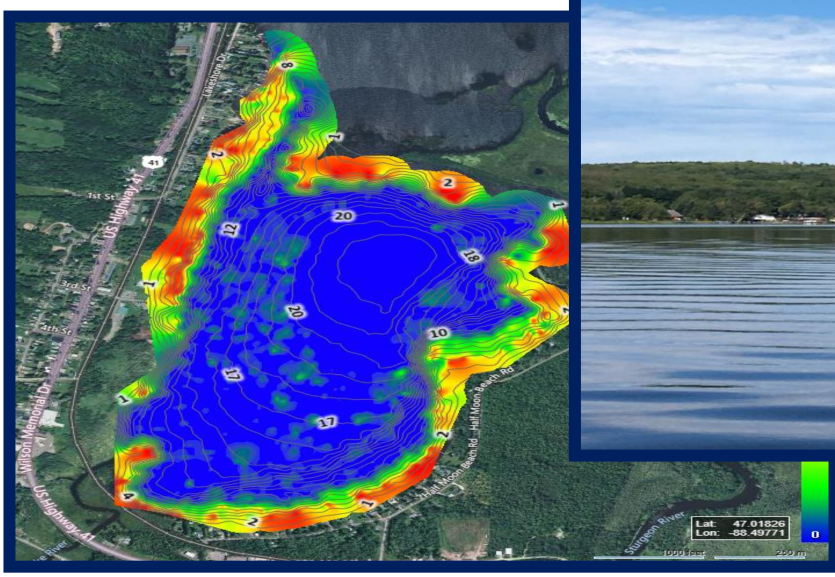
Pike Bay Aquatic Vegetation Evaluation with Professional Management Recommendations Houghton County, Michigan



Provided for: The Chassell Township Board

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September, 2023

1.0 EXECUTIVE SUMMARY

Pike Bay is nestled within the larger Portage Lake in the western Upper Peninsula of Michigan in Chassell Township, Houghton County, Michigan (T53-54N, R.34W). The Bay area surveyed is approximately 418 acres with a mean depth of 12.2 feet and a maximum depth of 23.1 feet. The approximate water volume is 4,963 acre-feet and the fetch (longest distance across) is approximately 1.3 miles.

A whole-lake aquatic plant survey and scan of aquatic vegetation biovolume was conducted on August 27, 2023. The lake scan consisted of 10,341 GPS soundings and the aquatic vegetation sampling survey utilized 373 GPS sampling stations in the lake. Previous surveys only assessed 74 sampling sites which is too low for the area of the Bay for precise estimates. Based on this evaluation, Pike Bay contains 26 native submersed, 2 native floating-leaved, and 5 native emergent aquatic plant species. This represents a very high and healthy biodiversity of native aquatic plants with 33 native aquatic plant species. The most dominant native aquatic plants were Wild Celery and Clasping-leaf Pondweed. There were two exotic invasive species found and included the submersed Eurasian Watermilfoil (EWM) and the emergent Purple Loosestrife. Approximately 57.5 acres of Eurasian watermilfoil were found, and Purple Loosestrife was noted at 25 locations around the shoreline.

Management recommendations are included later in this report but the recommended use of only systemic aquatic herbicides on the Eurasian Watermilfoil is recommended. In addition, the current distribution of Purple Loosestrife allows for manual removal so that chemicals do not need to be applied. This will help protect wetland flora and fauna. Both of these invasives must be urgently addressed to reduce their relative cover and protect the numerous native aquatic plant species in Pike Bay.

The following conclusions and recommendations can be made based on this evaluation:

1. Protect the robust and healthy native aquatic plant biodiversity in the lake.
2. Reduce invasive species such as Eurasian Watermilfoil and Purple Loosestrife.

3. Purple Loosestrife can be hand-removed without the use of herbicides were it is found. The roots must be removed with a shovel and all of the plant discarded in a sealed bag.
4. A licensed aquatic herbicide applicator should be retained for treatments beginning in 2024. To avoid any conflicts of interest, an independent consulting limnologist (such as Restorative Lake Sciences) should be retained to make objective treatment recommendations based on independent, whole-lake aquatic vegetation surveys.
5. In nearshore areas, especially beaches, the use of benthic mats and weed rollers can reduce aquatic plant germination and growth without the use of chemicals and help create favorable beach conditions.
6. The use of aquatic herbicides should be limited to ONLY areas of invasive aquatic plant growth of Eurasian Watermilfoil. The goal is to preserve as many native aquatic plants as possible for the fishery.
7. Consider future purchase of a boat washing station and place at the access site. The systems are costly (usually around $30,000 per unit) but are worth the investment. Periodic grants are available.

Restorative Lake Sciences recommends an annual whole-lake GPS survey and scan to determine the relative abundance of all native and invasive aquatic plant species, their relative abundance, and the percent cover of the lake surface area as well as follow up surveys in key areas. This data will be used each year to make management decisions about where to treat and what method(s) to use as these may change with time and results. Survey data can also be used to determine treatment efficacy. Additionally, consideration of future water quality monitoring of the Bay is recommended. Such data would allow for the generation of trends in water quality parameters over time to determine the progression of the Bay relative to trophic state.

2.0 PIKE BAY AQUATIC VEGETATION COMMUNITIES

2.1 Overview of Aquatic Vegetation and the Role for Lake Health

The overall health of Pike Bay is strongly connected to the type and density of aquatic vegetation present in the Bay. Aquatic plants (macrophytes) are an essential component in the littoral zones of most lakes in that they serve as habitat and food for macroinvertebrates, contribute oxygen to the surrounding waters through photosynthesis, stabilize bottom sediments (if in the rooted growth form), and contribute to the cycling of nutrients. In addition, decaying aquatic plants contribute organic matter to lake sediments which further supports healthy growth of successive aquatic plant communities that are necessary for a balanced aquatic ecosystem. An overabundance of aquatic vegetation may cause organic matter to accumulate on the lake bottom faster than it can break down.

Aquatic plants generally consist of rooted submersed, free-floating submersed, floating-leaved, and emergent growth forms. The emergent growth form (i.e., cattails) is critical for the diversity of insects onshore and for the health of nearby wetlands. Submersed aquatic plants can be rooted in the lake sediment (i.e., pondweeds), or free-floating in the water column (i.e., Coontail). Nonetheless, there is evidence that the diversity of submersed aquatic macrophytes can greatly influence the diversity of macroinvertebrates associated with aquatic plants of different structural morphologies (Parsons and Matthews, 1995). Therefore, it is possible that declines in the biodiversity and abundance of submersed aquatic plant species and associated macroinvertebrates, could negatively impact the fisheries of inland lakes. Alternatively, the overabundance of aquatic vegetation can compromise recreational activities, aesthetics, and property values. Similarly, an overabundance of exotic aquatic plant species can also negatively impact native aquatic plant communities and create an unbalanced aquatic ecosystem. **The biodiversity present in Pike Bay is optimum and ideal for a healthy lake fishery, but it is being threatened by invasive aquatic plants that can displace native biodiversity and impair the lake fishery over time.**

2.2 Aquatic Vegetation Sampling Methods

The aquatic plant sampling methods used for lake surveys of aquatic plant communities commonly consist of shoreline surveys, visual abundance surveys, transect surveys, AVAS surveys, and Point-Intercept Grid surveys. Such surveys are conducted on most inland lakes to assess the changes in aquatic vegetation structure and to record the relative abundance and locations of native aquatic plant species. Due to the large size and shallow mean depth of Pike Bay, a whole-lake GPS Point-Intercept grid matrix survey with 373 sampling sites was conducted from August 27, 2023 to assess all aquatic plants, including submersed, floating-leaved, and emergent species.

Additionally, a whole-lake scan of the aquatic vegetation in Pike Bay was conducted on August 27, 2023 with a WAAS-enabled Lowrance HDS 9 GPS with variable frequency transducer. This data included 10,341 bottom soundings.

Data was uploaded into a cloud software program to reveal maps that displayed depth contours (Figure 1), aquatic vegetation biovolume (Figure 2 and Table 1), and sediment relative hardness (Figure 3 and Table 2). On the aquatic vegetation biovolume map, the color blue refers to areas that lack vegetation. The color green refers to low-lying vegetation. The colors red/orange refer to tall-growing vegetation. There are many areas around the littoral (shallow) zone of the lake that contain low-growing plants like Chara or Coontail. In addition, any emergent canopies or lily pads will show as red color on the map. For this reason, the scans are conducted in conjunction with a whole lake GPS survey to account for individual species identification of all aquatic plants in the lake.

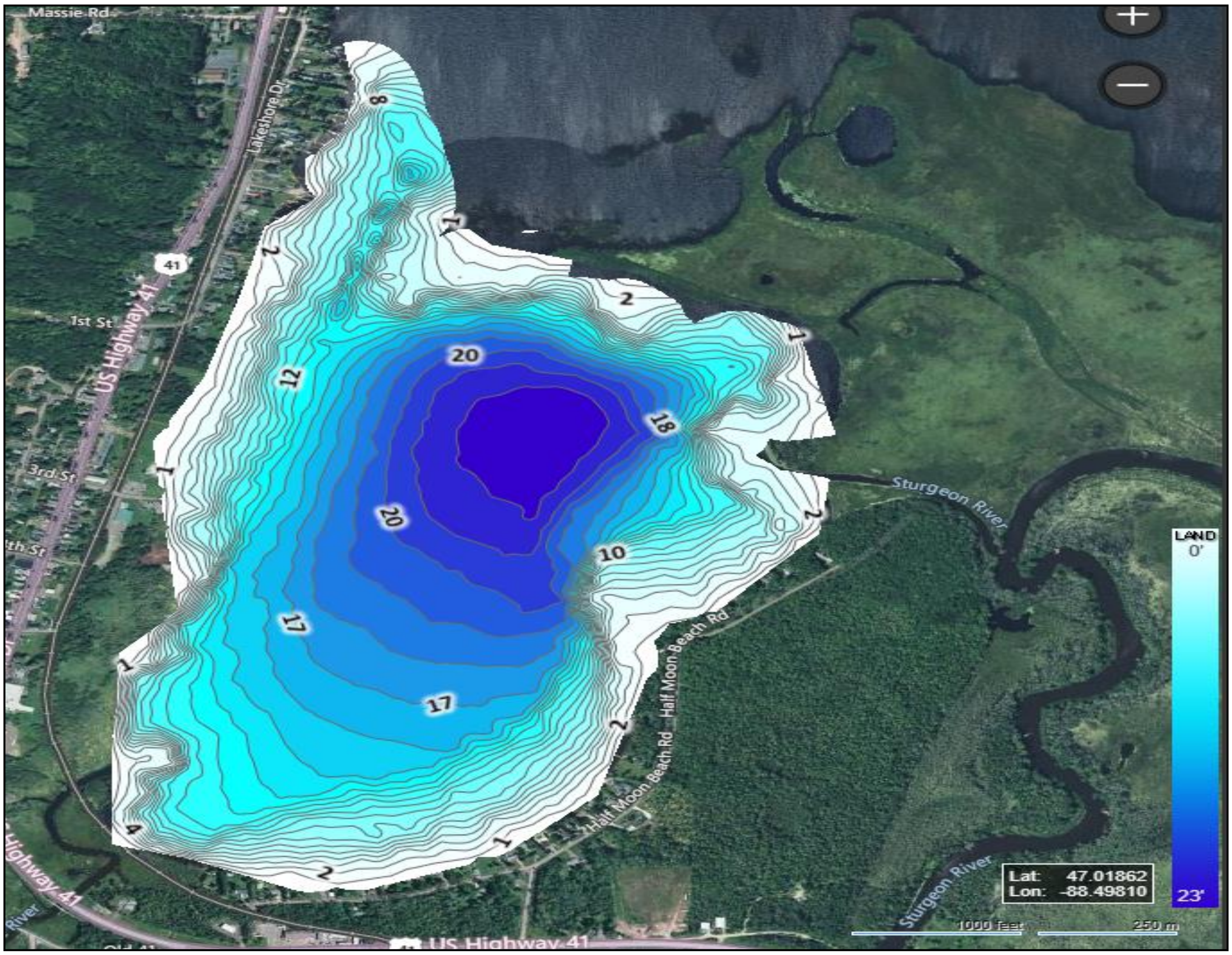

Figure 1. Depth contours in Pike Bay, Chassell, MI (August 27, 2023).

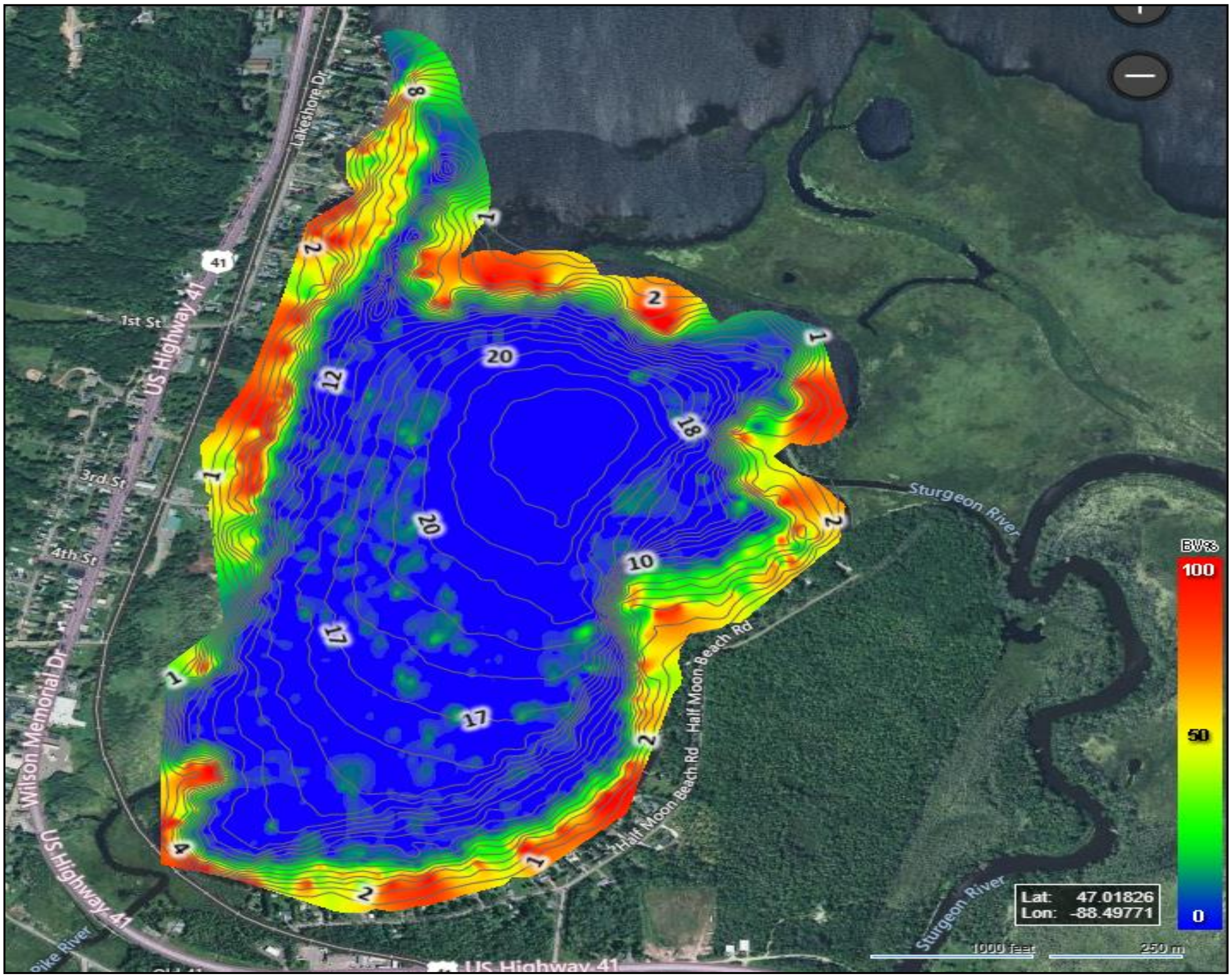

Figure 2. Aquatic vegetation biovolume scan map of Pike Bay (August 27, 2023). Note: The blue color represents areas that are not covered with aquatic vegetation. The green color represents low-growing aquatic vegetation, and the red colors represent high-growing aquatic vegetation. This scan does not differentiate between invasive and native aquatic vegetation biovolume which is why the GPS-point intercept survey is also executed in concert with the whole-lake scan.

Table 1. Pike Bay aquatic vegetation biovolume by category percent cover of each category (relative cover on August 27, 2023).

Biovolume Cover Category	% Relative Cover of Bottom by Category
0-20%	81.7
20-40%	6.6
40-60%	6.8
60-80%	1.0
>80%	3.9

The robust aquatic vegetation in Pike Bay is supported by an abundance of fertile lake sediments. The lighter colors in Figure 3 below represent softer sediments that likely contain ample organic matter (carbon) for enhanced vegetation growth although most of the orange color represents a sandy bottom. The bottom hardness map shows that most of the lake bottom consists of fairly consolidated sediment throughout the lake with a few areas with soft organic bottom. Table 2 below shows the categories of relative bottom hardness with 0.0-0.1 referring to the softest and least consolidated bottom and >0.4 referring to the hardest, most consolidated bottom for the two lake basins. This scale does not mean that any of the lake contains a truly “hard” bottom but rather a bottom that is more cohesive and not flocculent.

Table 2. Pike Bay relative hardness of the lake bottom by category or hardness and percent cover of each category (relative cover on August 27, 2023).

Lake Bottom Relative Hardness Category	% Relative Cover of Bottom by Category
0.0-0.1	0.06
0.1-0.2	5.90
0.2-0.3	77.86
0.3-0.4	16.08
>0.4	0.1

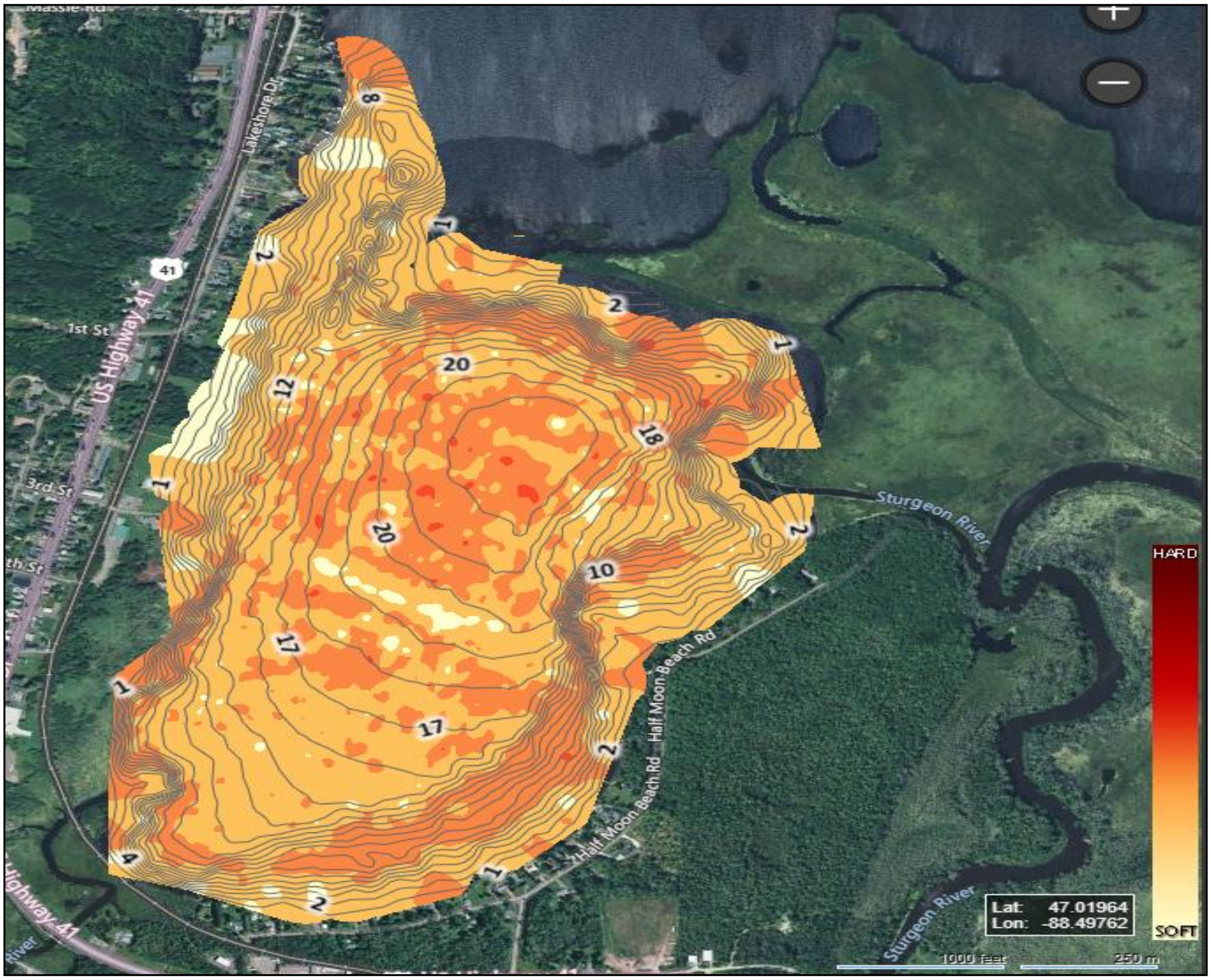

Figure 3. Pike Bay sediment relative hardness scan map (August 27, 2023).

2.3 Pike Bay Exotic Aquatic Plant Species

Exotic aquatic plants (macrophytes) are not native to a particular site, but are introduced by some biotic (living) or abiotic (non-living) vector. Such vectors include the transfer of aquatic plant seeds and fragments by boats and trailers (especially if the lake has public access sites), waterfowl, or by wind dispersal. In addition, exotic species may be introduced into aquatic systems through the release of aquarium or water garden plants into a water body. An aquatic exotic species may have profound impacts on the aquatic ecosystem.

Exotic aquatic plants (macrophytes) are not native to a particular site, but are introduced by some biotic (living) or abiotic (non-living) vector. Such vectors include the transfer of aquatic plant seeds and fragments by boats and trailers (especially if the lake has public access sites), waterfowl, or by wind dispersal. In addition, exotic species may be introduced into aquatic systems through the release of aquarium or water garden plants into a water body. **An aquatic exotic species may have profound impacts on the aquatic ecosystem.** Eurasian Watermilfoil (*Myriophyllum spicatum*; Figure 4) is an exotic aquatic macrophyte first documented in the United States in the 1880's (Reed 1997), although other reports (Couch and Nelson 1985) suggest it was first found in the 1940's. In recent years, this species has hybridized with native milfoil species to form hybrid species. Eurasian Watermilfoil has since spread to thousands of inland lakes in various states through the use of boats and trailers, waterfowl, seed dispersal, and intentional introduction for fish habitat. Eurasian Watermilfoil is a major threat to the ecological balance of an aquatic ecosystem through causation of significant declines in favorable native vegetation within lakes (Madsen et *al*. 1991), in that it forms dense canopies (Figures 5 and 6) and may limit light from reaching native aquatic plant species (Newroth 1985; Aiken et *al*. 1979). Additionally, Eurasian Watermilfoil can alter the macroinvertebrate populations associated with particular native plants of certain structural architecture (Newroth 1985). **Approximately 57.5 acres of Eurasian Watermilfoil was found in Pike Bay during the August 27, 2023 survey (Figure 7) and an intensive management program is proposed below.** Eurasian Watermilfoil growth in Pike Bay is capable of producing dense surface canopies in shallow areas. The species of invasive aquatic plants present, and relative abundance of each plant are recorded and then the amount of cover in the littoral zone is calculated. Figure 8 displays the relative abundance of invasive milfoil in Pike Bay.

Figure 4. Hybrid Eurasian Watermilfoil plant with seed head and fragments (©RLS).

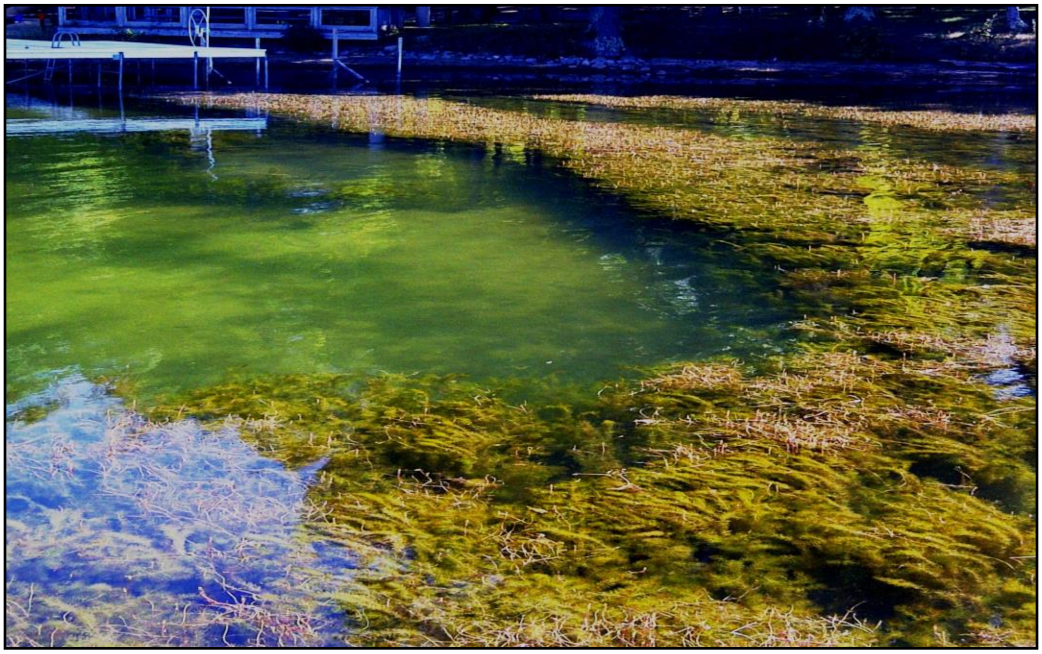

Figure 5. Hybrid Eurasian Watermilfoil Canopy on an inland lake (©RLS).

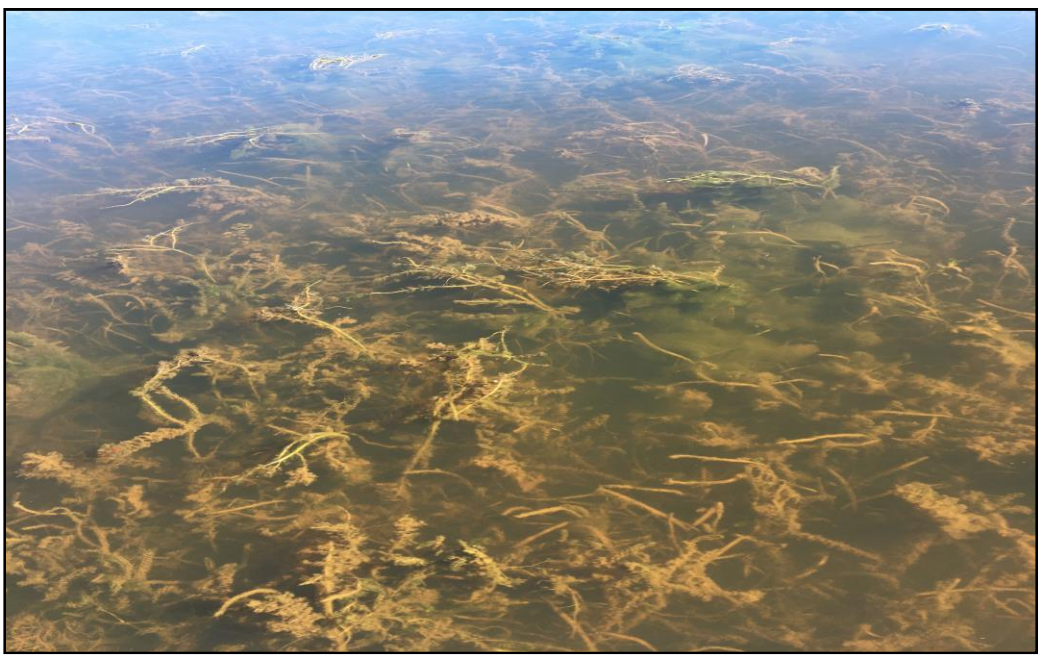

Figure 6. Dense invasive hybrid Watermilfoil in Pike Bay, Chassell, Michigan (August 27, 2023).

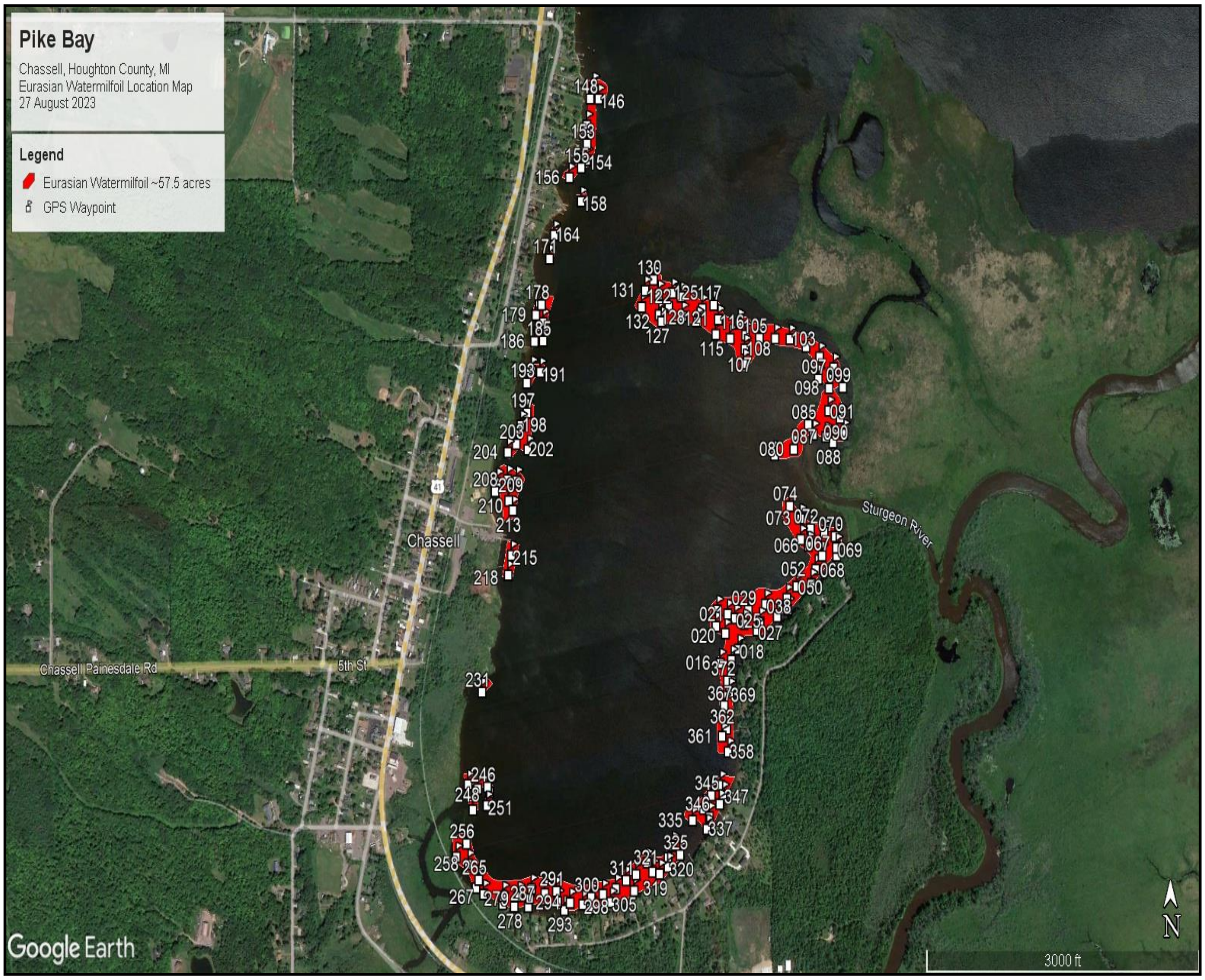

Figure 7. Eurasian Watermilfoil distribution in Pike Bay (August 27, 2023).

Purple Loosestrife (*Lythrum salicaria*; Figure 9) is an invasive (i.e. exotic) emergent aquatic plant that inhabits wetlands and shoreline areas. *L. salicaria* has showy magenta-colored flowers that bloom in mid-July and terminate in late September. The seeds are highly resistant to tough environmental conditions and may reside in the ground for extended periods of time. It exhibits rigorous growth and may out-compete other favorable native emergents such as Cattails (*Typha latifolia*) and thus reduce the biological diversity of localized ecosystems. The plant is spreading rapidly across the United States and is converting diverse wetland habitats to monocultures with substantially lower biological diversity. It should be removed promptly if found (i.e., by hand pulling or using a shovel to remove the roots and then discarding the plant into the garbage) to avoid further infestation. If the plant is not promptly removed by hand, it could dominate in wetland areas and require larger-scale systemic herbicide treatments. **This plant was found in 25 locations around the shoreline of Pike Bay (Figure 10).**

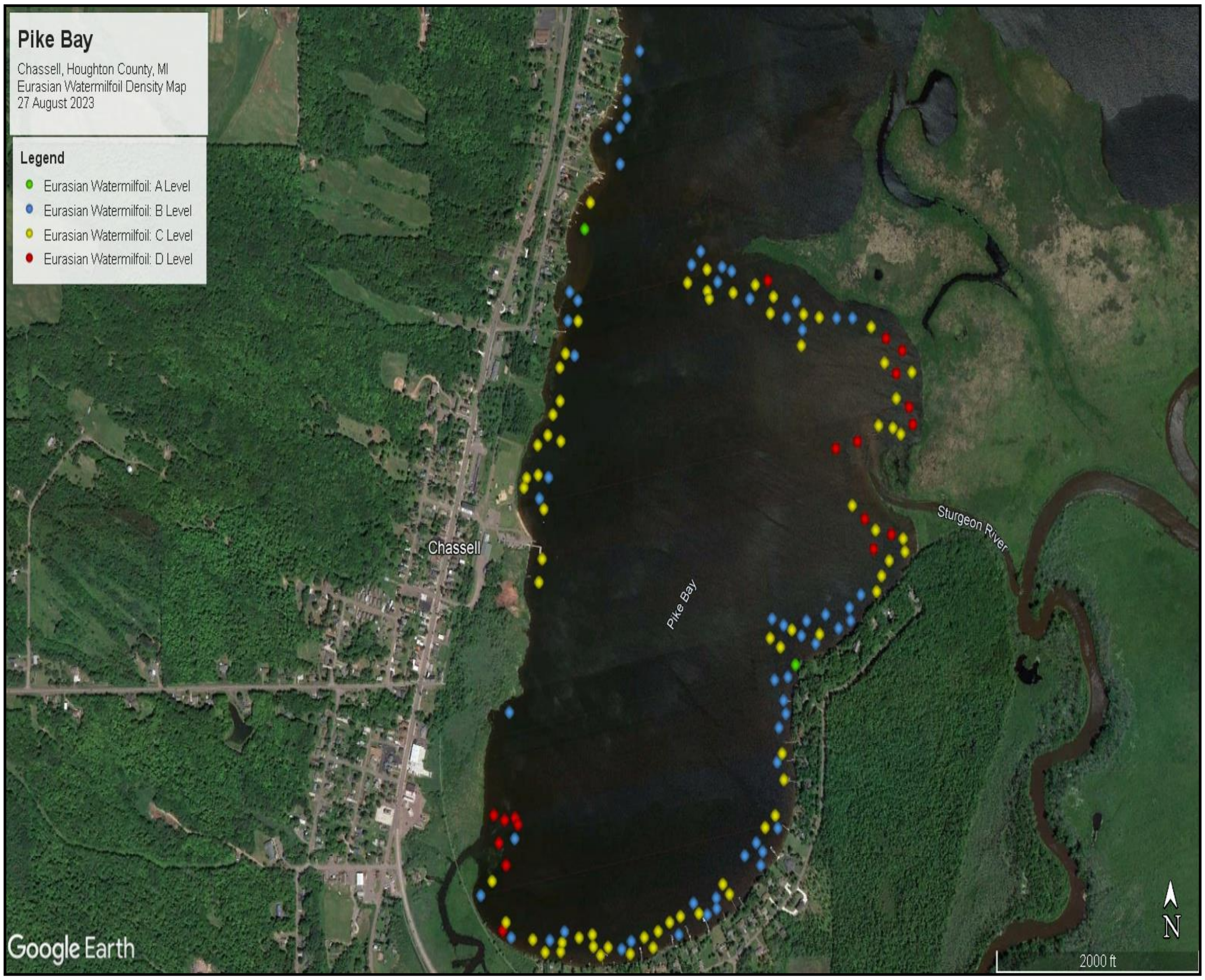

Figure 8. Eurasian Watermilfoil milfoil relative abundance Pike Bay (August 27, 2023).

Figure 9. Invasive Purple Loosestrife invading a lake wetland.

Figure 10. Invasive Purple Loosestrife around the shoreline of Pike Bay (August 27, 2023).

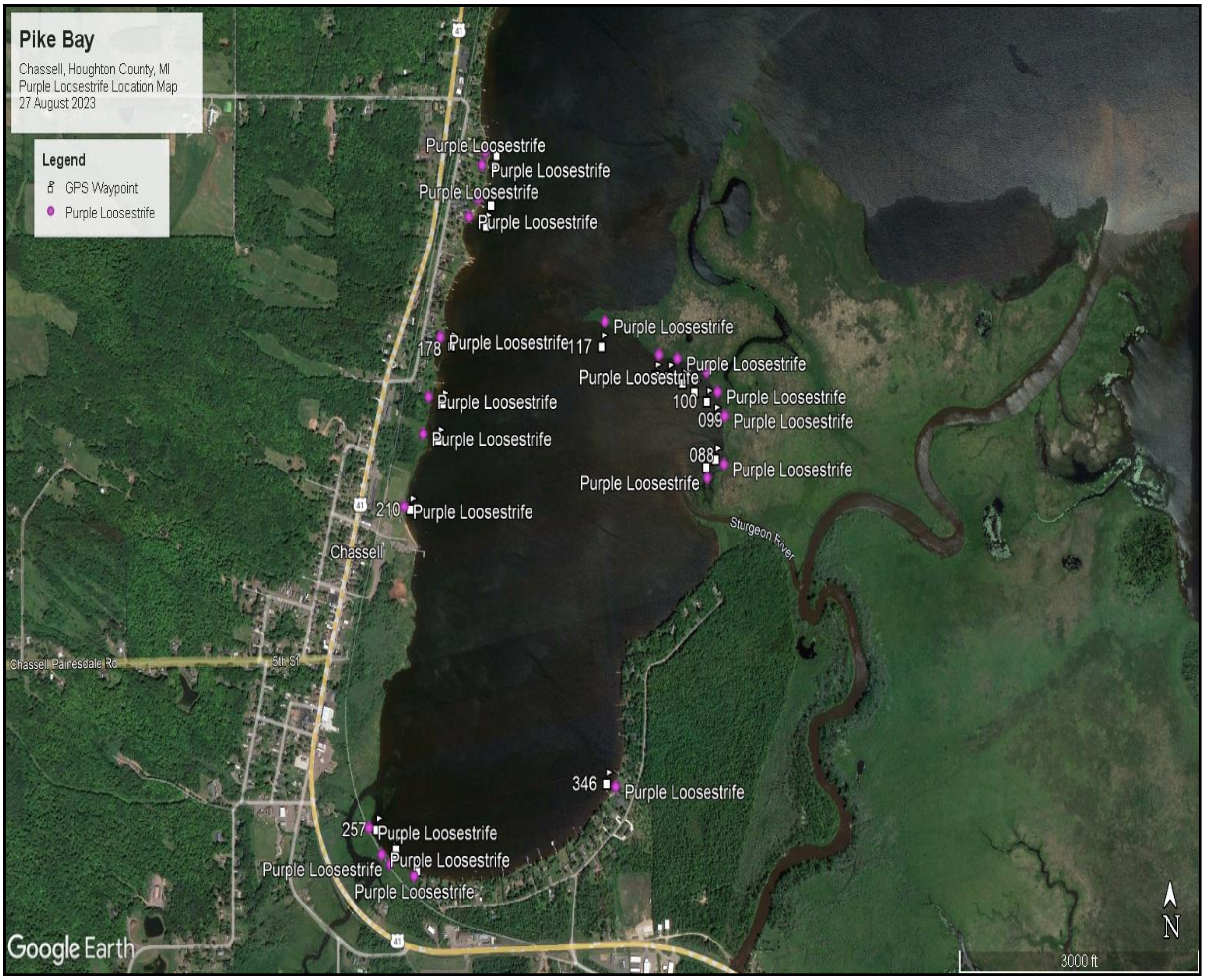

Figure 11. Locations of invasive emergent Purple Loosestrife around Pike Bay, Chassell, Michigan (August 27, 2023).

2.4 Pike Bay Native Aquatic Plant Species

There are hundreds of native aquatic plant species in the waters of the United States. The most diverse native genera include the Potamogetonaceae (Pondweeds) and the Haloragaceae (Watermilfoils). Native aquatic plants may grow to nuisance levels in lakes with abundant nutrients (both water column and sediment) such as phosphorus, and in sites with high water transparency. The diversity of native aquatic plants is essential for the balance of aquatic ecosystems, because each plant harbors different macroinvertebrate communities and varies in fish habitat structure.

Pike Bay contained 26 native submersed, 2 floating-leaved, and 5 emergent aquatic plant species, for a total of 32 native aquatic macrophyte species (Tables 3 and 4). There are designated density codes for the aquatic vegetation surveys, where a = found (occupying < 2% of the surface area of the lake), b = sparse (occupying 2-20% of the surface area of the lake), c = common, (occupying 21-60% of the surface area of the lake), and d = dense (occupying > 60% of the surface area of the lake). Photos of all native aquatic plants are shown below in Figures 12-44. The majority of the emergent macrophytes may be found along the shoreline of the lake. The majority of the floating-leaved lily pads can be found near the shoreline and near wetlands. The emergent plants, such as (Cattails), and *Scirpus acutus* (Bulrushes) are critical for shoreline stabilization as well as for wildlife and fish spawning habitat. Additionally, the floating-leaved aquatic plants such as yellow and white water lilies are excellent fishery cover and house numerous snails and aquatic macroinvertebrates that are critical for the fishery food chain.

The most dominant aquatic plants in the main part of the lake included the submersed Wild Celery and Clasping-leaf Pondweed. Wild Celery has long, green, ribbon-like leaves and can grow very thick in shallow areas. After Wild Celery has been fertilized, it forms a distinctive coil. The plant was intentionally planted into Michigan lakes by the MDNR several decades ago to serve as food for migratory waterfowl. It has become a nuisance in some lakes but is a native aquatic plant. Clasping-leaf Pondweed grows tall into the water column in shallow areas and creates dense stands of bright-green colored stalks that serve as excellent fish forage habitat.

Table 3. Pike Bay native aquatic plant species relative abundance (August 27, 2023).

Native Aquatic Plant Species Name	***Native Aquatic Plant Common Name***	***A Level***	***B Level***	***C Level***	***D Level***
Chara vulgaris	Muskgrass	6	161	2	0
Stuckenia filiformis	Thread-leaved False Pondweed	3	1	0	0
Stuckenia pectinata	Thin-leaf Pondweed	7	23	0	1
Potamogeton zosteriformis	Flat-stem Pondweed	1	17	1	0
Potamogeton vaseyi	Vasey’s Pondweed	0	25	5	1
Potamogeton alpinus	Alpine Pondweed	2	1	0	0
Potamogeton gramineus	Variable-leaf Pondweed	1	30	12	1
Potamogeton epihydrus	Ribbon-leaf Pondweed	3	2	1	0
Potamogeton foliosus	Leafy Pondweed	4	1	0	0
Potamogeton friesii	Flat-stalked Pondweed	2	1	0	0
Potamogeton pusillus	Slender Pondweed	3	2	1	0
Potamogeton robbinsii	Fern-leaf Pondweed	5	4	1	0
Potamogeton praelongus	White-stem Pondweed	2	6	0	0
Potamogeton perfoliatus	Clasping-leaf Pondweed	2	85	77	13
Potamogeton illinoensis	Illinois Pondweed	0	3	0	0
Potamogeton amplifolius	Large-leaf Pondweed	11	46	15	19
Zosterella dubia	Water Stargrass	2	40	13	6
Vallisneria americana	Wild Celery	1	12	18	164
Myriophyllum heterophyllum	Variable Watermilfoil	0	2	0	0
Ceratophyllum demersum	Coontail	6	55	12	1
Elodea canadensis	Common Waterweed	11	75	7	1
Utricularia vulgaris	Common Bladderwort	7	16	0	0
Najas flexilis	Slender Naiad	8	63	3	1
Ranunculus reptans	Creeping Buttercup	2	1	0	0
Littorella uniflora	Shoreweed	2	1	1	0
Sparganium fluctuans	Floating Bur-Reed	3	1	1	0
Nymphaea odorata	White Waterlily	13	28	16	8

Nuphar variegata	Yellow Waterlily	2	9	3	0
Eriocaulon aquaticum	Seven-angled Pipewort	4	2	1	0
Typha latifolia	Cattails	2	9	5	15
Schoenoplectus acutus	Bulrushes	0	4	6	20
Pontedaria cordata	Pickerelweed	0	5	4	1
Glyceria maxima	Reed Sweet-Grass	0	0	0	1

Table 4. Pike Bay native aquatic plant species frequency (August 27, 2023).

Native Aquatic Plant Species Name	*Native Aquatic Plant Common Name*	*Frequency (% Sampling Locations Found)*
Chara vulgaris	Muskgrass	45.3
Stuckenia filiformis	Thread-leaved False Pondweed	8.3
Stuckenia pectinata	Sago Pondweed	8.0
Potamogeton zosteriformis	Flat-stem Pondweed	5.1
Potamogeton vaseyi	Vasey's Pondweed	8.3
Potamogeton alpinus	Alpine Pondweed	0.8
Potamogeton gramineus	Variable-leaf Pondweed	11.8
Potamogeton epihydrus	Ribbon-leaf Pondweed	1.6
Potamogeton foliosus	Leafy Pondweed	1.3
Potamogeton friesii	Flat-stalked Pondweed	0.8
Potamogeton pusillus	Slender Pondweed	1.6
Potamogeton robbinsii	Fern-leaf Pondweed	2.7
Potamogeton praelongus	White-stem Pondweed	2.1
Potamogeton perfoliatus	Clasping-leaf Pondweed	46.1
Potamogeton illinoensis	Illinois Pondweed	0.8
Potamogeton amplifolius	Large-leaf Pondweed	24.4
Zosterella dubia	Water Stargrass	16.4
Vallisneria americana	Wild Celery	52.0
Myriophyllum heterophyllum	Variable Watermilfoil	0.5
Ceratophyllum demersum	Coontail	19.8
Elodea canadensis	Common Waterweed	25.2
Utricularia vulgaris	Common Bladderwort	6.2
Najas flexilis	Slender Naiad	20.4
Ranunculus reptans	Creeping Buttercup	0.8
Littorella uniflora	Shoreweed	1.1
Sparganium fluctuans	Floating Bur-Reed	1.1
Nymphaea odorata	White Waterlily	17.4

Nuphar variegata	Yellow Waterlily	3.8
Eriocaulon aquaticum	Seven-angled Pipewort	1.9
Typha latifolia	Cattails	8.6
Schoenoplectus acutus	Bulrushes	8.0
Pontedaria cordata	Pickerelweed	2.7
Glyceria maxima	Reed Sweet-Grass	0.3

Figure 12. Chara (Muskgrass)

Figure 13. Thread-leaved False Pondweed

Figure 14. Sago Pondweed

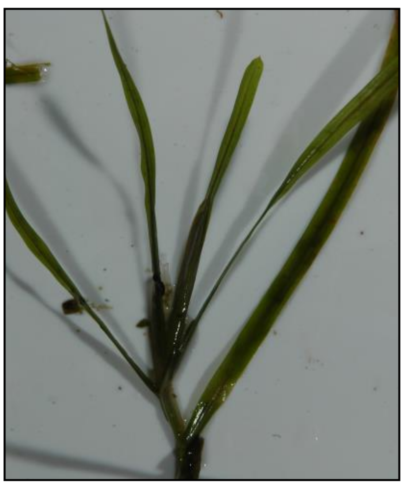

Figure 15. Flat-stem Pondweed

Figure 16. Vasey's Pondweed

Figure 17. Alpine Pondweed

Figure 18. Variable-leaf Pondweed

Figure 19. Ribbon-leaf Pondweed

Figure 20. Leafy Pondweed

Figure 21. Flat-stalked Pondweed

Figure 22. Slender Pondweed

Figure 23. Fern-leaf Pondweed

Figure 24. White-stem Pondweed

Figure 25. Clasping-Leaf

Figure 26. Illinois Pondweed

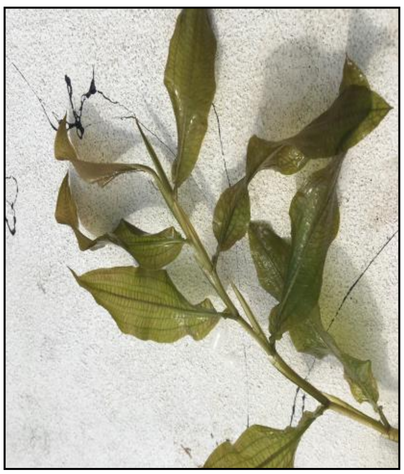

Figure 27. Large-leaf Pondweed

Figure 28. Water Stargrass

Figure 29. Wild Celery

Figure 30. Variable Watermilfoil

Figure 31. Coontail

Figure 32. Common Waterweed

Figure 33. Common Bladderwort

Figure 34. Slender Naiad

Figure 35. Creeping Buttercup

Figure 36. Shoreweed

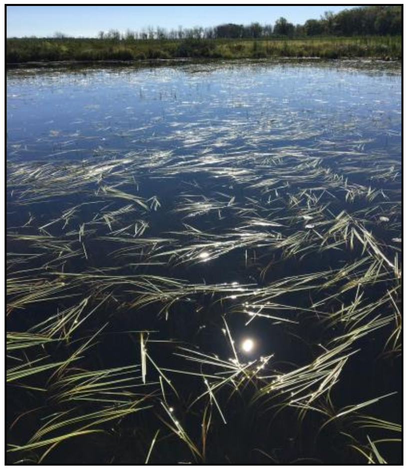

Figure 37. Floating-Bur-Reed

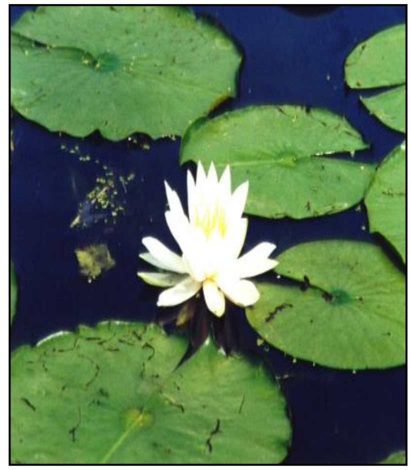

Figure 38. White Waterlily

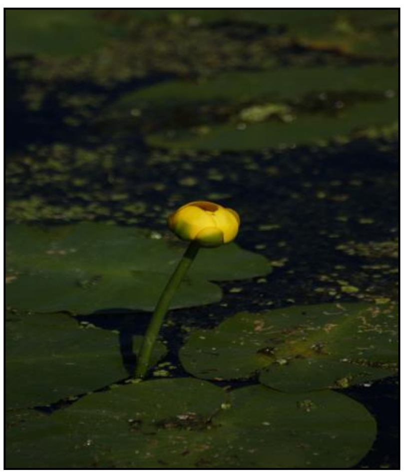

Figure 39. Yellow Waterlily

Figure 40. Seven-angled Pipewort

Figure 41. Bulrushes

Figure 42. Pickerelweed

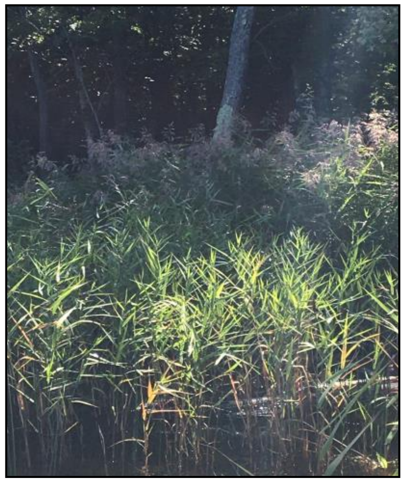

Figure 43. Reed Sweet-grass

Figure 44. Cattails

3.0 PIKE BAY AQUATIC VEGETATION MANAGEMENT METHODS

3.1 Pike Bay Aquatic Plant Management Methods

The management of only invasive aquatic plants is recommended for Pike Bay to protect the fisheries and substantial native aquatic plant biodiversity. **The goals of an aquatic plant management program are to improve aquatic vegetation biodiversity, improve water quality and wildlife habitat, protect recreational use of a water resource, and protect and enhance waterfront property values.** Regardless of the management goals, all management decisions must be site-specific and should consider the socio-economic, scientific, and environmental components of the management plan.

The management of nuisance level exotic aquatic plants is necessary in Pike Bay due to accelerated growth and distribution. Management options should be environmentally and ecologically sound and financially feasible. Options for control of aquatic plants are limited yet some are capable of achieving strong results when used properly. Exotic aquatic plant species should be managed with solutions that will yield long-term results. The sections below discuss the individual lake management methods (tools) considered and then ultimately recommend specific methods.

3.1.1 Aquatic Herbicides and Applications

The use of aquatic chemical herbicides is regulated by the Michigan Department of Environment, Great Lakes, and Energy (EGLE) and requires a permit. Aquatic herbicides are generally applied via an airboat or skiff equipped with mixing tanks and drop hoses (Figure 45). The permit contains a list of approved herbicides for a particular body of water, as well as dosage rates, treatment areas, and water use restrictions. **Contact and systemic aquatic herbicides are the two primary categories used in aquatic systems.**

Contact herbicides such as diquat, flumioxazin, and hydrothol cause damage to leaf and stem structures; whereas systemic herbicides are assimilated by the plant roots and are lethal to the entire plant. **Wherever possible, it is preferred to use a systemic herbicide for longer-lasting aquatic plant control of invasives.** In Pike Bay, the use of contact herbicides (such as diquat and flumioxazin) would be highly discouraged since those offer short-term control of plants and are most commonly used on nuisance native aquatic plant species. **The native aquatic plants within Pike Bay are critical for the lake fishery and should all be protected. They also assist with preventing further infestations from invasives.**

Algaecides such as copper sulfate should also be avoided in Pike Bay. **Copper accumulates in lake sediments and bio-persists over time.** It is harmful to sediment biota and can be released into the water column with sediment perturbations.

Systemic herbicides such as 2, 4-D, triclopyr, and now ProcellaCOR® are systemic herbicides used to treat milfoil that occurs in a scattered distribution. Fluridone (trade name, SONAR®) is a systemic whole-lake herbicide treatment that is applied to the entire lake volume in the spring and is used for extensive infestations. **Due to the cost and potential impacts of fluridone on native aquatic plants in Pike Bay, the use of fluridone is not recommended. Additionally, the hybrid genetics of most of the milfoil in Pike Bay may reduce the efficacy of fluridone at the current permitted doses.**

The use of heavy dose systemic herbicide is recommended to effectively kill the roots of invasive milfoil over time. Currently, ProcellaCOR® at doses of 4-6 PDU's offers notable efficacy with respect to milfoil reduction. Different herbicides should be used annually to reduce the probability of tolerance. Thus, in future years, products containing 2,4-D or triclopyr could be rotated annually. A review of the previous herbicide treatments beginning in 2014 indicates that most of these products are being used together annually.

Figure 45. An herbicide treatment airboat and crew preparing for a lake treatment.

Table 5. Aquatic herbicide treatment history as reported by PLM in historical treatment reports to EGLE. No reports were submitted for 2019-2022 for treatments.

Date	Acres Treated	Products Used
6-25-14	78.8	Sculpin G (160#/acre)
7-24-14	2.0	Sculpin G (160#/acre)
6-23-15	29.5	Renovate Max G, Renovate OTF, Sculpin G
7-22-15	5.6	Renovate OTF, Renovate Max G, Sculpin G
8-18-15	11	Renovate OTF, Sculpin G
9-28-15	4	Renovate OTF, Sculpin G
6-14-16	1.2	Renovate OTF
6-22-16	107.5	Cygnet Plus, Renovate 3, Renovate OTF, Sculpin G, Tribune
6-20-17	12	Cygnet Plus, Renovate 3, Renovate OTF
8-3-17	1	Renovate OTF
8-6-18	106.5	ProcellaCOR EC, Renovate 3, Renovate OTF, Tribune, Cygnet Plus

3.1.2 Mechanical Harvesting

Mechanical harvesting involves the physical removal of nuisance aquatic vegetation with the use of a mechanical harvesting machine (Figure 46). The mechanical harvester collects numerous loads of aquatic plants as they are cut near the lake bottom. The plants are off-loaded onto a conveyor and then into a dump truck.

Harvested plants are then taken to an offsite landfill or farm where they can be used as fertilizer. Mechanical harvesting is preferred over chemical herbicides when primarily native aquatic plants exist, or when excessive amounts of plant biomass need to be removed**. Mechanical harvesting is usually not recommended for the removal of watermilfoil since the plant may fragment when cut and re-grow on the lake bottom.** In addition, it does not allow for removal of vegetation in target areas since Pike Bay has invasive milfoil growing with numerous native aquatic plant species.

Figure 46. A mechanical harvester.

3.1.3 Diver Assisted Suction Harvesting (DASH)

Suction harvesting via a Diver-Assisted Suction Harvesting (DASH) boat (Figure 47) involves hand removal of individual plants by a SCUBA diver in selected areas of lake bottom with the use of a hand-operated suction hose. Samples are dewatered on land or removed via fabric bags to an offsite location. **This method is generally recommended for small (less than 10 acres) spot removal of vegetation since it is usually cost-prohibitive on a larger scale.** The advantage it has is that it can be selective in what species it removes since a diver is guiding the suction hose to targeted plants.

This process may remove either plant material or sediments and may require a USACE bottomlands permit. Furthermore, this activity may cause re-suspension of sediments (Nayar et *al*., 2007) which may lead to increased turbidity and reduced clarity of the water.

Figure 47. A DASH boat for hand-removal of watermilfoil or other nuisance vegetation. ©Restorative Lake Sciences

3.1.4 Benthic Barriers and Nearshore Management Methods

The use of benthic barrier mats (Figure 48) or Weed Rollers (Figure 49) have been used to reduce weed growth in small areas such as in beach areas and around docks. The benthic mats are placed on the lake bottom in early spring prior to the germination of aquatic vegetation. They act to reduce germination of all aquatic plants and lead to a local area free of most aquatic vegetation. Benthic barriers may come in various sizes between 100-400 feet in length. They are anchored to the lake bottom to avoid becoming a navigation hazard.

The cost of the barriers varies among vendors but can range from $100-$1,000 per mat. Benthic barrier mats can be purchased online at: www.lakemat.com or www.lakebottomblanket.com. The efficacy of benthic barrier mats has been studied by Laitala et *al.* (2012) who report a minimum of 75% reduction in invasive milfoil in the treatment areas. Lastly, benthic barrier mats should not be placed in areas where fishery spawning habitat is present and/or spawning activity is occurring.

Weed Rollers are electrical devices which utilize a rolling arm that rolls along the lake bottom in small areas (usually not more than 50 feet) and pulverizes the lake bottom to reduce germination of any aquatic vegetation in that area. They can be purchased online at: www.crary.com/marine or at: www.lakegroomer.net.

Both methods are useful in shallow lakes such as Pike Bay and work best in beach areas and near docks to reduce nuisance aquatic vegetation growth. These technologies could be used in beach areas on the lake if the bottom substrate is consolidated (firm).

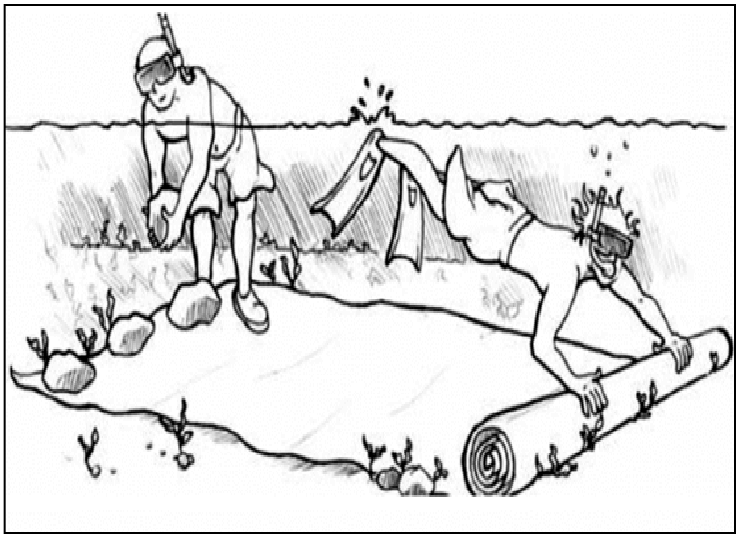

Figure 48. A Benthic Barrier. Photo courtesy of Cornell Cooperative Extension.

Figure 49. A Weed Roller.

3.1.5 Boat Washing Stations

In 2019, the Michigan Natural Resources Environmental Protection Act (PA 451 of 1993, Part 413) was amended with new boating and fishing laws that aim to prevent the introduction and spread of invasive aquatic species. Due to this amendment, technologies such as boat washing stations are becoming prevalent and necessary.

With over 13 million registered boaters in the U.S. alone, the need for reducing transfer of aquatic invasive species (AIS) has never been greater. The Minnesota Sea Grant program identifies five major boat wash scenarios which include: 1) permanent washing stations at launch sites, 2) Portable drive-thru or transient systems, 3) Commercial car washes, 4) Home washing, and 5) Mandatory vs. volunteer washing. Boat washing stations are voluntary for incoming and exiting boaters. Boat washing stations promote the Clean Waters Clean Boats volunteer education program by educating boaters to wash boating equipment (including trailers and bait buckets) before entry into every lake.

Critical elements of this education include: 1) how to approach boaters, 2) demonstration of effective boat and trailer inspections and cleaning techniques, 3) the recording of important information, 4) identification of high-priority invasive species, and 5) sharing findings with others. **If a boat washing station is installed on Pike Bay, the Township should work together to educate the public and lake users on proper cleaning techniques and other invasive species information.**

A “Landing Blitz” can be held once the station is in place and the public can be invited to a field demonstration of how to use the washing station. Figure 50 displays a typical CD3 boat washing station that is solar-powered.

Figure 50. A boat washing station on an inland lake.

4.0 PIKE BAY EVALUATION CONCLUSIONS & RECOMMENDATIONS

The information given in the aforementioned sections for the long-term management of aquatic vegetation in Pike Bay should be considered for effective management and ultimate protection of the lake water quality, balance of native aquatic plants, and protection of waterfront property values. **The overall goals of this proposed management program are listed in Table 6 along with where the proposed improvements should be implemented in and around the Bay. The proposed aquatic vegetation management program conclusions and recommendations include the following:**

1. Protect the robust and healthy native aquatic plant biodiversity
2. Reduce invasive species such as Eurasian Watermilfoil and emergent invasives such as Purple Loosestrife
3. Purple Loosestrife can be hand-removed without the use of herbicides were it is found.
4. Regular aquatic vegetation inventories of the entire Bay are recommended to determine the native biodiversity and to evaluate treatment efficacy over time
5. A licensed aquatic herbicide applicator should continue treatments under the direction of an independent limnological surveyor. This reduces bias and conflicts of interest.
6. In nearshore areas, especially beaches, the use of benthic mats and weed rollers can reduce aquatic plant germination and growth without the use of chemicals.
7. The use of aquatic herbicides should be limited to ONLY areas of invasive aquatic plant growth and only systemic herbicides should be used for longer control and to avoid damage to natives.
8. Consider the future purchase of a boat washing station to be installed at the access site. The systems are costly (usually around $30,000 per unit) but are worth the investment. Periodic grants are available.
9. Consider annual water quality monitoring of the Bay with physical water quality parameters such as water temperature, dissolved oxygen, pH, conductivity, total dissolved solids, and Secchi transparency, and chemical water quality parameters such as total and ortho-phosphorus, total Kjeldahl and inorganic nitrogen, and chlorophyll-a. Annual trends in water quality may help to explain future conditions in the Bay.

Table 6. Proposed aquatic vegetation management methods for Pike Bay.

Management Activity	Primary Goal	Secondary Goal	Best Locations to Use
Systemic aquatic herbicides for Eurasian Watermilfoil	To reduce % cover of EWM throughout lake	To protect native aquatic plant biodiversity	ONLY where EWM is located
Hand-removal of invasive emergent Purple Loosestrife	To stop it from spreading to other areas of the lake	To protect native aquatic plant biodiversity	ONLY where it is located
Benthic Barriers/Weed Rollers	To prevent germination of nuisance weeds in beach areas	To reduce dependency on chemicals in nearshore areas	Beach areas only
Lake Vegetation Surveys/Scans	To determine % cover by invasives and use as data tool	To compare year to year reductions in nuisance vegetation areas	Entire Bay, annually and follow-ups as needed
Water Quality Monitoring	To determine trophic status of the lake annually	To compare trend in water quality parameters with time	Entire Bay; 2 deep locations

5.0 SCIENTIFIC LITERATURE CITED

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