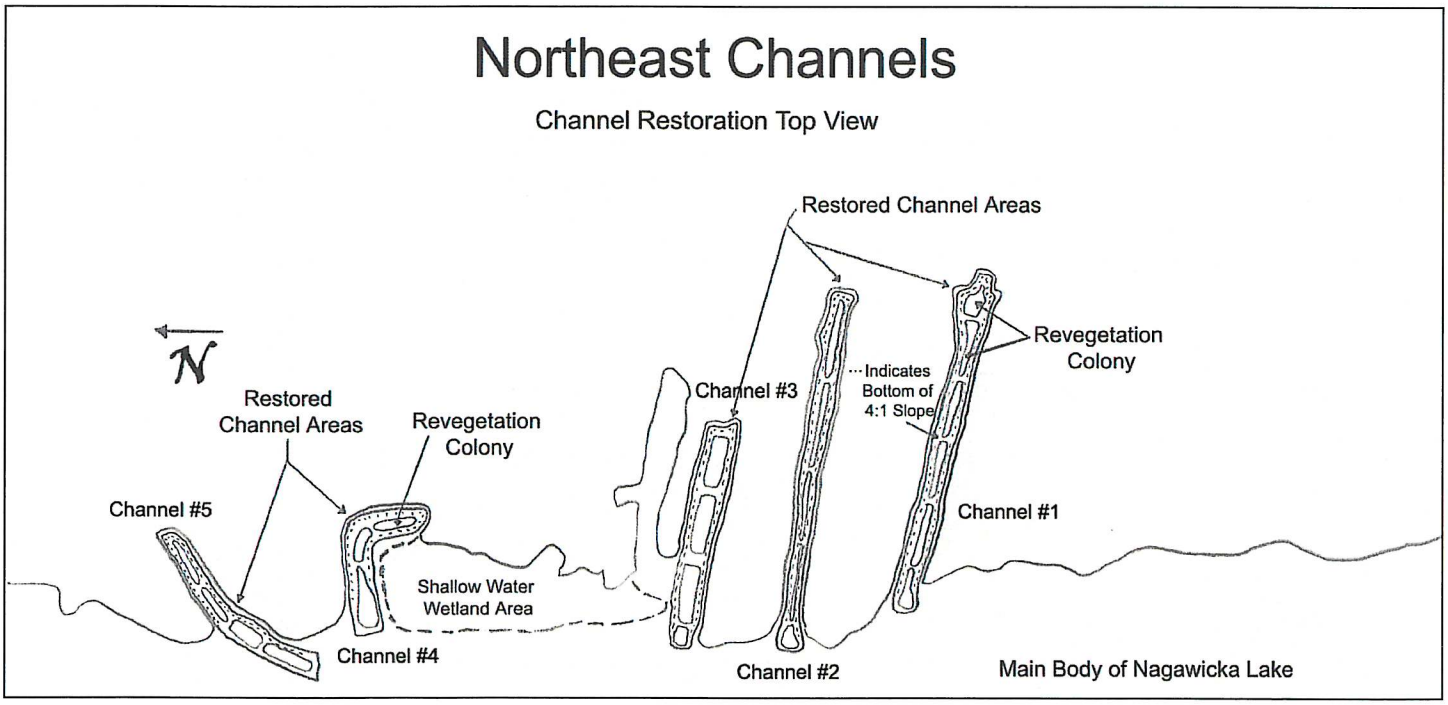
<u>Emergent Standards</u>
% of the nearshore area colonized with emergents
% of the nearshore vegetation that is native
% known restored species
% damaged by animal or boat traffic
Stand size of known restored species
Water depths in healthy stand areas

<u>General Information</u>
Signs of siltation on vegetation
Flocculent sediment depths

Restoration Plans for the Northeast Channels







Restoration Methodology for the Northeast Channels

Description of Restoration Area

The northeast channels consist of 6 individual channels that reach from the main body of Nagawicka Lake into the residential developments away from the main shoreline area. These channels, while used primarily for navigational purposes, also support a diverse variety of vegetation on their shorelines, near shore areas, and along the submerged channel substrate as well. Over time, these channels have accumulated high amounts of organic matter (cut aquatic vegetation, duckweed, leaf litter, etc.). Navigation through these areas has become difficult to impossible. The removal of sediment mainly from the center of the channel will allow for reasonable access by the landowners. The channel shorelines are well stabilized with a variety of species include swamp willow cattails, misc. sedges, white water lilies, soft stem bulrush, wild iris along with a variety of others.

Revegetation Plan

The revegetation focus for these channels is to create increased accessibility while protecting the diverse shoreline vegetation and corresponding soil stability. The commitment to leaving a minimum 5' undredged buffer along the water's edge will help to keep the near shore sediment stable. In addition to holding exposed sediments in place, restored native vegetation will take hold before exotic species such as Eurasian Water Milfoil or curly-leaf pondweed have a chance to invade. Dredging in these areas will follow the basic project protocol of 4:1 side slopes to a 5' water depth. Again, areas along water's edge will have a minimum 5' undredged buffer allowing for stability of shoreline vegetation and sediment. The final width of the channel bottom will be sacrificed where necessary to ensure the stability of the undredged buffer area along the water's edge. These areas will be vegetated with a variety of emergent species. Since the water depths in these areas are very shallow, a wide diversity of species can be used. Emergents will be placed at a density of 1 plant per linear ft. along the majority of the 2 channels where dredging is to occur since there is little to no development along these channels. Final dredge depths are not expected to reach natural bottom which will allow for the use of weighted propagules for submergent restoration plantings in the channel second from the top and second from the bottom.

Revegetation Species List for Both Channels 3 and 4

Submergent Species
water celery
sago pondweed
clasping – leaf pondweed
slender naiad

Shallow Water Emergent Species (inches to 1.5' water depth)
blue flag iris
common arrowhead
river bulrush
burreed

Deep Water Emergent Species (1.5' to 3' water depth)
softstem bulrush
pickeralweed
slender arrowhead

Estimated Planting Needs – Northeast Channels – Channel 3

*All planting will be done by boat to minimize migration of sediment into dredged areas
*1 long replanted submergent plant colony (15'x100'= 1,500 sq. ft.)
*500 submergent plants (weighted propagules) utilized
*Planting density 1 plant per 3 sq. ft.
*No exclosures utilized
*Approximately 2,000 emergent plants utilized along shorelines in this area
*Due to shallow water depths in this area, a wide diversity of emergent species can be used

Estimated Planting Needs – Northeast Channels – Channel 4

*All planting will be done by boat to minimize migration of sediment into dredged areas
*1 long replanted submergent plant colony (15'x100'= 1,500 sq. ft.)
*500 submergent plants (weighted propagules) utilized
*Planting density 1 plant per 3 sq. ft.
*No exclosures utilized
*Approximately 2,000 emergent plants utilized along shorelines in this area
*Due to shallow water depths in this area, a wide diversity of emergent species can be used

Monitoring and Maintenance Plan

*No mechanical harvesting in dredged areas for a minimum of 5 years.

*Beginning the first spring after sediment removal, the area will be treated for Eurasian Water Milfoil with 2,4D prior to native plant emergence. Successive year's spraying will be determined each August during the second seasonal monitoring/evaluation site visit of the vegetation restoration.

*Monitoring of native emergent & submergent success to be done in June and early August each year.

*Any necessary replanting is to be done in July beginning in the 3rd year after dredging. Evaluation of any new replanting is to be completed during the August site visit/evaluation.

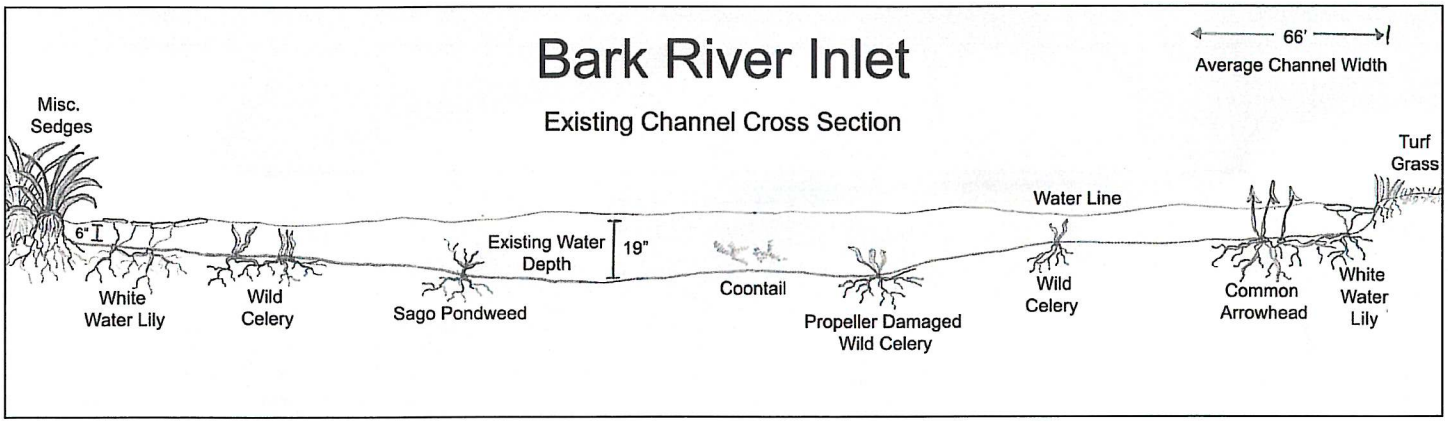
*The following performance standards are to be documented on each site visit/evaluation

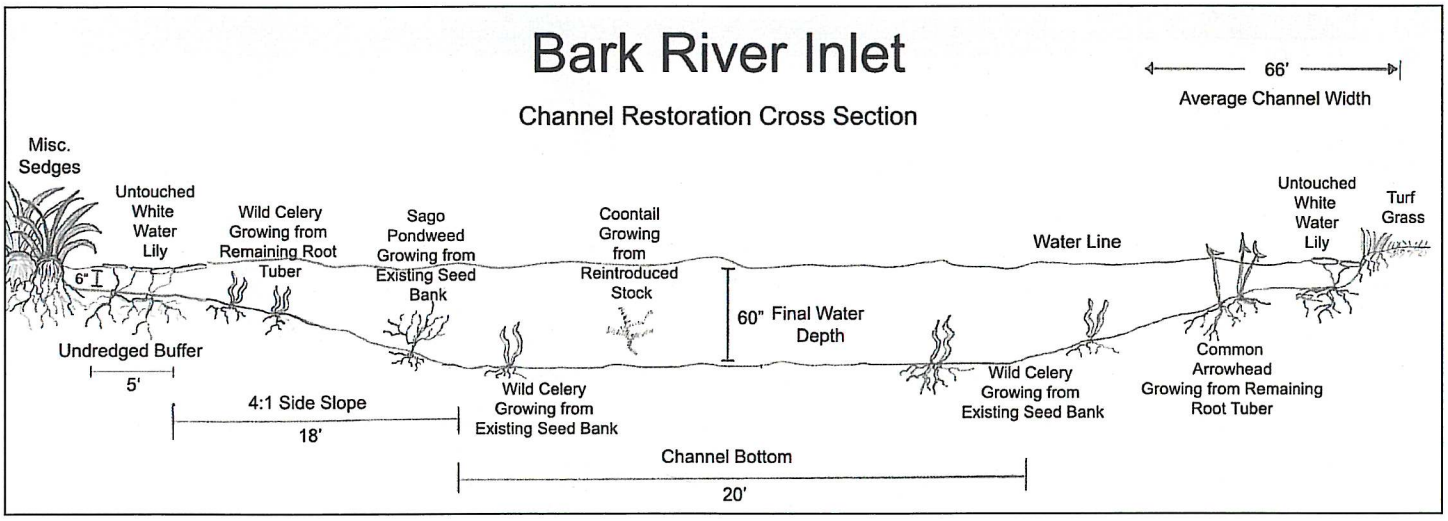
<u>Submergent Standards</u>
% of the dredged area covered in native vegetation
% dredged area submergent regrowth native species
% known restored species
% damaged by animal or boat traffic
Water depths in health stand areas

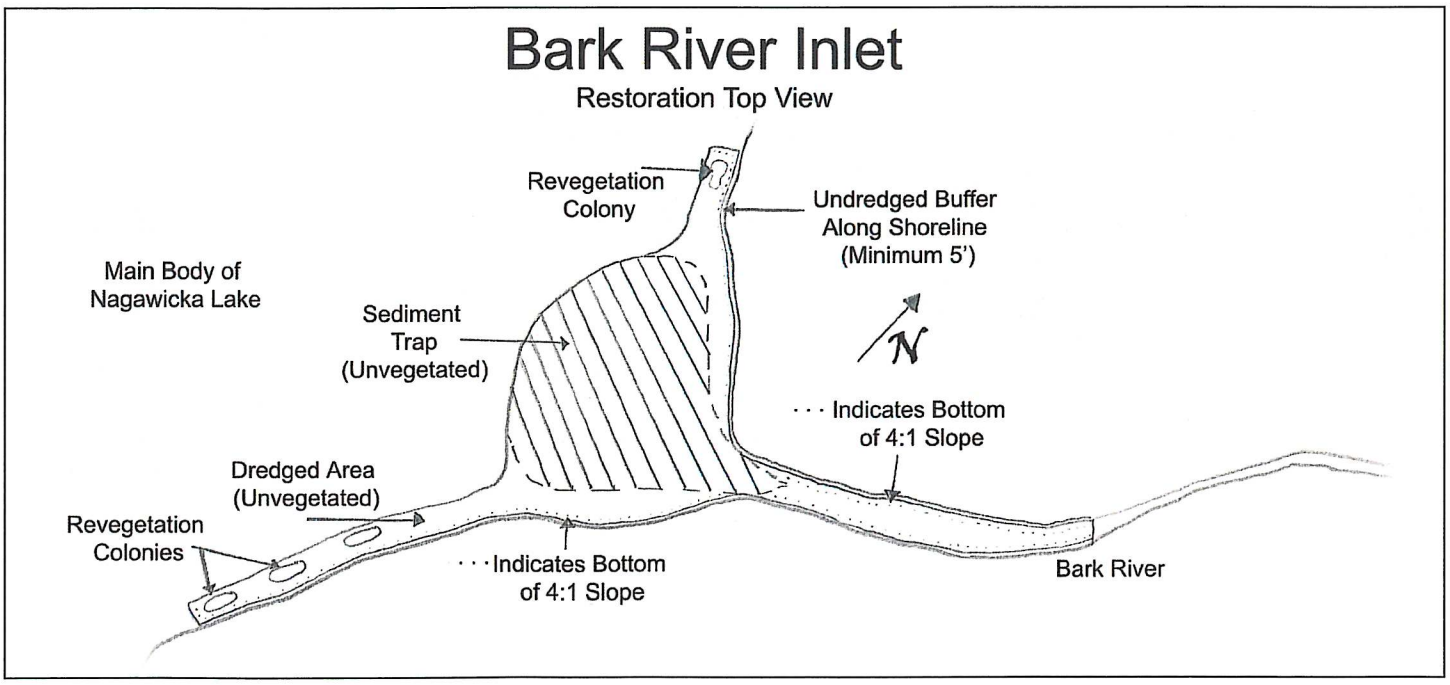
<u>Emergent Standards</u>
% of the nearshore area colonized with emergents
% of the nearshore vegetation that is native
% known restored species
% damaged by animal or boat traffic
Stand size of known restored species
Water depths in healthy stand areas

<u>General Information</u>
Signs of siltation on vegetation
Flocculent sediment depths

Restoration Plans for the Bark River Inlet







Restoration Methodology for the Bark River Inlet

Description of Restoration Area

The Bark River Inlet is the main tributary into Nagawicka Lake. A large portion of the Bark River's watershed is agricultural in nature which accounts for much of the siltation occurring in the restoration area. The existing vegetation is sparse and extremely sediment laden. Continued sedimentation into the area may be limited through the addition of the sediment trap at the mouth of the Bark River. Areas directly adjacent to the sediment trap area are also quite shallow and have a soft, flocculent substrate. Little to no aquatic vegetation exists in much of this area.

Revegetation Plan

The focus of the revegetation in this area is along the adjacent shoreline areas away from the impacts of the most dramatic sedimentation. The sediment trap and the immediate shoreline areas adjacent to it are not expected to provide very good quality habitat. These areas are anticipated to be continually impacted by sediment inputs from the Bark River watershed therefore limited revegetation success. Dredging in the river and along the shoreline areas will follow the basic project protocol of 4:1 side slopes to the 5' water depth. Areas along water's edge will have a minimum 5' undredged buffer allowing for stability of shoreline vegetation and sediment. These areas will be vegetated with a variety of emergent species. Emergents will be placed at a density of 1 plant per linear ft. in undeveloped areas and in similar clusters along lot line areas in developed areas. Final dredge depths are not expected to reach natural bottom which will allow the use of weighted propagules for the submergent restoration plantings.

Revegetation Species List

Submergent Species
water celery
sago pondweed
clasping – leaf pondweed
slender naiad

Shallow Water Emergent Species (inches to 1.5' water depth)
blue flag iris
common arrowhead
river bulrush
burreed

Deep Water Emergent Species (1.5' to 3' water depth)
softstem bulrush
pickeralweed
slender arrowhead

Estimated Planting Needs – Bark River Inlet - SR-5

*All planting will be done by boat to minimize migration of sediment into dredged areas
*1 long replanted submergent plant colony (15'x100'= 1,500 sq. ft.)
*500 submergent plants (weighted propagules) utilized
*Planting density 1 plant per 3 sq. ft.
*No exclosures utilized
*Approximately 2,000 emergent plants utilized along shorelines in this area
*Due to shallow water depths and their dense stalks (to tolerate the flow from the Bark River), river bulrush, softstem bulrush, burreed, and wild iris will be the dominant emergent species replanted in this area

Monitoring and Maintenance Plan

*No mechanical harvesting in dredged areas for a minimum of 5 years.

*Beginning the first spring after sediment removal, the area will be treated for Eurasian Water Milfoil with 2,4D prior to native plant emergence. Successive year's spraying will be determined each August during the second seasonal monitoring/evaluation site visit of the vegetation restoration.

*Monitoring of native emergent & submergent success to be done in June and early August each year.

*Any necessary replanting is to be done in July beginning in the 3rd year after dredging. Evaluation of any new replanting is to be completed during the August site visit/evaluation.

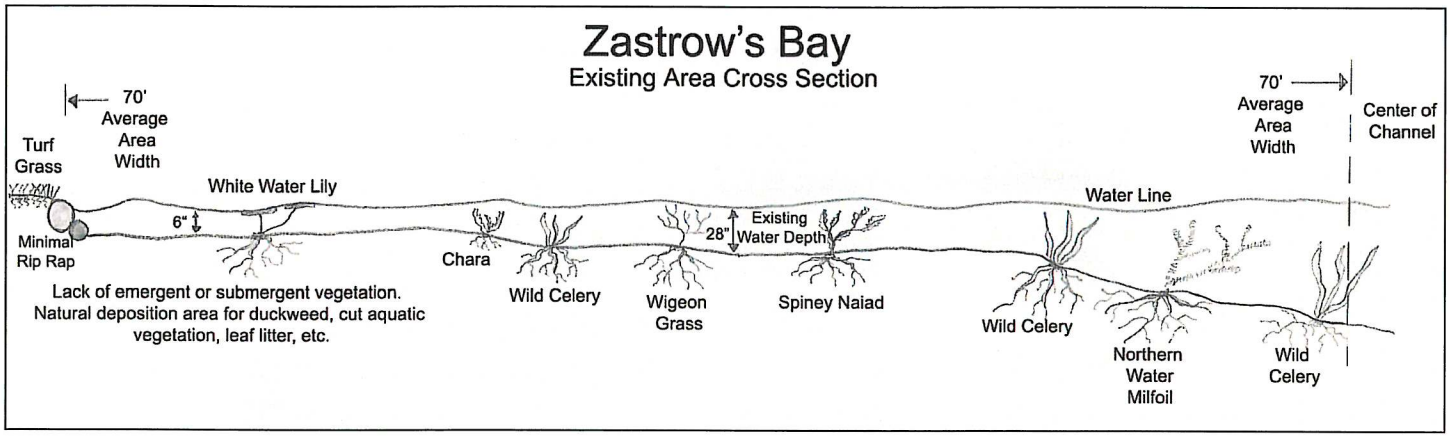
*The following performance standards are to be documented on each site visit/evaluation

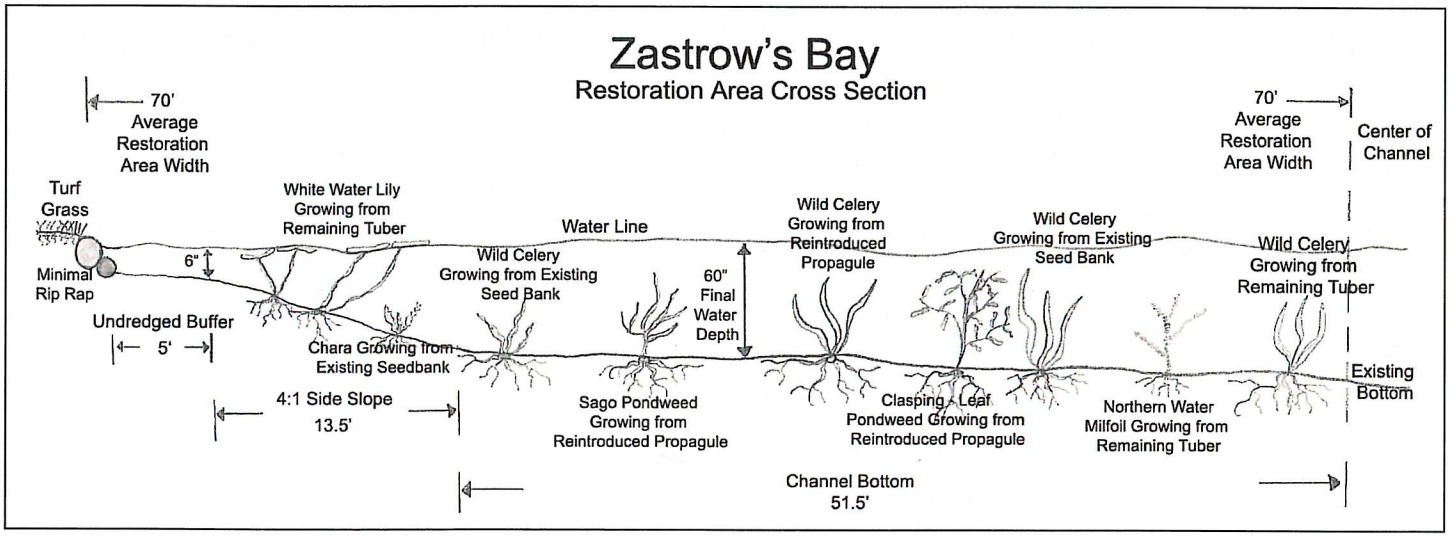
<u>Submergent Standards</u>
% of the dredged area covered in native vegetation
% dredged area submergent regrowth native species
% known restored species
% damaged by animal or boat traffic
Water depths in health stand areas

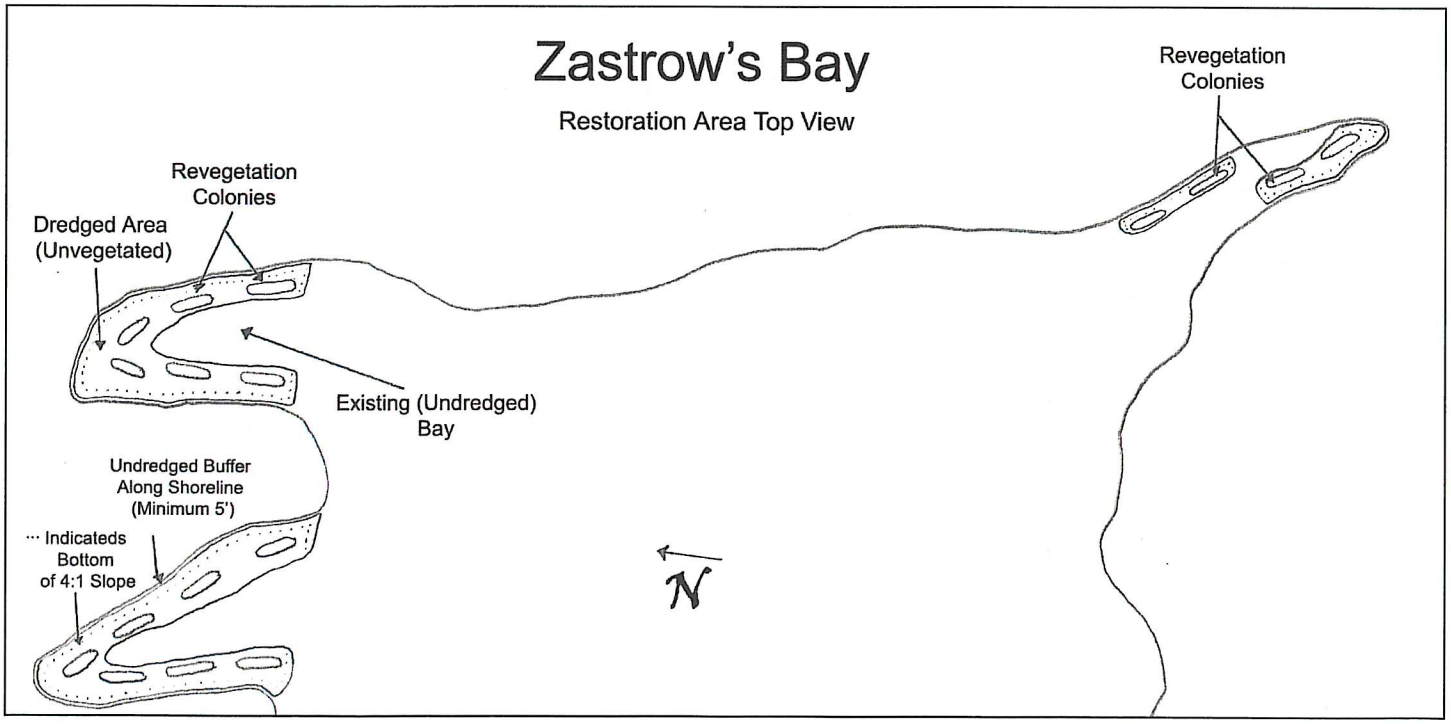
<u>Emergent Standards</u>
% of the nearshore area colonized with emergents
% of the nearshore vegetation that is native
% known restored species
% damaged by animal or boat traffic
Stand size of known restored species
Water depths in healthy stand areas

<u>General Information</u>
Signs of siltation on vegetation
Flocculent sediment depths

Restoration Plans for Zastrow's Bay







Restoration Methodology for Zastrow's Bay

Description of Restoration Area

Zastrow's Bay is heavily developed residential area. There are 3 'sub-bays' located here. The two northern bays are very similar in sedimentation and existing plant communities. Very shallow water depths are seen within and just waterward of the pierhead line around both bays. The natural bathymetry and prevailing summer winds allow for continued accumulation of organic matter (cut aquatic vegetation, duckweed, leaf litter, etc.) along the shorelines. This accumulation of material not only impacts navigation, but also has a limiting effect on near shore vegetation.

This accumulation of organic material also exists in the southern sub-bay of Zastrow's Bay. In addition, this bay also has a large stormwater inlet that adds additional sediment to the area. Two small areas of sub-bay show the most impact of the sedimentation. These areas are similar to the northern sub-bays in that deeper water levels found farther out in the center of the bays support a diverse, healthy, stable aquatic plant community. Species found in all three areas include water celery, clasping-leaf pondweed, sago pondweed, whorled and northern milfoil, along with a variety of others.

Revegetation Plan

The revegetation focus for this area is to stabilize the newly dredged areas while blending with the healthy communities in the center of the bays. The stabilization of the newly dredged areas is not only to hold exposed sediments in place, but also to return native vegetation to the areas before exotic species such as Eurasian Water Milfoil or curly-leaf pondweed have a chance to take hold. Dredging in these areas will follow the basic project protocol of 4:1 side slopes to a 5' water depth. Areas along water's edge will have a minimum 5' undredged buffer allowing for stability of shoreline vegetation and sediment. These areas will be vegetated with a variety of emergent species. Emergents will be placed at a density of 1 plant per linear ft. in clusters along lot line areas. Nearly all of the land adjacent to the dredging in Zastrow's Bay is developed. Final dredge depths are not expected to reach natural bottom which will allow for the use of weighted propagules for the restoration plantings.

Revegetation Species List

Main Species
water celery
sago pondweed
clasping–leaf pondweed
slender naiad

Shallow Water Emergent Species (inches to 1.5' water depth)
blue flag iris
common arrowhead
river bulrush
burreed

Deep Water Emergent Species (1.5' to 3' water depth)
softstem bulrush
pickeralweed
slender arrowhead

Estimated Planting Needs

Zastrow's Bay West Channel – MR – 1
*All planting will be done by boat to minimize migration of sediment into dredged areas
*A V-shaped submergent plant colony (60'x100'= 6,000 sq. ft.)
*2,000 submergent plants (weighted propagules) utilized
*Planting density 1 plant per 3 sq. ft.
*An exclosure will be utilized in this area
*Approximately 1,000 emergent plants utilized along shorelines in this area
*Due to varying water depths along the top of the dredge prism, a mix of shallow and deeper water emergents will be utilized in the nearshore area clustered along property lines
*The exclosure will be erected a minimum of 10' from any piers
*The exclosure will only be utilized for one growing season

Zastrow's Bay East Channel – MR – 2
*All planting will be done by boat to minimize migration of sediment into dredged areas
*A V-shaped submergent plant colony (60'x150'= 9,000 sq. ft.)
*3,000 submergent plants (weighted propagules) utilized
*Planting density 1 plant per 3 sq. ft.
*An exclosure will be utilized in this area
*Approximately 1,000 emergent plants utilized along shorelines in this area
*Due to varying water depths along the top of the dredge prism, a mix of shallow and deeper water emergents will be utilized in the nearshore area clustered along property lines
*The exclosure will be erected a minimum of 10' from any piers
*The exclosure will only be utilized for one growing season

Zastrow's Bay South Channel – SR – 1
*All planting will be done by boat to minimize migration of sediment into dredged areas
*A V-shaped submergent plant colony (50'x30'= 1,500 sq. ft.)
*500 submergent plants (weighted propagules) utilized
*Planting density 1 plant per 3 sq. ft.
*No exclosure will be utilized in this area
*Approximately 1,000 emergent plants utilized along shorelines in this area
*Due to varying water depths along the top of the dredge prism, a mix of shallow and deeper water emergents will be utilized in the nearshore area clustered along property lines

Monitoring and Maintenance Plan

*No mechanical harvesting in dredged areas for a minimum of 5 years.

*Beginning the first spring after sediment removal, the area will be treated for Eurasian Water Milfoil with 2,4D prior to native plant emergence. Successive year's spraying will be determined each August during the second seasonal monitoring/evaluation site visit of the vegetation restoration.

*Monitoring of native emergent & submergent success to be done in June and early August each year.

*Any necessary replanting is to be done in July beginning in the 3rd year after dredging. Evaluation of any new replanting is to be completed during the August site visit/evaluation.

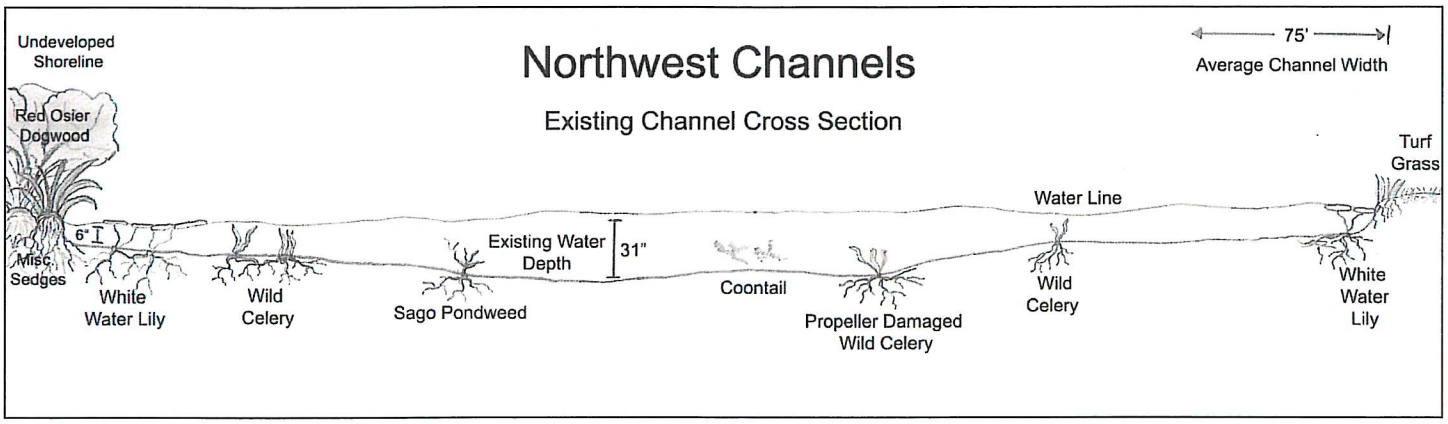
*The following performance standards are to be documented on each site visit/evaluation

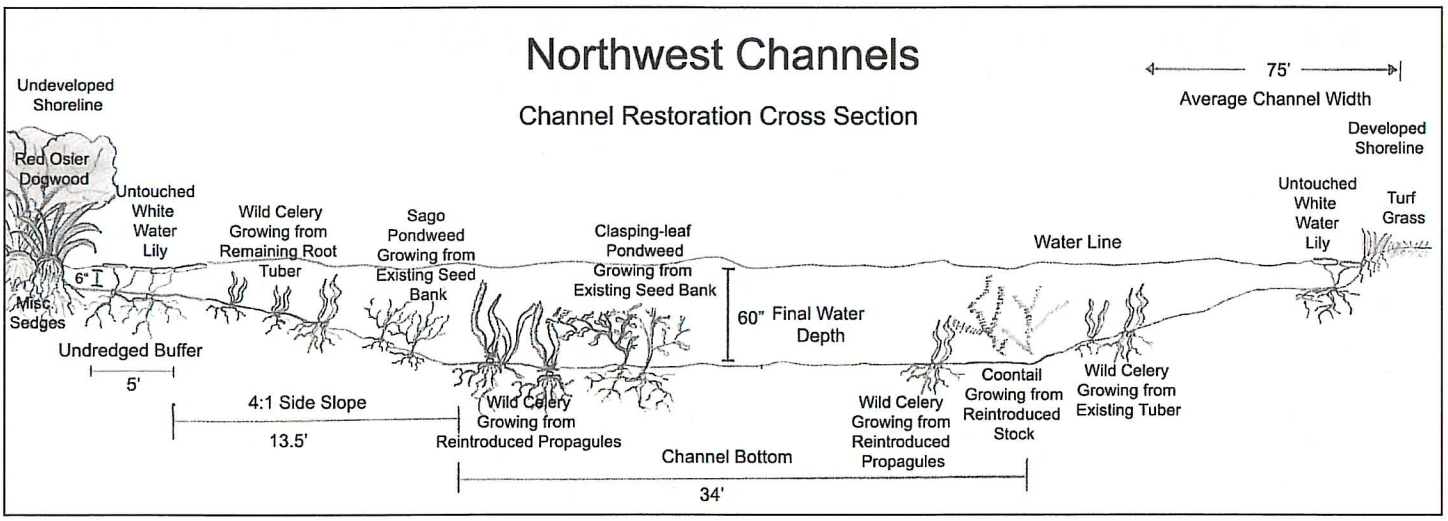
Submergent Standards
% of the dredged area covered in native vegetation
% dredged area submergent regrowth native species
% known restored species
% damaged by animal or boat traffic
Water depths in health stand areas

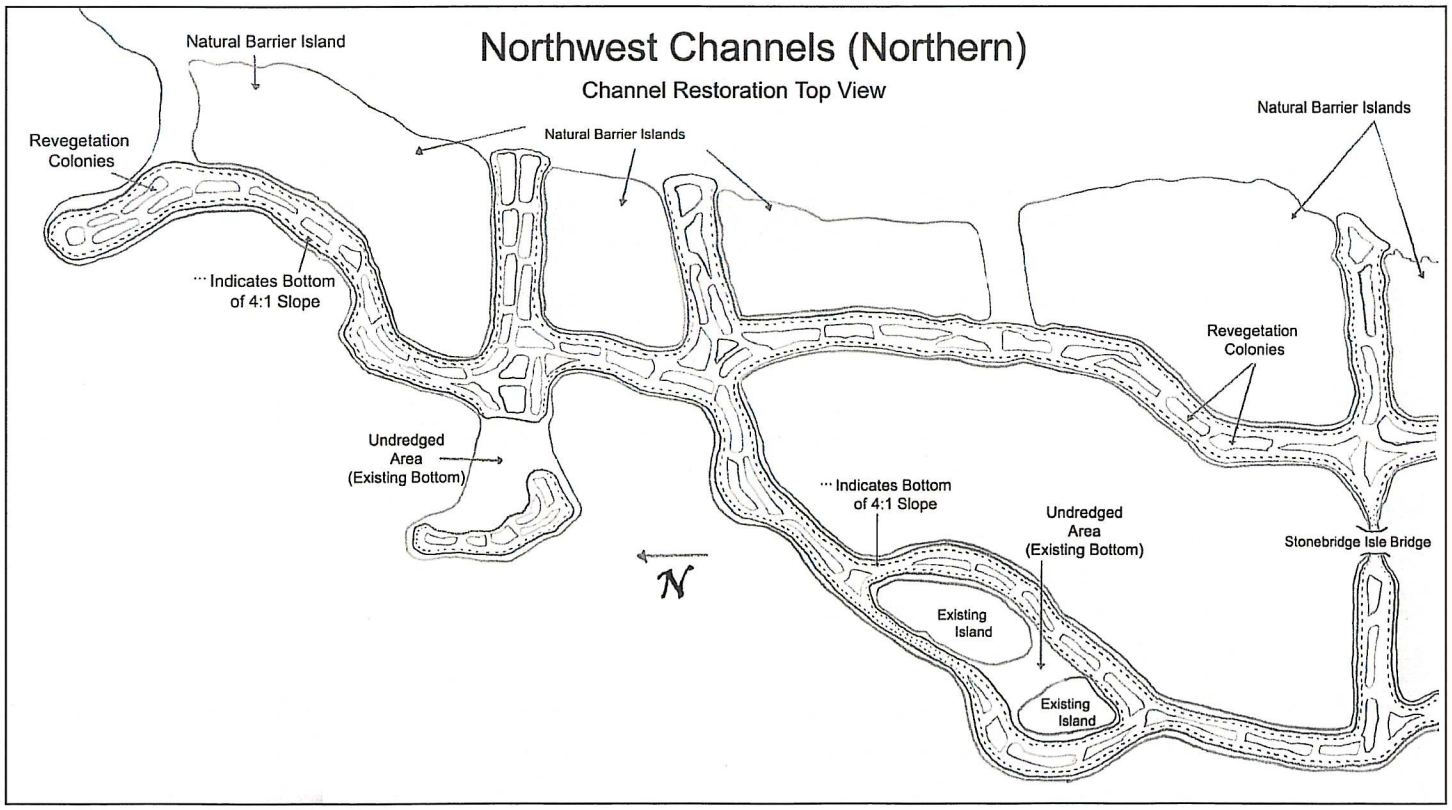
Emergent Standards
% of the nearshore area colonized with emergents
% of the nearshore vegetation that is native
% known restored species
% damaged by animal or boat traffic
Stand size of known restored species
Water depths in healthy stand areas

General Information
Signs of siltation on vegetation
Flocculent sediment depths

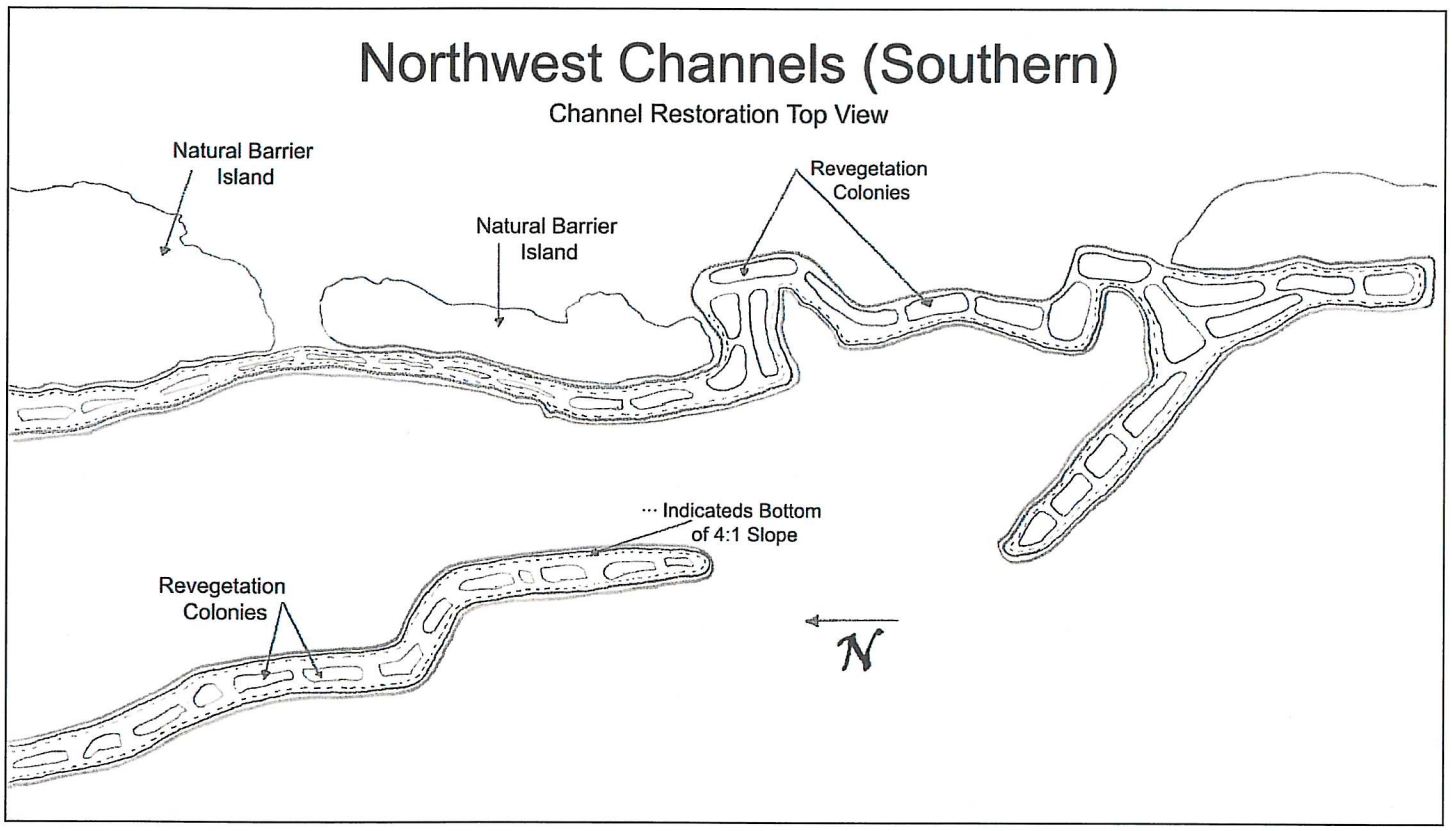
Restoration Plans for the Northwest Channels







Restoration Plans for the Northwest Channels



Restoration Methodology for the Northwest Channels

Description of Restoration Area

The Northwest Channels are a large network of channels that reach from the main body of the Nagawicka Lake into the residential developments away from the main shoreline. These channels, while used primarily for navigational purposes, also support a diverse variety of vegetation on their shorelines, near shore areas, and along the submerged channel substrate as well. Over time, these channels have accumulated thick layers of organic matter (cut aquatic vegetation, duckweed, leaf litter, etc.). Navigation through these areas has become very difficult in some areas and impossible in others. The removal of sediment mainly from the center of the channel will allow for reasonable access by the landowners. The channel shorelines are mostly stabilized either with a limited amount of rock or through variety of native plant species include swamp willow, cattails, misc. sedges, white water lilies, soft stem bulrush, wild iris along with a variety of others.

Revegetation Plan

The revegetation focus for these channels is to create increased accessibility while protecting the stability of the shorelines and the diverse shoreline vegetation found along the natural barrier islands. The commitment to leaving a minimum 5' undredged buffer along the water's edge will help to keep the near shore sediment stable. In addition to holding exposed sediments in place, restored native vegetation will take hold before exotic species such as Eurasian Water Milfoil or curly-leaf pondweed have a chance to invade. Dredging in these areas will follow the basic project protocol of 4:1 side slopes to a 5' water depth. Again, areas along water's edge will have a minimum 5' undredged buffer

allowing for stability of shoreline vegetation and sediment. The final width of the channel bottom will be sacrificed where necessary to ensure the stability of the undredged buffer area along the water's edge. Final dredge depths are not expected to reach natural bottom which will allow for the primary use of weighted propagules for the restoration plantings.

Revegetation Species List

Main Species
water celery
sago pondweed
clasping–leaf pondweed
coontail

Auxiliary Species (availability dependant)
elodea
whorled milfoil
wigeon grass
floating-leaf pondweed

Additional Comments

The deepest part of the dredged channel will be shifted more to the developed side of the channels where possible. The final width of the channel bottom will be sacrificed where necessary to ensure the stability of the undredged buffer area along the water's edge. The access channels that connect directly to the lake are impacted by ice as well. The northernmost of these corridors is not used by adjacent landowners to access the lake and has become nearly impassible.