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EAU CLAIRE HEADWATERS LAKES (SMITH, SHUNENBERG, & SWEET), BAYFIELD COUNTY

2026-2030 Addendum to the Town of Barnes Aquatic Plant Management Plan
WDNR WBICS: 2743500, 2743600, 2743700

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Town of Barnes – Addendum 5

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1.0 Introduction

The Headwater Lakes of the Eau Claire Chain of Lakes is made up of three small, separate lakes connected by channels of the Eau Claire River. The upstream most lake is Sweet (Swett), followed by Shunenberg Lake, then Smith Lake. Smith Lake is connected to Upper Eau Claire Lake (Figure 1). All three lakes were surveyed in 2024 for curly-leaf pondweed, native aquatic vegetation, depth, and substrate as a part of a two-year project to determine an aquatic plant management approach for these lakes.

Figure 1: Headwaters Lakes of the Eau Claire Chain of Lakes (WDNR Surface Water Data Viewer, July 2025)

2.0 Lake Characteristics

2.1 Depth and Substrate - Sweet or Swett Lake

Sweet or Swett Lake (SWL) is the furthest upstream lake of the Eau Claire Chain of Lakes. At 85 acres, a maximum depth of 38-ft and an average depth of 14-ft, it is the largest of the three lakes known as the "Headwater Lakes". The lake is connected to Shunenberg (SHL), then Smith (SML), then Upper, Middle, and Lower Eau Claire Lakes in the Eau Claire Chain of Lakes in the Towns of Barnes and Gordon in Bayfield and Douglas Counties. SWL is considered a deep lowland drainage lake and is accessible from Upper Eau Claire through SML and SHL, although access can be tricky with shallow water connections.

Fish include musky, panfish, largemouth bass, northern pike and walleye. The lake's water is moderately clear. SWL is in the Upper St. Croix and Eau Claire Rivers watershed which is 277.89 mi². Land use in the watershed is primarily forest (83.90%), wetland (9.50%) and a mix of open (4.30%) and other uses (2.40%). This watershed has 153.93 stream miles, 7,654 lake acres and 13,694 wetland acres.

Depth readings during a 2024 278-point (Figure 2) whole-lake, point-intercept (PI) aquatic plant survey completed by Endangered Resource Services (ERS) revealed the lake had two deep holes – a relatively small, nearly circular one in the northwest corner near the outlet channel that bottoms out at over 25ft, and a large oblong one on the east-central side that drops to almost 40ft (Figure 2). On the north, west, and south-central shorelines, the lake drops off sharply into these deep holes, while shallow flats on the eastern, southeast, and southwest margins slope more gradually.

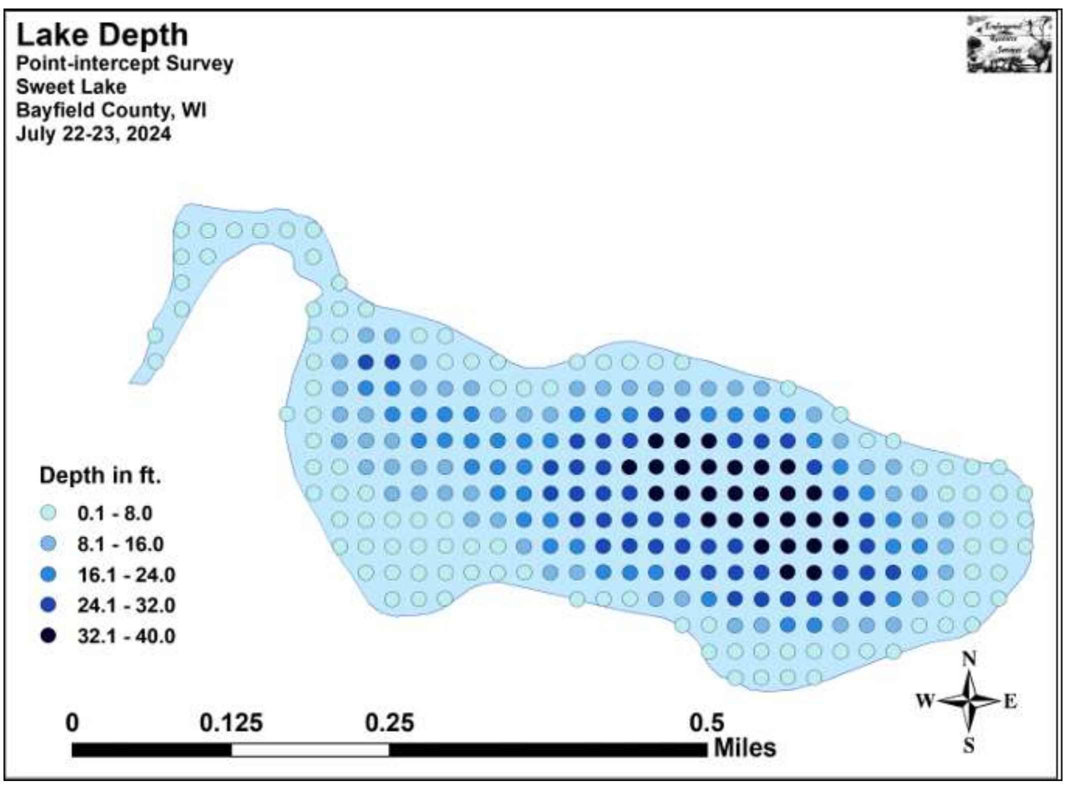

Figure 2: 2024 SWL depth (Berg, 2024)

Of the 180 points where the bottom substrate could be determined, the bottom was 51.1% sandy, marly, and organic muck (92 points), 40.6% pure sand (73 points), and 8.3% cobble and gravel (15 points) (Figure 3). Areas along the immediate shoreline were pure sand, although rocky substrates were also common on the margins of the north and southeast sides. With increasing depth, most areas with these firm substrates gradually transitioned to sandy muck. Almost all nutrient-rich organic muck occurred on the lake's southwest shoreline, while, in the lake outlet, the side bays were dominated by a nutrient-poor marly muck.

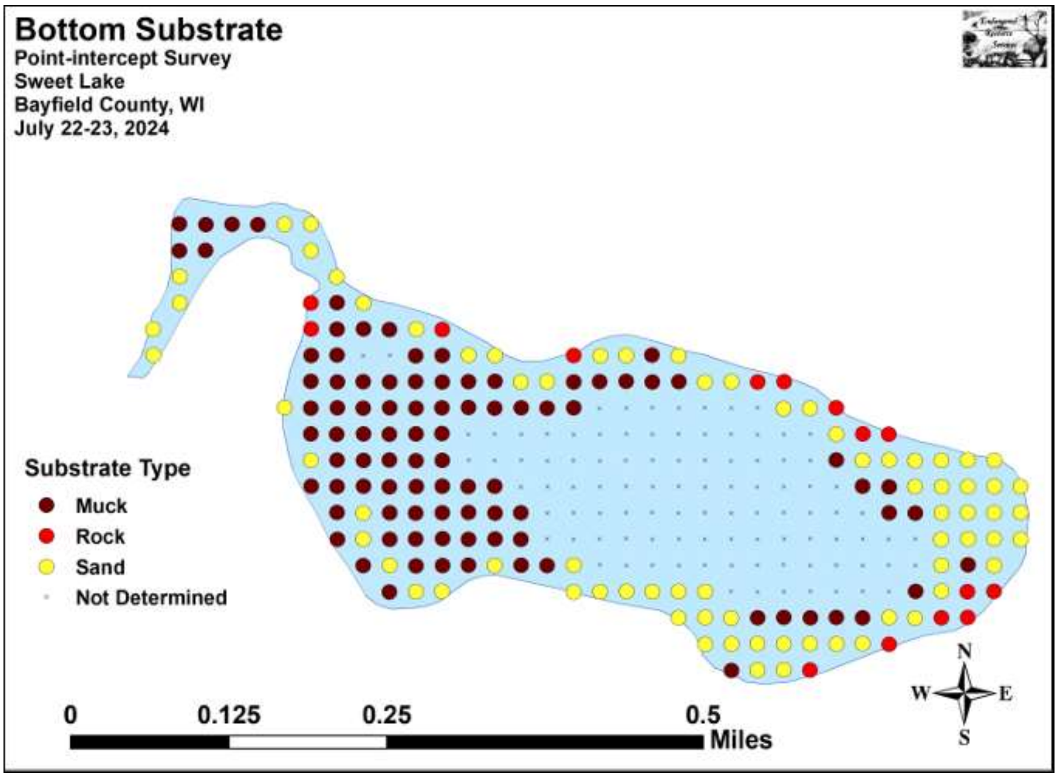

Figure 3: 2024 SWL substrate (Berg, 2024)

2.2 Depth and Substrate - Shunenberg Lake

Shunenberg Lake, the middle lake of the three Headwater lakes, is a 43-acre drainage lake that reaches a maximum depth of over 15ft in the north spring hole with an average depth of approximately 4ft. The lake is connected to SML to the west and SWL to the east. SHL is considered a shallow lowland drainage lake and is accessible from Upper Eau Claire through SML, although access can be tricky with shallow water connections.

Fish include musky, panfish, largemouth bass, northern pike and walleye. Depth readings taken at 186 survey points revealed that, other than the north and west spring holes, the lake is a more or less uniformly shallow oblong bowl that drops gradually from the shoreline into the central 3-6ft trough. The inlet channel from Sweet Lake and the outlet channel leading to Smith were especially shallow (Figure 4).

During the 2024 survey, the bottom substrate was categorized as 85.5% sandy, marly, and organic muck (159 points), and 14.5% pure sand (27 points) (Figure 4). Most areas along the immediate shoreline were pure sand, although some gravel areas inter-point in the lake inlet and outlet were found. With increasing depth, most areas with these firm substrates gradually transitioned to sandy muck. Pockets of nutrient-rich organic muck were scattered along the lake's western shoreline, while some nearshore areas on the lake's east sides also had nutrient-poor marly muck (Figure 4).

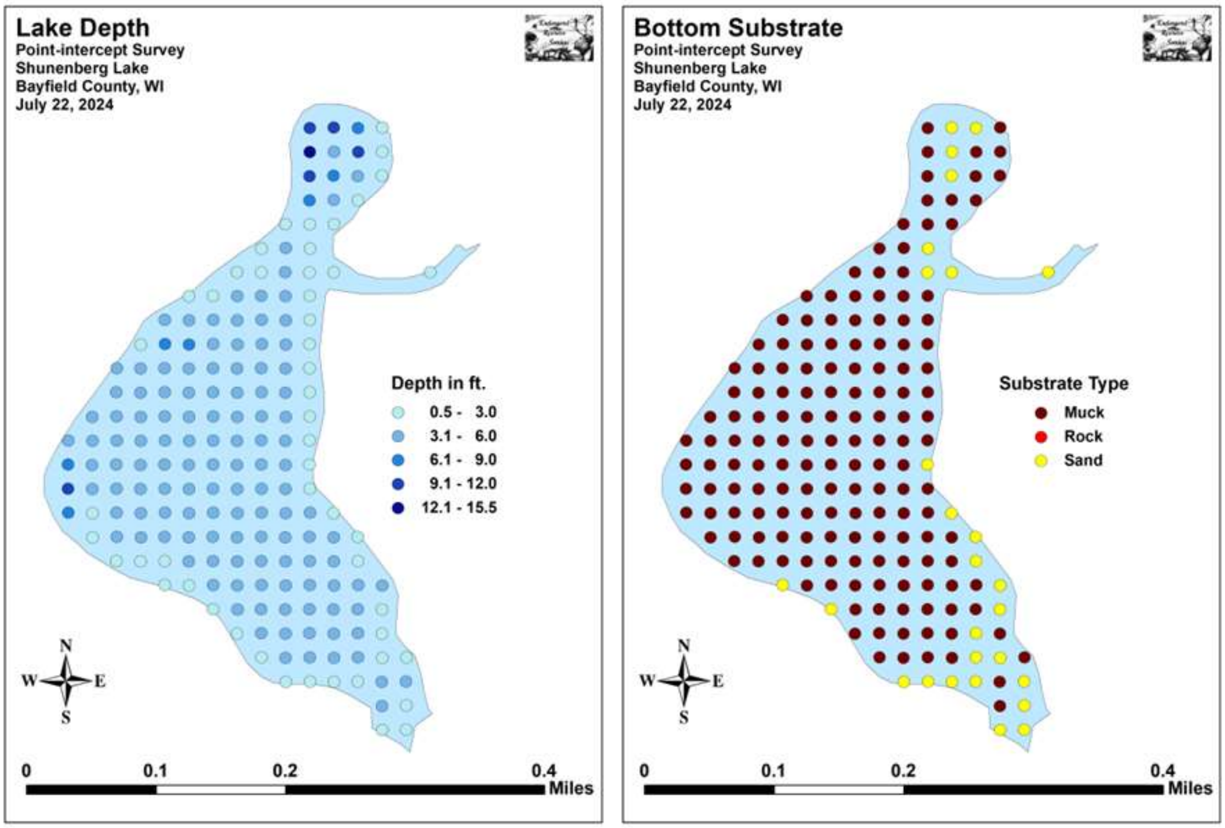

Figure 4: SHL depth and substrate (Berg, 2024)

2.3 Depth and Substrate - Smith Lake

Smith Lake, the furthest downstream and smallest of the Headwater lakes, is a 32-acre drainage lake that reaches a maximum depth of 8ft with an average depth of approximately 4ft. The lake is connected to Upper Eau Claire Lake to the west and SHL to the east. SML is considered a shallow lowland drainage lake and is accessible from Upper Eau Claire Lake, although access can be tricky due to shallow water.

Fish include musky, panfish, largemouth bass, northern pike and walleye. Depth readings taken at Smith Lake's 143 survey points (Figure 5) revealed the lake is a uniform oblong bowl that drops gradually from the shoreline into the central 6-8ft trough. The inlet channel from SHL and the outlet channel leading to Upper Eau Claire Lake were especially shallow (Figure 5)

During the 2024 survey, the bottom substrate was categorized as 79.0% sandy, marly, and organic muck (113 points), and 21.0% pure sand (30 points) (Figure 5). Most areas along the immediate shoreline and in the lake inlet and outlet were pure sand. With increasing depth, most areas gradually transitioned to sandy muck. The only nutrient-rich organic muck occurred on the lake's east shoreline, while some nearshore areas on the lake's north and east sides also had nutrient-poor marly muck.

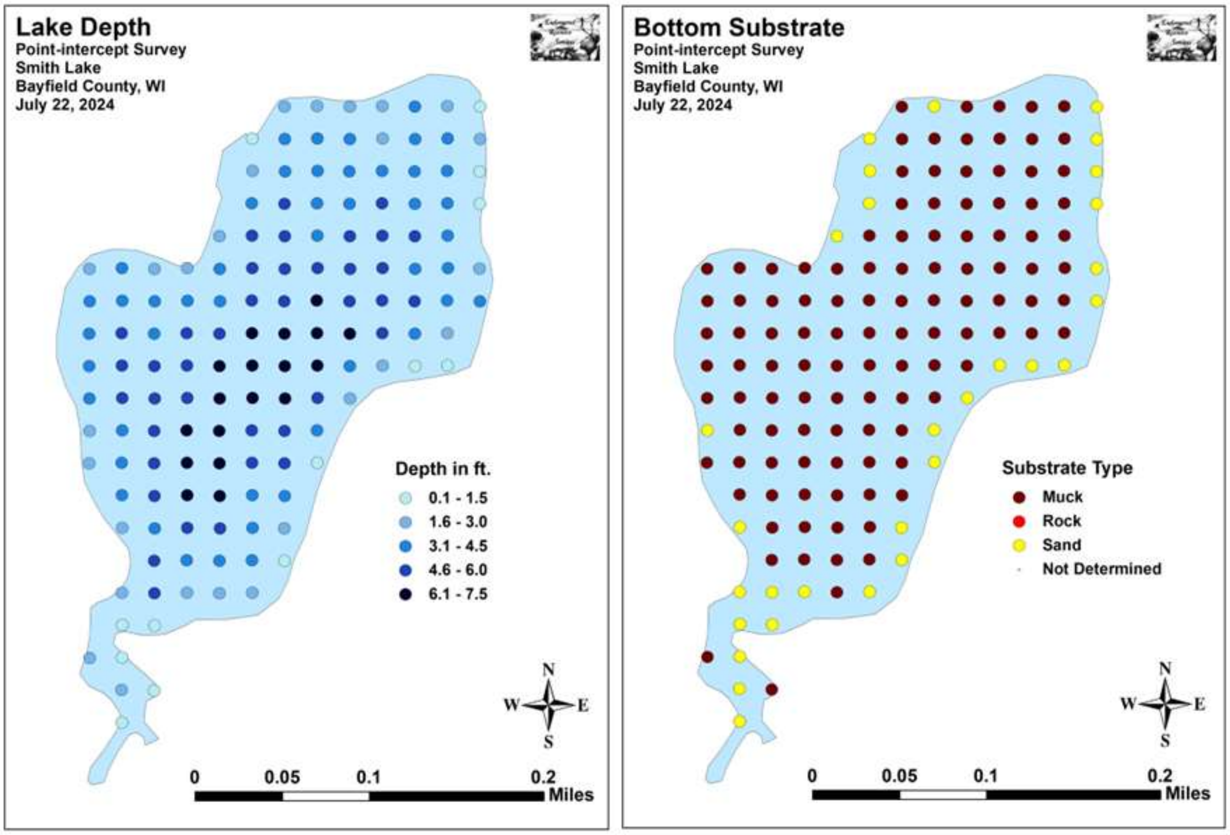

Figure 5: SML depth and substrate (Berg, 2024)

2.4 Priority Navigable Waters Features (Critical Habitat) – Headwaters Lakes

The Wisconsin Department of Natural Resources (WDNR) has designated certain waterways as Priority Navigable Waters (PNW), which are essential for recreational boating, angling, hunting, and enjoying natural scenic beauty. These designated waterways include lakes less than 50 acres, waters with self-sustaining musky, sturgeon, and walleye populations, tributaries to and rivers connecting naturally reproducing populations, and perennial tributaries to trout streams.

All three of the Headwater Lakes have PNW designations defined in Critical Habitat Designation Reports for SHL and SWL (WDNR, 2013a) (WDNR, 2013b). Figure 6, taken from the WDNR Surface Water Data Viewer[1], reflects the current designations for the three lakes. SML and SHL are both <50acres in surface area. All three are considered musky and walleye waters. The entire surface water area of SML and SHL is considered "Sensitive Area" for submergent aquatic plants important to fish and wildlife habitat, and extensive riparian wetland based on a critical habitat designation survey completed by WDNR personnel in 2007-08.

[1] https://dnrmaps.wi.gov/H5/?Viewer=SWDV

SWL includes sensitive areas for similar reasons as SML and SHL but also contains “other PNW designations” including areas of woody habitat, fish spawning substrate, springs, natural scenic beauty, and public navigation thoroughfares.

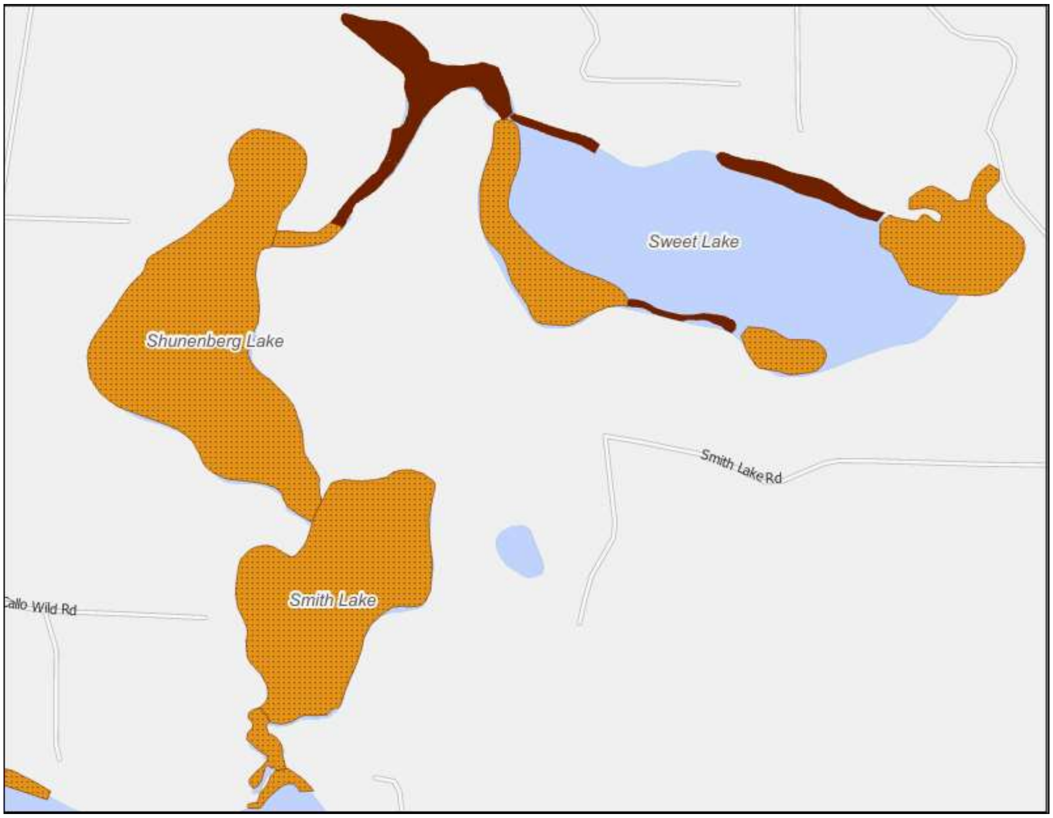

Figure 6: Headwaters Lakes “Priority Navigation Water”: Sensitive Area Designation – orange; Other PNW designations – brown

2.4.1 Recommendations to Protect and Improve Critical Habitat

Critical habitat reports from the WDNR provide recommendations to protect, enhance, or improve critical habitat, sensitive areas, and other PNW designations. For the Headwaters lakes the following recommendations were made.

- Prioritize for permanent land protection.
- Do not remove rush beds. Place piers outside of rushes, or if that’s not possible extend the piers beyond the rushes for boat mooring.
- Restore/replant rush beds that have been destroyed in the past.
- Leave fallen trees in the water.
- Implement Fish Sticks project.
- Established lawn within 50 feet of the water’s edge should be replanted with native vegetation to minimize erosion and pollution and improve fish and wildlife habitat.
- Buffers, overhanging vegetation and fallen trees should remain to provide cover and prevent shoreline erosion which could cause undesirable increases in sedimentation on walleye

spawning shoals and bluegill nesting sites, consisting of an abundance of cobble, gravel and sand.

- Remove riprap and implement shoreline restoration using native shoreline plants. Riprap is not necessary because the wave energy is low for the entire lake. If shoreline erosion is a problem, overland runoff from rooftops, driveways, and lawns or reckless motorboat use are the most likely causes.
- Monitor groundwater quality to determine if septic systems are polluting the lake.
- Consider consolidating piers and/or rafts for community rather than single-parcel use.
- Implement lakewide slow-no-wake ordinance. Lakes less than 50 acres with a public boat landing are automatically Slow-No-Wake by statute. All three lakes would benefit from minimizing habitat and water quality problems that result from motorboat use on small, fragile lakes. These problems include disturbing the lake bottom, re-suspending nutrients and sediment that fuel algae blooms, and propeller damage to aquatic plants.

2.5 Water Quality – Headwaters Lakes

The natural resources of the Upper, Middle, and Lower Eau Claire Lakes are a defining feature for the Town of Barnes. The Eau Claire Chain is comprised of the Upper Eau Claire, Middle Eau Claire, and Lower Eau Claire Lakes, as well as eight smaller connecting lakes for a total surface area of 3,488 acres of waters. These lakes are the headwaters of the Eau Claire River and are recognized as outstanding resource waters. These clear lakes are connected by streams with the Middle and Lower Lakes connected through a navigable channel controlled by a mechanical small boat lock.

Water quality in the connected lakes is not as well studied; however, some data does exist through the Citizen Lake Monitoring Network[2] (CLMN). CLMN is a water quality monitoring partnership between the WDNR, the Wisconsin Lakes Partnership, and over 1,000 citizen volunteers statewide. The goals of the CLMN are to collect high-quality data, to educate and empower volunteers, and to share this data and knowledge. Volunteers measure water clarity using the Secchi disk, as an indicator of water quality (based on clarity). They also comment on other parameters including lake level, water color, murkiness, and how they perceive the lake on any given monitoring date using a 1 to 5 scale with 1 being “great, fantastic” and 5 being “really bad”.

Volunteers may also collect chemistry data including total phosphorus (TP) and chlorophyll-a (Chla). Phosphorus is one of the nutrients needed to grow aquatic plants. Chlorophyll-a is a pigment or chemical compound responsible for the green appearance of most plants and measuring its concentration is an indication of the number of algae (also a plant) suspended in the water. Volunteers may also collect temperature and dissolved oxygen data; and monitor for the first appearance of aquatic invasive species near boat landings, other access points, or along the shoreline. Water quality data for Sweet, Shunenberg, and Smith Lakes is limited but what is available is presented here.

2.5.1 Smith Lake

There is no water quality data available for Smith Lake other than comments made by the aquatic plant surveyor. During the 2024 summer aquatic plant survey, the surveyor indicated he could see the bottom

[2] For more information about the CLMN go to: https://dnr.wisconsin.gov/topic/lakes/clmn

over the entirety of the lake, suggesting decent water clarity. There is no data related to phosphorus and chlorophyll concentrations in the lake water.

2.5.2 Shunenberg Lake

Shunenberg Lake has the most water quality data available of the three lakes. Data is available from 2001, from 2004 to 2011, and from 2014 to 2016. The following figures were taken from the WDNR Water Explorer.[3] Figure 7 reflects all Secchi disk readings that have been recorded in the WDNR Surface Water Integrated Monitoring System (SWIMS) database. Comments made by volunteers collecting the data suggest that the Secchi disk was able to be seen all the way to the bottom of the lake during most sampling events. Water color was listed as green; the water was mostly clear, and lake conditions were considered "beautiful, could not be better". The data collected does not present any discernible long-term trend in water clarity.

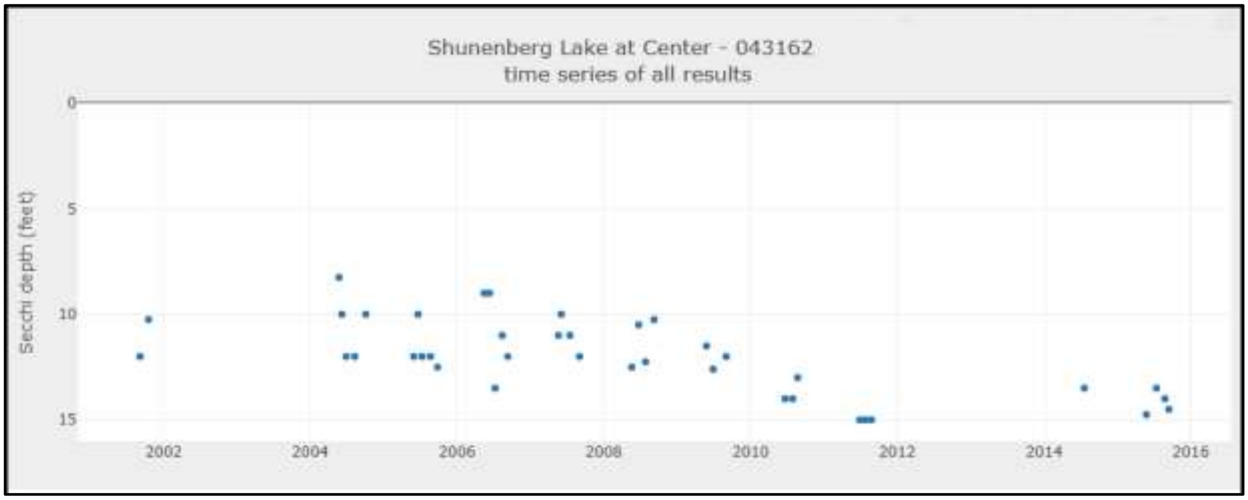

Figure 7: Secchi disk readings of water clarity – SHL 2001, 2004-2011, 2014-2016 (WEx, 2025)

Figure 8 reflects the results of TP analysis from all the water samples collected from SHL. Concentrations remained steady at just under 0.02mg/l (20.0 µg/l). The data collected does not present any discernible long-term trend in phosphorus concentration.

[3] https://dnr.wisconsin.gov/topic/SurfaceWater/WEx.html

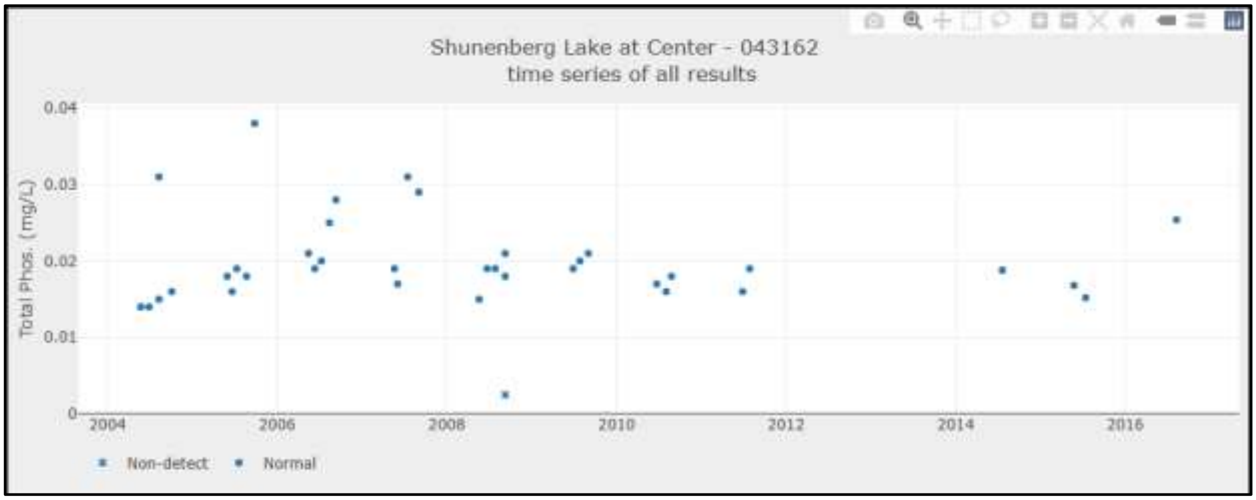

Figure 8: TP concentration in water samples from SHL – SHL 2001, 2004-2011, 2014-2016 (WEx, 2025)

Figure 9 reflects the results of Chla analysis from all the water samples collected from SHL. Concentrations ranged from <0.5 µg/l to 2.0 µg/l, all considered very low. The data show a long-term trend toward improving or lower values in the late summer (WEx, 2025).

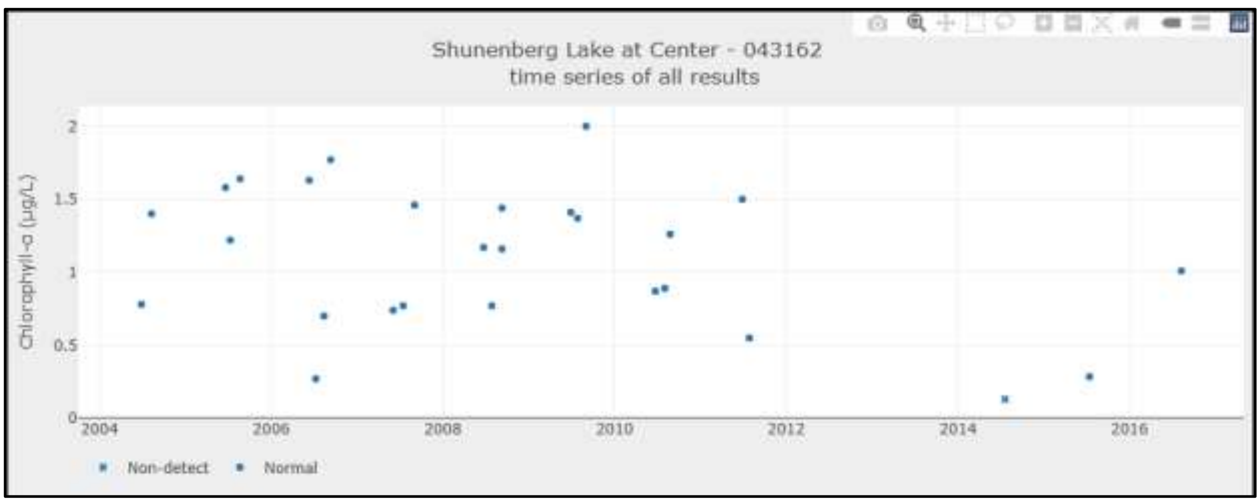

Figure 9: TP concentration in water samples from SHL – SHL 2001, 2004-2011, 2014-2016 (WEx, 2025)

2.5.3 Sweet Lake

There have only been two Secchi disk readings of water clarity recorded for Sweet Lake. Both were collected in October 2001. Both readings were over 10ft suggesting good water clarity. No other water quality data has been collected from SWL.

2.6 Trophic State Index – Lake Productivity

Water clarity (based on Secchi disk readings), TP, and Chla are parameters that can be used to determine the productivity or trophic status of a lake. These terms refer to how fertile a lake is – i.e., how much plant biomass can it produce. The Carlson trophic state index (TSI) is a frequently used biomass-related index. The trophic state of a lake is defined as the total weight of living biological material (or biomass) in a lake at a specific location and time. Eutrophication is the movement of a lake's trophic state in the direction of more plant biomass. Eutrophic lakes tend to have abundant growth of aquatic plants, high nutrient concentrations, and low water clarity due to algae blooms (Figure 10). Oligotrophic lakes, on the other end of the spectrum, are nutrient poor and have little plant and algae growth (Figure 10). Mesotrophic lakes have intermediate nutrient levels and only occasional algae blooms (Figure 10). Based on actual data (Secchi depth in feet and TP and Chla in ug/L), Figure 10 can be used to determine the productivity of a given lake. Secchi and Chla results put Shunenberg Lake in the oligotrophic range, and TP concentrations put the lake in the mesotrophic range.

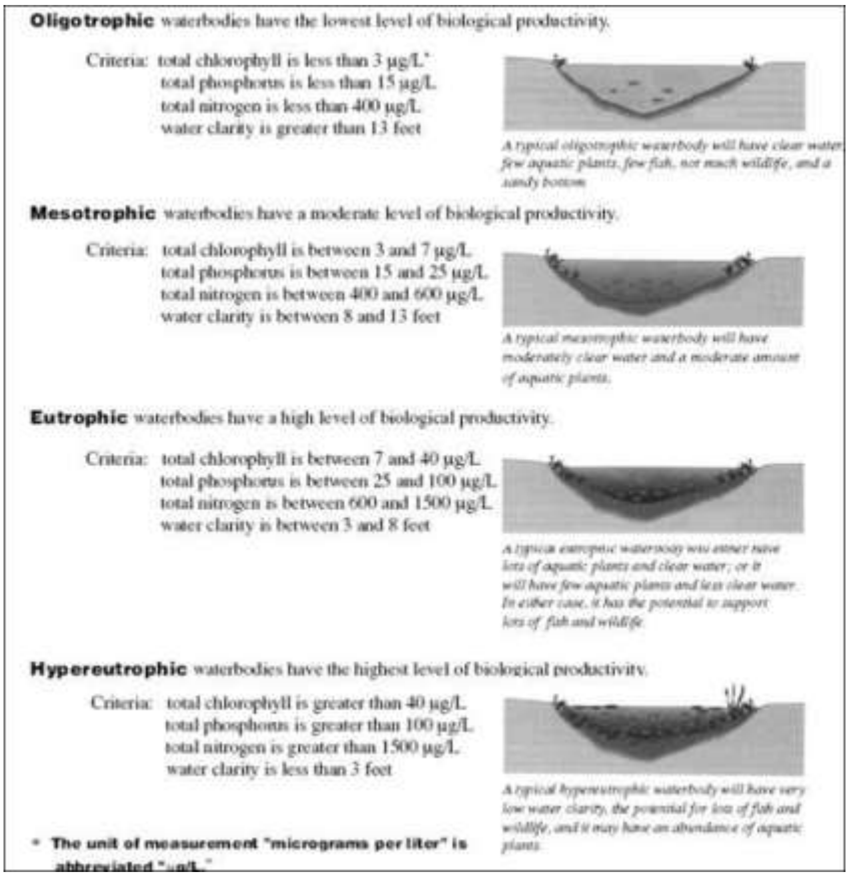

Figure 10: Trophic states in lakes

The measurements of all three water quality parameters (Secchi - feet, TP & Chla - µg/L) can be converted to values that fit in a “zero” to 100 scale (called the TSI Scale) and compared together to establish trends and make general assumptions about a lake. TSI values from 0-40 are considered oligotrophic, 40-50 are mesotrophic, 50-70 are eutrophic, and anything above 70 is considered hypereutrophic (Table 1).

Table 1: TSI Scale (Cedar Corporation, 2006)

TSI Value	Water Quality Attributes	Fisheries, Recreation or Example Lakes
<30	**Oligotrophic:** Clear water, oxygen through the year in the hypolimnion. Water supply may be suitable unfiltered.	Salmonid fisheries dominate.
30-40	Hypolimnia of shallower lakes may become anoxic during the summer.	Salmonid fisheries in deep lakes only. Example: Lake Superior (WDNR)
40-50	**Mesotrophic:** Water moderately clear but increasing probability of anoxia in hypolimnion during summer. Possible iron, manganese, taste and odor problems may worsen in water supply. Water turbidity requires filtration.	Walleye may predominate and hypolimnetic anoxia results in loss of salimonoids.
50-60	**Eutrophic:** Lower boundary of classic eutrophy. Decreased transparency, anoxic hypolimnion during the summer, macrophyte problems evident, warm water fisheries dominant.	Bass may dominate.
60-70	Dominance of blue-green algae, algal scums probable, extensive macrophyte problems. Possible episodes of severe taste and odor from water supply. Anoxic hypolimnion, water-water fisheries.	Nuisance macrophytes, algal scums and low transparency may discourage swimming and boating.
70-80	**Hypereutrophic:** Light limited productivity, dense algal blooms and macrophyte beds.	Lake Menomin & Tainter Lake, Dunn County, WI (WDNR).
>80	Algal scums, few macrophytes, summer fishery kills.	Dominant rough fish.

Figure 11 plots the summer (July-August) averages all available water quality data for TP, Chl-a, and Secchi (water clarity) from Shunenberg Lake. In the figure, dark blue represents oligotrophic values, light blue represents mesotrophic values, and green represents eutrophic values. When comparing the TSI of all three parameters, patterns may emerge from the data over time. Carlson and Havens (2005) discussed these patterns. In SHL, TP has been consistently higher than Chla, which for the most part has been equal to Secchi (Figure 11). From Carlson and Havens, this pattern suggests that some factor other than phosphorus (perhaps zooplankton grazing or limited nitrogen availability) limits algal biomass. From a water quality perspective, this pattern suggests algal bloom occurrence may not change rapidly in response to TP, because TP concentrations are greater than the needs of the algae.

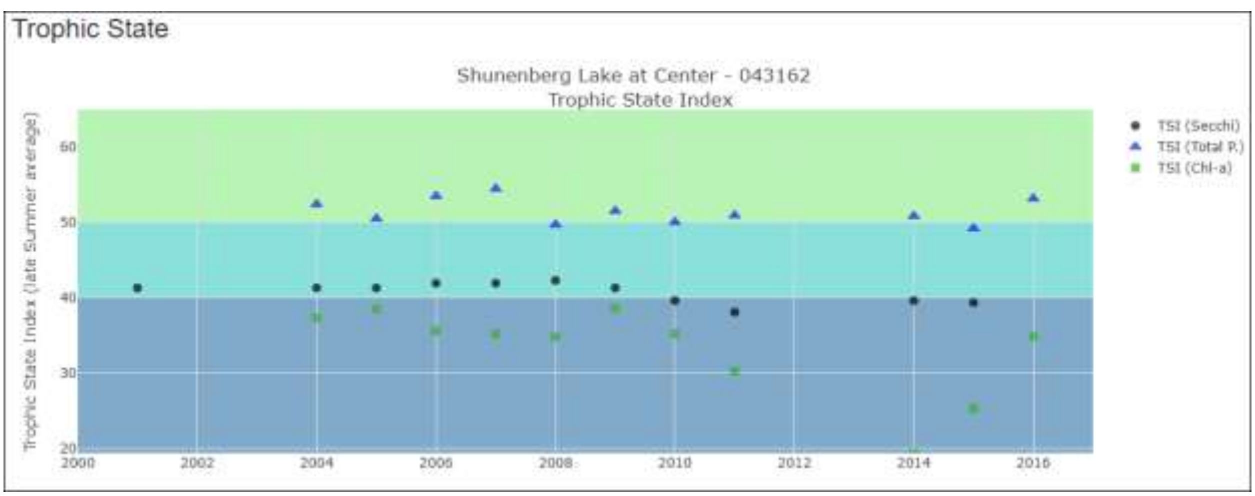

Figure 11: Trophic State Index (TSI) placement and relationship for Total Phosphorus, Chlorophyll-a, and Secchi disk readings of water clarity (WEx, 2025)

2.7 Temperature and Dissolved Oxygen

Temperature and dissolved oxygen (DO) are important factors that influence aquatic organisms and nutrient availability in lakes. As temperature increases during the summer in deeper lakes, the colder water sinks to the bottom and the lake develops three distinct layers as shown in Figure 7. This process, called stratification, prevents mixing between the layers due to density differences which limits the transport of nutrients and dissolved oxygen between the upper and lower layers. However, this process only occurs when the water is deep enough and/or the lake sheltered enough to make it possible. Only SWL is deep enough to stratify, both SML and SHL are shallow and remain “mixed” with temperature and DO mostly consistent from the surface of the lake to the bottom of the lake during the entire open water season.

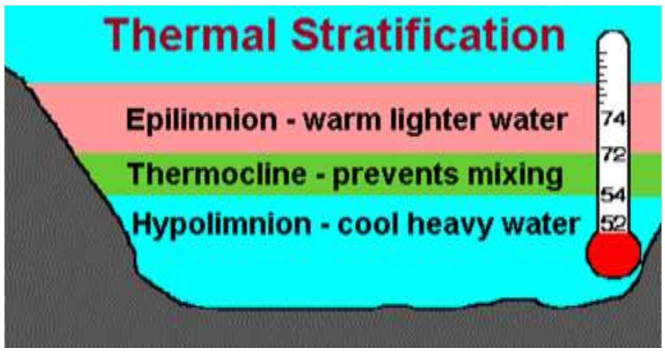

Figure 12: Summer thermal stratification

3.0 Aquatic Plant Surveys

There is always some natural variation from year to year in the makeup of the aquatic plant community in a lake. However, human changes caused by development and boating and the introduction and management of an invasive species like curly-leaf pondweed (CLP), may have more obvious impacts on aquatic plants. Completing a whole-lake, point-intercept (PI), summer aquatic plant survey is generally the first step toward documenting changes in the aquatic plant community of a lake. Point-intercept surveys are based on a set number of sampling points for a given lake and are fully repeatable. They provide a statistical basis to compare changes in the aquatic plant community.

The first such surveys on the Headwaters lakes were completed by the WDNR in 2008 but only on SWL and SHL. In 2024, Endangered Resource Services (ERS) repeated PI surveys on SHL and SWL and completed the first PI survey on SML. Figures 13-15 show the number of PI survey points and those points with vegetation, also called the littoral or plant-growing zone of the lake, for each of the Headwater lakes based on the 2024 survey.

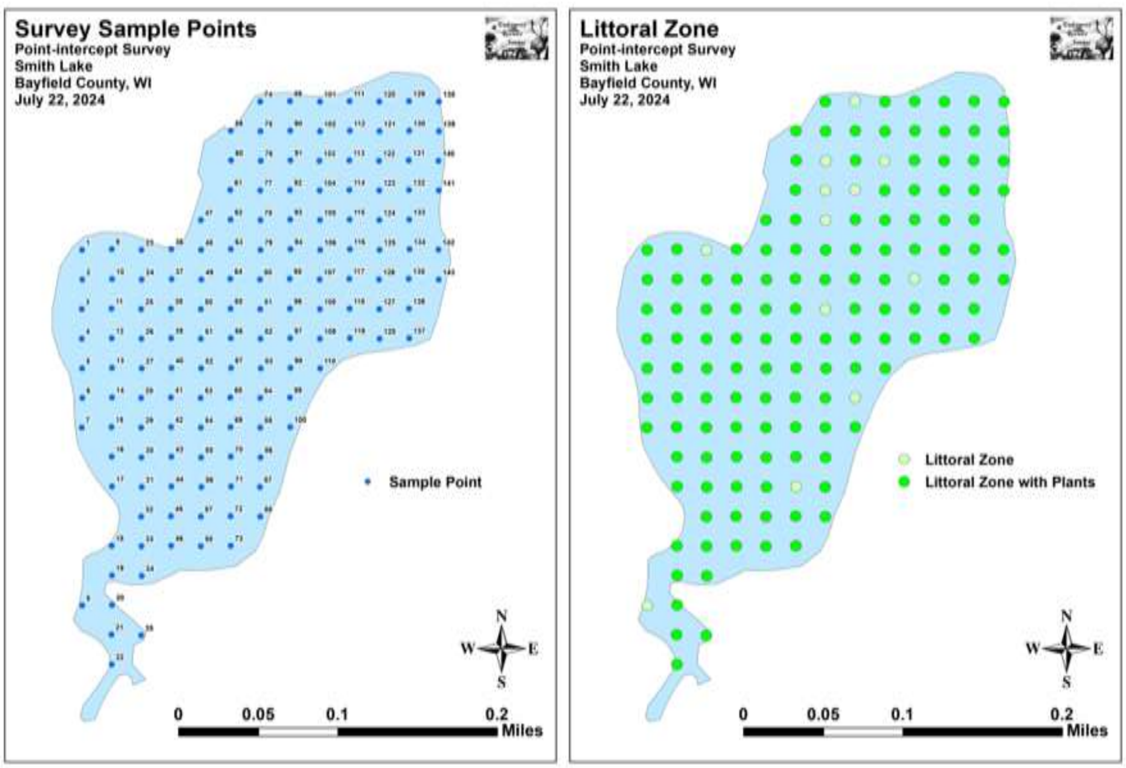

Figure 13: SML PI survey points and littoral zone (Berg, 2024a)

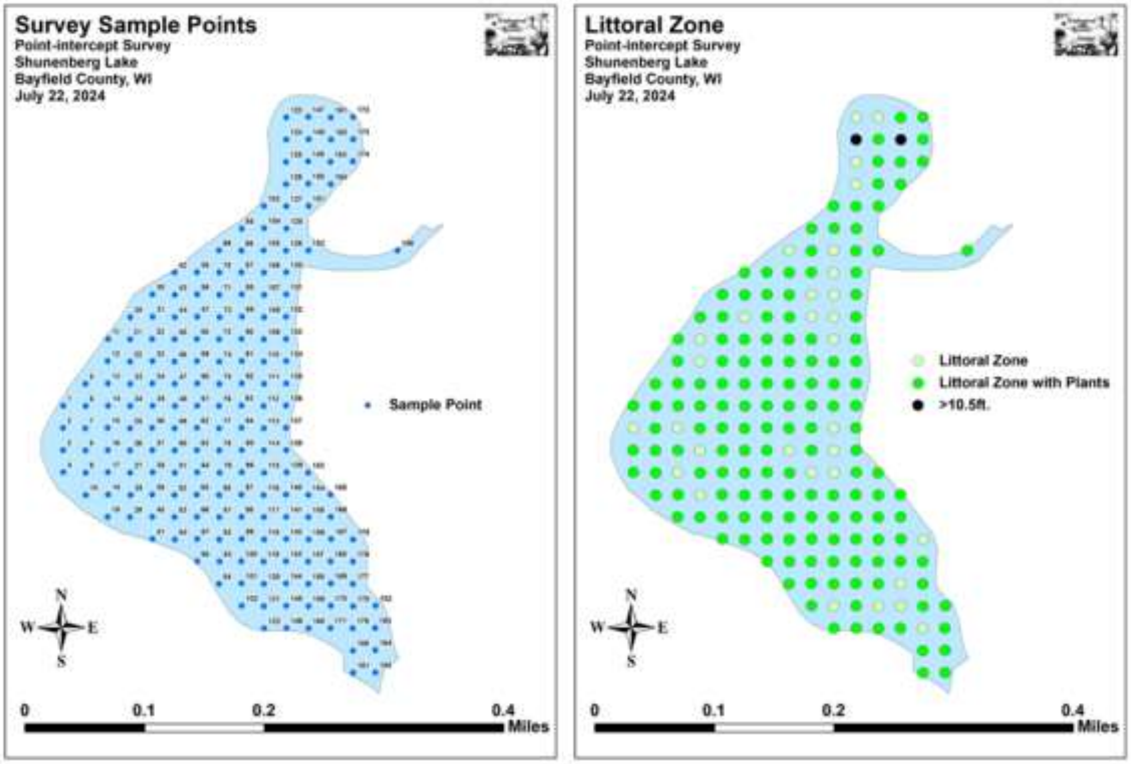

Figure 14: SHL PI survey points and littoral zone (Berg, 2024b)

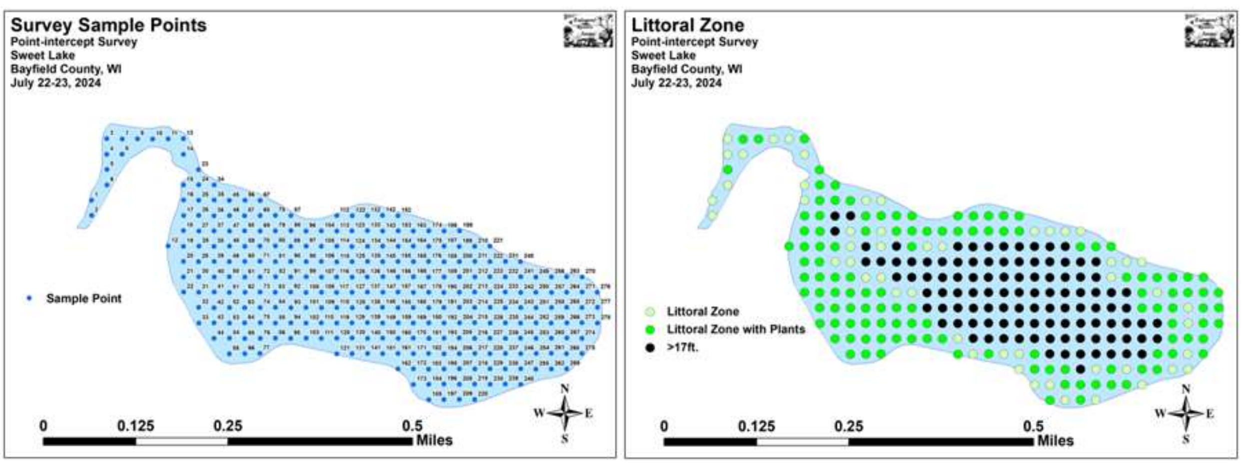

Figure 15: SWL PI survey points and littoral zone (Berg, 2024c)

3.1 2024 Early Season, Whole-lake, CLP Point-intercept Surveys

In 2024, two PI surveys were completed on each of the Headwater lakes. The first was an early season, cool water survey specifically looking for CLP. The other was a summer survey identifying all the aquatic plants in the lake. Information in the next several sections relate to plant survey work and reports completed by ERS (Berg, 2024a) (Berg, 2024b) (Berg, 2024c).

3.1.1 Smith Lake - CLP

Using a standard formula that considers the shoreline shape and distance, water clarity, depth, and total acreage, the WDNR generated a 143-point sampling grid for Smith Lake. Using this grid, CLP was sampled for at each point in and adjacent to the lake's littoral zone. Each survey point was located using a handheld mapping GPS unit (Garmin 76CSx) and a rake was used to sample an approximately 2.5ft section of the bottom. If found at a sample point, or within 6ft of a sampling point, CLP was assigned a rake fullness value of 1-3 or V (visual) as an estimation of abundance. On June 14th, transects covering 3.1 miles throughout the lake were surveyed and a rake sample was taken at all 143 points. No evidence of CLP, Eurasian watermilfoil (Myriophyllum spicatum (EWM)), or yellow iris (Iris pseudacorus) was found anywhere in the system. (Figure 16).

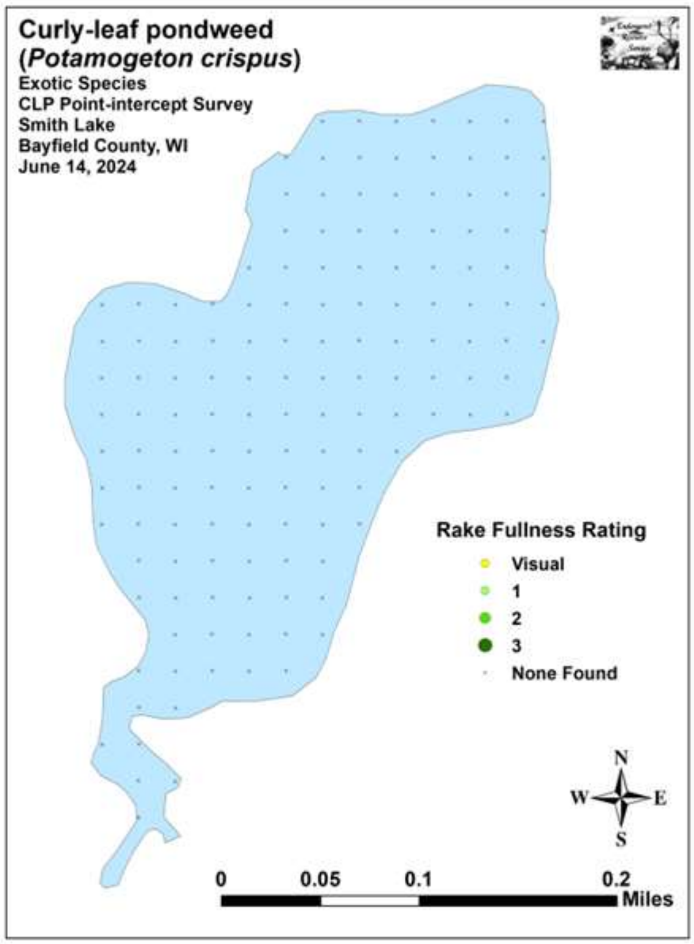

Figure 16: June 14, 2024 CLP density and distribution in SML

3.1.2 Shunenberg Lake - CLP

On June 14th, transects covering 4.2 miles throughout the lake were surveyed and a rake sample at all 186 points was taken. CLP was found in the rake at a single point (rake fullness of 2) and it was recorded as a visual at five points (Figure 17). A few yellow iris clusters growing on the east shoreline were also found. No EWM was found at any point.

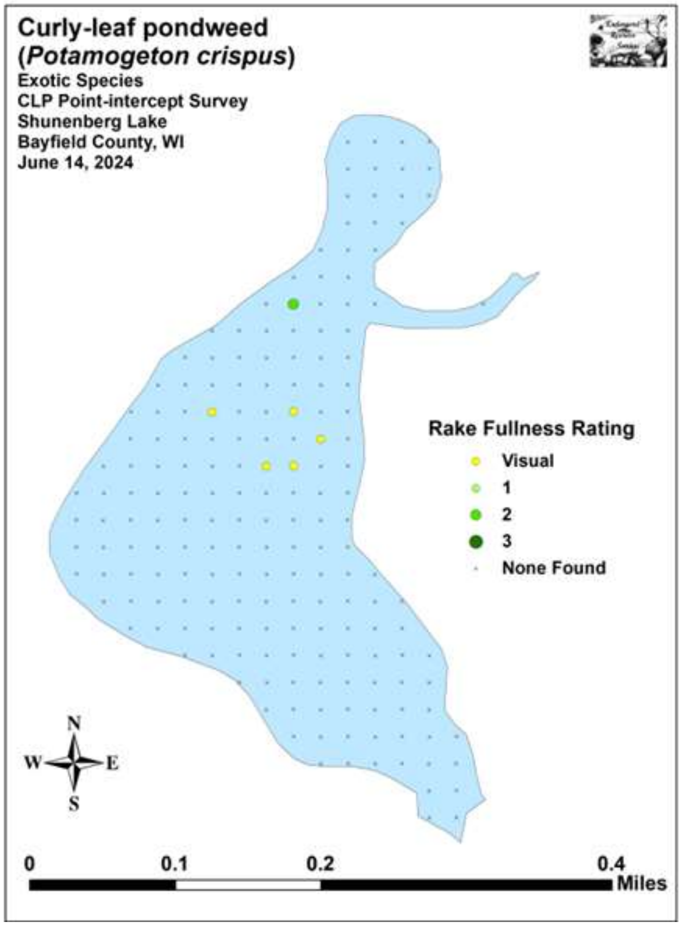

Figure 17: June 14, 2024 CLP density and distribution and photo of yellow iris in SHL

3.1.3 Sweet Lake – CLP

On June 14th, transects covering 3.1 miles throughout the lake were surveyed and a rake sample was taken at all 157 points that were under 15ft deep. No evidence of CLP, EWM, or yellow iris was found anywhere in the system. (Figure 18).

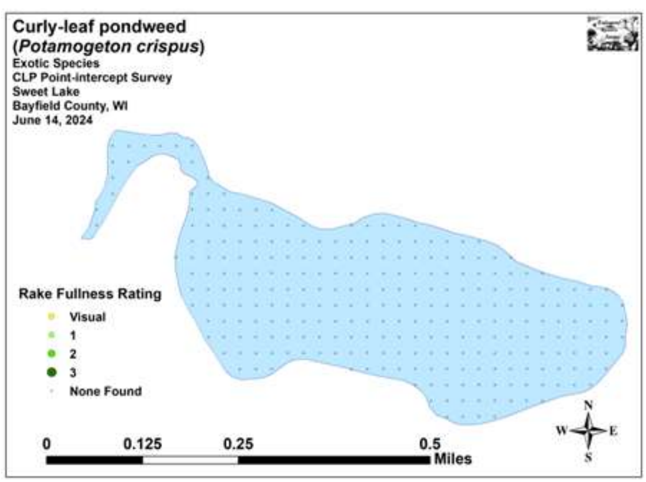

Figure 18: June 14, 2024 CLP density and distribution in SWL

3.2 2024 Summer Whole-lake, Point-intercept Aquatic Plant Surveys

ERS completed whole-lake PI surveys on the three Headwaters lakes between July 22 & 23. Surveys began with a general boat survey to gain familiarity with the lake's aquatic plants. All plants found were identified by ERS, a datasheet was built from the species identified, and uncommon species were photo documented. During the actual PI survey, each survey point was located with a GPS, depth at the point was recorded using a metered pole, and a rake sample was taken. All plants on the rake and any that were dislodged by the rake were identified and assigned a rake fullness value of 1-3 as an estimation of abundance. If a plant was sighted within 6ft of a sample point but not on the rake it was recorded as a visual (V). In addition, a total rake fullness rating was also noted. Substrate (bottom) type was assigned at each point where the bottom was visible, or it could be reliably determined using the rake.

3.2.1 Smith Lake – Summer PI

The entirety of SML fell within the littoral zone with plants found growing at 131 points, approximately 91.6% of the total lake bottom. Plant diversity was moderately high with a Simpson Index value of 0.83. Richness was, however, only low/moderate with 27 species found in the rake. This total increased to 41 species including visuals and plants seen during the boat survey. Localized richness was also low/moderate with a calculated 1.91 mean native species per site with native vegetation. The points with the highest richness occurred along the eastern shoreline in areas with more nutrient-rich organic muck. On the low-nutrient sand, sandy muck, and marly muck substrates that dominated most of the rest of the lake, few sites had more than three species present (Figure 19).

Biomass at sites with vegetation was moderate with a mean total rake fullness of 1.92. Like localized richness, visual analysis of the map showed most nearshore areas over organic muck had dense plant growth, while most areas over sand and nutrient-poor muck had low to moderate plant densities (Figure 19). Overall plant colonization was slightly skewed to shallow water as the mean depth of 4.3ft was less than the median depth of 4.5ft. All plant survey statistics are presented in Table 2.

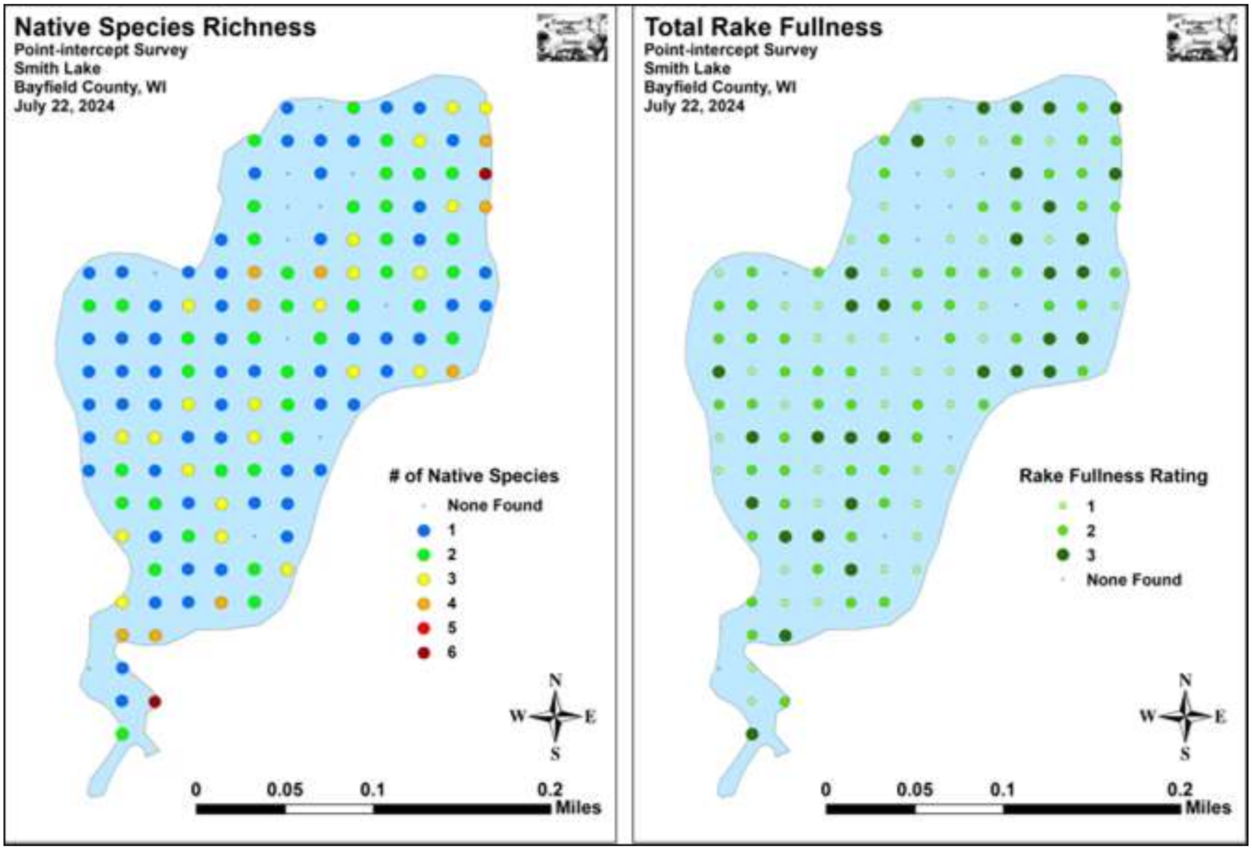

Figure 19: Native Species Richness and Total Rake Fullness in SML

Table 2: Aquatic plant PI survey summary statistics - Smith Lake – Bayfield, Wisconsin July 22, 2024

Summary Statistics: Smith Lake	
Total number of points sampled	143
Total number of sites with vegetation	131
Total number of sites shallower than the maximum depth of plants	143
Frequency of occurrence at sites shallower than maximum depth of plants	91.6
Simpson Diversity Index	0.83
Number of sites sampled using rake on Rope (R)	0
Number of sites sampled using rake on Pole (P)	143
Maximum depth of plants (ft)	7.5
Mean depth of plants (ft)	4.3
Median depth of plants (ft)	4.5
Average number of all species per site (shallower than max depth)	1.75
Average number of all species per site (veg. sites only)	1.91
Average number of native species per site (shallower than max depth)	1.75
Average number of native species per site (sites with native veg. only)	1.91
Species richness	27
Species richness (including visuals)	32
Species richness (including visuals and boat survey)	41
Mean total rake fullness (veg. sites only)	1.92

3.2.2 Shunenberg Lake – Summer PI

During the 2024 survey, aquatic plants were found growing at 153 points or on approximately 82.3% of the total lake bottom and in 83.2% of the lake's 10.5ft littoral zone. Plant diversity was very high with a Simpson Index value of 0.88. Richness was, however, only low/moderate with 24 species found in the rake. This total increased to 36 species when including visuals and plants seen during the boat survey. Localized richness was also low/moderate as a mean native species at sites with native vegetation of 2.27 species/site was calculated. Most high richness points occurred along the southwest and northeast shorelines and immediately south of the inlet in areas with more nutrient-rich organic muck. On the low-nutrient sand and sandy muck substrates that dominated most of the rest of the lake, few sites were found that had more than two species present (Figure 20).

Biomass at sites with vegetation was moderate with a mean total rake fullness of 1.90. Like SML, visual analysis of the map showed most nearshore areas over organic muck had dense plant growth, while most areas over sand and nutrient-poor muck had low to moderate plant densities (Figure 20). Overall plant colonization was slightly skewed to shallow water as the mean depth of 3.8ft was less than the median depth of 4.0ft. All plant survey statistics are presented in Table 3.

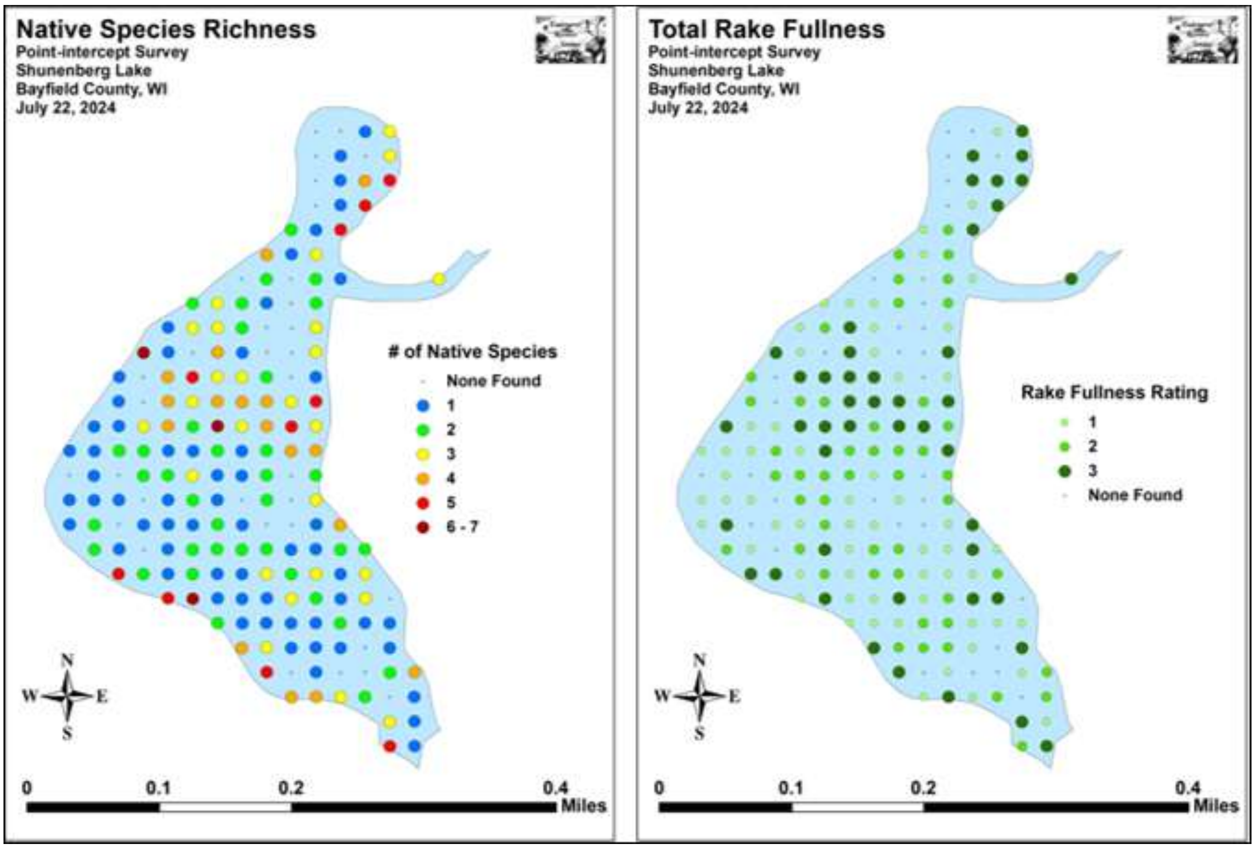

Figure 20: Native Species Richness and Total Rake Fullness in SHL

Table 3: Aquatic plant PI survey summary statistics - Shunenberg Lake – Bayfield, Wisconsin July 22, 2024

Summary Statistics: Shunenberg Lake	
Total number of points sampled	186
Total number of sites with vegetation	153
Total number of sites shallower than the maximum depth of plants	184
Frequency of occurrence at sites shallower than maximum depth of plants	83.2
Simpson Diversity Index	0.88
Number of sites sampled using rake on Rope (R)	0
Number of sites sampled using rake on Pole (P)	186
Maximum depth of plants (ft)	10.5
Mean depth of plants (ft)	3.8
Median depth of plants (ft)	4.0
Average number of all species per site (shallower than max depth)	1.89
Average number of all species per site (veg. sites only)	2.27
Average number of native species per site (shallower than max depth)	1.89
Average number of native species per site (sites with native veg. only)	2.27
Species richness	24
Species richness (including visuals)	30
Species richness (including visuals and boat survey)	36
Mean total rake fullness (veg. sites only)	1.90

3.2.3 Sweet Lake – Summer PI

During the 2024 survey, plants were found growing at 120 points or approximately 43.2% of the total lake bottom and 70.2% of the lake's 17.0ft littoral zone.

Plant diversity was very high with a Simpson Index value of 0.89. Richness was, however, only low/moderate with 26 species found in the rake. This total increased to 36 species when including visuals and plants seen during the boat survey. Localized richness was also low/moderate with a calculated mean native species at sites with native vegetation of 1.97 species/site. Like the other two lakes, the points with the highest richness occurred in the southwest bay in areas with nutrient-rich organic muck. On the sand, rock, and low-nutrient muck substrates that dominated most of the rest of the lake, few sites had more than two species present (Figure 21).

Biomass at sites with vegetation was a moderate mean total rake fullness of 2.04. Again, visual analysis of the map showed most nearshore areas over organic muck had dense plant growth, while most areas over nutrient-poor substrates had low to moderate plant densities (Figure 21). Overall plant colonization was sharply skewed to deep water as the mean depth of 6.1ft was much greater than the median depth of 5.3ft. All plant survey statistics are presented in Table 3.

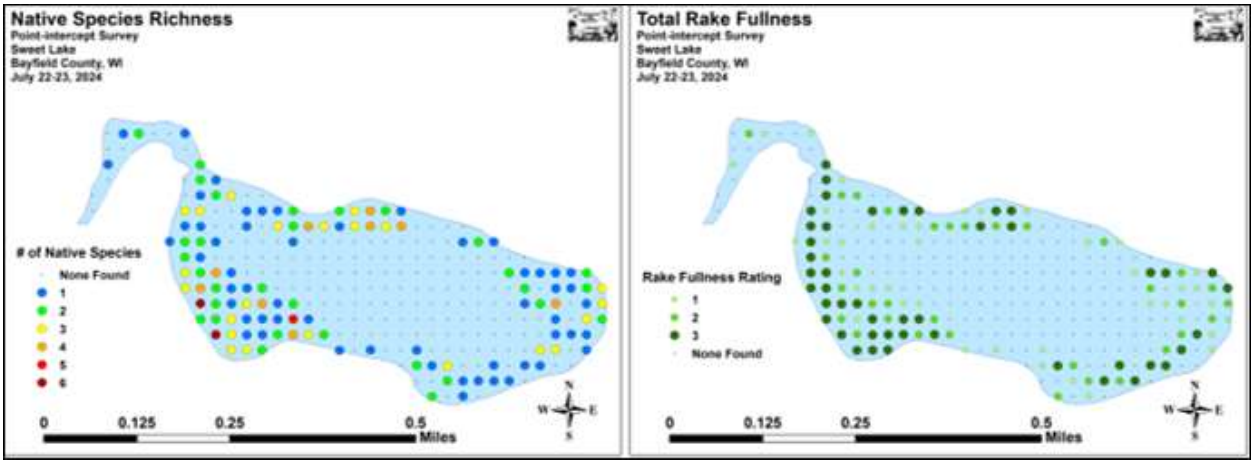

Figure 21: Native Species Richness and Total Rake Fullness in SWL

Table 4: Aquatic plant PI survey summary statistics - Sweet Lake – Bayfield, Wisconsin July 22-23, 2024

Summary Statistics: Sweet Lake	
Total number of points sampled	278
Total number of sites with vegetation	120
Total number of sites shallower than the maximum depth of plants	171
Frequency of occurrence at sites shallower than maximum depth of plants	70.2
Simpson Diversity Index	0.89
Number of sites sampled using rake on Rope (R)	0
Number of sites sampled using rake on Pole (P)	180
Maximum depth of plants (ft)	17.0
Mean depth of plants (ft)	6.1
Median depth of plants (ft)	5.3
Average number of all species per site (shallower than max depth)	1.38
Average number of all species per site (veg. sites only)	1.97
Average number of native species per site (shallower than max depth)	1.38
Average number of native species per site (sites with native veg. only)	1.97
Species richness	26
Species richness (including visuals)	34
Species richness (including visuals and boat survey)	36
Mean total rake fullness (veg. sites only)	2.04

3.3 2022 Floristic Quality Index

The FQI index measures the impact of human development on a lake's aquatic plants. The 124 species in the index are assigned a Coefficient of Conservatism (C) which ranges from 1-10. The higher the value assigned, the more likely the plant is to be negatively impacted by human activities relating to water quality or habitat modifications. Plants with low values are tolerant of human habitat modifications, and they often exploit these changes to the point where they may crowd out other species. Statistically speaking, the higher the index value, the healthier the lake's aquatic plant community is assumed to be. Nichols (1999) identified four eco-regions in Wisconsin: Northern Lakes and Forests, North Central Hardwood Forests, Driftless Area and Southeastern Wisconsin Till Plain. He recommended making comparisons of lakes within ecoregions to determine the target lake's relative diversity and health. Upper Eau Claire Lake is in the Northern Lakes and Forests Ecoregion.

Aquatic plant species are only included in calculating the FQI if they are identified on a rake. Visuals or plants identified during the boat survey are not included in the index and are excluded from FQI analysis.

FQI calculations from the 2024 summer PI surveys are included in Tables 5-7, in order SML, SHL, and SWL. The number of species, coefficient of conservatism, and FQI are similar for each of the three lakes. Nichols (1999) reported an average mean C for the Northern Lakes and Forest Region of 6.7, putting all three lakes slightly below average for this part of the state. Only three species – Crested arrowhead, Small bur-reed, and Creeping bladderwort had Coefficients of 9. None of the species identified has Coefficients of 10. The FQI from each of the lakes was higher than the median FQI of 24.3 reported for the Northern Lakes and Forest Region by Nichols. They were also higher than the FQI's calculated during the 2008 WDNR survey.

Tables 5-7: 2024 FQI Calculations – Smith, Shunenberg, and Sweet Lakes

Species	Common Name	C
Bidens beckii	Water marigold	8
Chara sp.	Muskgrass	7
Eleocharis palustris	Creeping spikerush	6
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Lemna minor	Small duckweed	4
Myriophyllum sibiricum	Northern water-milfoil	6
Najas flexilis	Slender naiad	6
Nymphaea odorata	White water lily	6
Polygonum amphibium	Water smartweed	5
Potamogeton foliosus	Leafy pondweed	6
Potamogeton friesii	Fries' pondweed	8
Potamogeton gramineus	Variable pondweed	7
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton robbinsii	Fern pondweed	8
Potamogeton strictifolius	Stiff pondweed	8
Potamogeton zosteriformis	Flat-stem pondweed	6
Sagittaria cristata	**Crested arrowhead**	**9**
Schoenoplectus acutus	Hardstem bulrush	6
Spirodela polyrhiza	Large duckweed	5
Stuckenia pectinata	Sago pondweed	3
Vallisneria americana	Wild celery	6
N		**23**
Mean C		**6.1**
FQI		**29.4**

Species	Common Name	C
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Lemna minor	Small duckweed	4
Myriophyllum sibiricum	Northern water-milfoil	6
Najas flexilis	Slender naiad	6
Nitella sp.	Nitella	7
Nymphaea odorata	White water lily	6
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton foliosus	Leafy pondweed	6
Potamogeton friesii	Fries' pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton robbinsii	Fern pondweed	8
Potamogeton strictifolius	Stiff pondweed	8
Potamogeton zosteriformis	Flat-stem pondweed	6
Sagittaria cristata	**Crested arrowhead**	**9**
Schoenoplectus acutus	Hardstem bulrush	6
Spirodela polyrhiza	Large duckweed	5
Stuckenia pectinata	Sago pondweed	3
Vallisneria americana	Wild celery	6
Ceratophyllum demersum	Coontail	3
N		**22**
Mean C		**6.0**
FQI		**28.1**

Species	Common Name	C
Brasenia schreberi	Watershield	6
Chara sp.	Muskgrass	7
Elodea canadensis	Common waterweed	3
Equisetum fluviatile	Water horsetail	7
Lemna minor	Small duckweed	4
Myriophyllum sibiricum	Northern water-milfoil	6
Najas flexilis	Slender naiad	6
Nitella sp.	Nitella	7
Nuphar variegata	Spatterdock	6
Polygonum amphibium	Water smartweed	5
Potamogeton friesii	Fries' pondweed	8
Potamogeton gramineus	Variable pondweed	7
Potamogeton natans	Floating-leaf pondweed	5
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton robbinsii	Fern pondweed	8
Ranunculus aquatilis	White water crowfoot	8
Sagittaria cuneata	Arum-leaved arrowhead	7
Schoenoplectus acutus	Hardstem bulrush	6
Sparganium natans	**Small bur-reed**	**9**
Spirodela polyrhiza	Large duckweed	5
Stuckenia pectinata	Sago pondweed	3
Typha latifolia	Broad-leaved cattail	1
Utricularia gibba	**Creeping bladderwort**	**9**
Utricularia vulgaris	Common bladderwort	7
N		**24**
Mean C		**6.0**
FQI		**29.6**

3.4 Previous PI Surveys

As a part of the critical habitat surveys completed by the WDNR in 2008, summer PI surveys were completed on SHL and SWL. The statistics for Shunenberg Lake are included in Table 5. Table 6 includes statistics from the Sweet Lake survey, however, information gained suggests that the survey was only completed on a subset of points rather than all the points in the littoral zone.

Table 6: Aquatic plant PI survey summary statistics - Shunenberg Lake – Bayfield, Wisconsin 7/30-8/1, 2008 (WDNR, 2013b)

Table 4. SH1 Aquatic Plant Sampling Summary Statistics	
SUMMARY STATISTICS	**SH1**
Total number of points sampled	215
Total number of sites with vegetation	170
Total number of sites shallower than maximum depth of plants	215
Frequency of occurrence at sites shallower than maximum depth of plants	79.07
Simpson Diversity Index	0.896
Maximum depth of plants (Feet)	12
Number of sites sampled using rake on Rope (R)	0
Number of sites sampled using rake on Pole (P)	218
Average number of all species per site (shallower than max depth)	1.80
Average number of all species per site (veg. sites only)	2.28
Average number of native species per site (shallower than max depth)	1.80
Average number of native species per site (veg. sites only)	2.28
Species Richness	23
Species Richness (including visuals)	27
Floristic Quality Index	27.70

Table 7: Aquatic plant PI survey summary statistics - Sweet Lake – Bayfield, Wisconsin 8/5-8/7, 2008 (WDNR, 2013a)

Table 28. SL9 Aquatic Plant Sampling Summary Statistics	
SUMMARY STATISTICS	**SL9**
Total number of points sampled	15
Total number of sites with vegetation	11
Total number of sites shallower than maximum depth of plants	15
Frequency of occurrence at sites shallower than maximum depth of plants	73.33
Simpson Diversity Index	0.814
Maximum depth of plants (Feet)	2
Number of sites sampled using rake on Rope (R)	0
Number of sites sampled using rake on Pole (P)	15
Average number of all species per site (shallower than max depth)	1.47
Average number of all species per site (veg. sites only)	2.00
Average number of native species per site (shallower than max depth)	1.47
Average number of native species per site (veg. sites only)	2.00
Species Richness	8
Species Richness (including visuals)	10
Floristic Quality Index	14.85

3.5 2024 Summer PI Aquatic Plant Community

3.5.1 Smith Lake

The most widely distributed plant species in SML were Slender naiad, Muskgrass, Clasping-leaf pondweed, and Flat-stem pondweed. They were present at 64.89%, 38.17%, 13.74%, and 12.98% of survey points with vegetation respectively; and, collectively, they accounted for 67.73% of the total relative frequency. Common waterweed (5.16%) and Water star-grass (4.76%) also had relative frequencies over 4.00%.

3.5.2 Shunenberg Lake

The most widely distributed plant species in SHL were Slender naiad, Muskgrass, Common waterweed, and Northern watermilfoil. They were present at 49.02%, 34.64%, 34.64%, and 27.45% of survey points with vegetation respectively; and, collectively, they accounted for 64.08% of the total relative frequency. Fries' pondweed (5.17%), Sago pondweed (4.31%), and Clasping-leaf pondweed (4.02%) also had relative frequencies over 4.00%.

3.5.3 Sweet Lake

The most widely distributed plant species in SWL were Muskgrass, Northern watermilfoil, Common waterweed, and Fries' pondweed. They were present at 49.17%, 24.17%, 16.67%, and 15.83% of survey points with vegetation respectively; and, collectively, they accounted for 53.81% of the total relative frequency. Water horsetail (6.36%), Clasping-leaf pondweed (5.51%), Slender naiad (4.24%), and Sago pondweed (4.24%) also had relative frequencies over 4.00%.

Photos of each of the most common plants species are in Figures 22 and 23.

Figure 22: (left to right – top to bottom) Muskgrass, Clasping-leaf pondweed, Flat-stem pondweed, Common waterweed, Northern watermilfoil (Berg, 2024b)

Figure 23: (left to right – top to bottom) Fries' pondweed, Sago pondweed, Water horsetail, Water stargrass (Berg, 2024b)

3.5.4 Changes in Native Aquatic Plant Species

Previous PI surveys of the Headwaters lakes are limited. A volunteer completed surveys in the early 2000's and the WDNR completed surveys on two of the lakes in 2008. The data collected by a volunteer could likely show some indication of species that were present at that time but some of the plants identified may be suspect. Although a complete PI survey was done by the WDNR in 2008 on Shunenberg Lake, only a small subset of points (15) was included in a PI survey on Sweet Lake the same year. Because these are the first whole-lake, point-intercept surveys completed by ERS, and the only complete data sets to work with, there is no comparison of changes in native aquatic plant species.

3.6 Other Aquatic Invasive Species in Cranberry Lake

No evidence of EWM was found in any of the Headwater lakes. However, Common forget-me-nots, yellow iris, Reed canary grass, and Common reed grass were found. Of these, yellow iris is likely the only one to be managed using physical removal.

3.7 Wild Rice

Wild rice is an aquatic grass which grows in shallow water in lakes and slow flowing streams. This grass produces a seed which is a nutritious source of food for wildlife and people. The seed matures in August and September with the ripe seed dropping into the sediment, unless harvested by wildlife or people. It is a highly protected and valued natural resource in Wisconsin. Only Wisconsin residents may harvest wild rice in the state. No wild rice was found in any of the Headwater lakes.

4.0 Aquatic Invasive Species Management

Since CLP was first found in Shunenberg Lake, the Town of Barnes has spent time with their DASH (BAISS) boat to remove it. The same is true for Smith Lake although not much CLP has been found there. No CLP was found in Sweet Lake, so no AIS management has occurred there to date. Monitoring efforts in the Headwater lakes should continue given that CLP and several other non-native aquatic invasive species are present in the system. If management of CLP (or EWM) is needed in the future, the Barnes BAISS boat will likely be used to remove it with DASH, or by diver/physical removal alone.

DASH involves scuba divers who swim along the bottom of the lake with a hydraulic suction tube and when an offending plant is found, it is dislodged by the diver and fed into the suction tube. Hydraulic suction brings the removed plant to the surface of the lake and deposits into a bag or bin on the boat (Figure 24).

Figure 24: DASH boat and underwater operation (ILM Environments)
https://www.youtube.com/watch?v=YQmLMKzc1UM

4.1 CLP or EWM Management

If any management of CLP (or EWM) becomes necessary in the Headwater lakes, a scenario-based approach to management is recommended over the next five years. A scenario-based approach means that any amount of CLP or EWM may be managed in the lake; however, the management actions implemented will be dictated by the conditions that exist in the lake at any given time. Not all CLP needs to be removed from the lake, but efforts should be made to keep it from gaining more purchase in the lake. To do this, a combination of manual/physical removal and DASH are recommended. The following monitoring and control activities have been outlined:

1) AIS will be monitored by volunteers and resource professionals every year.
    a. Pre-management surveys will be completed annually as soon as an AIS begins to make an appearance to judge the severity of seasonal growth.
    b. AIS bedmapping will be completed annually at the appropriate times for the AIS discovered (early to mid-June for CLP, summer or fall for EWM) in an effort to track its expansion or decline.
2) Areas of AIS with sparse, isolated plants can and should be hand pulled or raked by volunteers in shallow water (≈ 5 feet) around docks and along shorelines.
    a. Can be completed at any time during the particular AIS's growing season
    b. Does not require a WDNR permit.

3) Snorkel, rake, and/or scuba diver removal of AIS can and should take place in areas with isolated plants, small clumps, or small beds of plants where practical and if resources are available.
    a. Would likely be completed by the Friends of the Eau Claire Lakes and supported by the Town of Barnes
    b. Can be completed at any time during the AIS's growing season
    c. Does not require a WDNR permit.
4) Diver-assisted Suction Harvest or DASH will likely be the most used management action. It has been and will continue to be used in place of or in combination with snorkel, rake, and/or scuba diver removal of CLP and other AIS in other lakes. DASH makes it possible to manage larger areas without the use of herbicides.
    a. Would likely be completed by the Friends of the Eau Claire Lakes and supported by the Town of Barnes
    b. Can be completed at any time prior to when turions are set
    c. DASH requires a WDNR Mechanical Harvesting permit.

The management actions outlined for CLP would also be effective for the management of EWM should it be found in the Headwater lakes over the next five years. Annual management decisions for CLP (or EWM) will always be based on the level of infestation, current understanding of management alternatives, resources available, what is acceptable to the constituency, and what the WDNR will approve.

4.2 Management of Other AIS

At the present time, only yellow iris is a candidate for management, and it can be done with physical removal. A new introduction of EWM in the Headwaters would be managed in the same way as CLP. Purple loosestrife, should it be found, can be physically removed. Red canary grass, Common reed grass, and Forget-me-nots are likely not to be managed. If management of these species is of interest, shoreland restoration using native vegetation would likely be the route to choose.

The lakes should also be actively monitored for zebra mussels and spiny waterflea. For more information about these and other AIS, review the more inclusive Aquatic Plant Management Plan for the Towns of Barnes, Gordon, and Highland in Bayfield and Douglas Counties of which this document is an addendum.

5.0 Aquatic Plant Management Goals

This Aquatic Plant Management Plan establishes the following goals for aquatic plant management in Headwater lakes (Smith, Shunenberg, and Sweet) of the Eau Claire lakes system:

AIS Monitoring. Annual monitoring of the Headwater lakes should be completed either through volunteer AIS surveys following CLMN AIS Monitoring protocol or hired contractors completing one or more surveys each year. In addition, BAISS boat volunteers monitor the waters they work on for AIS.

AIS Management. At present, physical removal by divers or DASH are the only management actions to be implemented. These management practices will be adapted to the conditions that are presented each year.

AIS Education and Awareness. Continue to educate property owners and lake users on aquatic invasive species through public outreach and education programs to help contain existing AIS and to prevent new introductions.

Research and Monitoring. Develop a better understanding of the lake and the factors affecting lake water quality through continued and expanded monitoring efforts.

Adaptive Management. Follow an adaptive management approach that measures and analyzes the effectiveness of control activities and modifies the management plan as necessary to meet goals and objectives.

5.1 Goal 1. AIS Monitoring

Determining when AIS management is needed will be dependent on annual or semi-annual AIS monitoring completed in the Headwater lakes by volunteers or resource professionals. If a new AIS is discovered, discussions pertaining to next season management will begin. Should it be determined that the application of aquatic herbicides or any other management action will come into play in the following year, additional pre-treatment surveys of aquatic plants may be completed to document the present of native plants. Post-treatment surveys may be included in the year of treatment and/or in the year after treatment. Pre and post treatment surveys are not required by the WDNR unless the chemically treated areas cover 10 or more acres or 10% of the surface area of the lake.

5.2 Goal 2. AIS Management

The goal of management is to keep existing AIS, in this case CLP, at low densities in the lakes through approved management actions that cause little or no disturbance to the native aquatic plant community. If a new AIS is identified in the lakes, the goal of management is the same.

5.3 Goal 3. AIS Education and Awareness

Aquatic invasive species can be transported via several vectors, but most new introductions are associated with human activity. Maintaining signs and continuing watercraft inspection at the public boat landings should be done to educate lake users about what they can do to prevent the spread of AIS.

Early detection and rapid response efforts increase the likelihood that a new AIS will be addressed successfully while the population is still localized and levels are not beyond that which can be contained. Once an AIS becomes widely established in a lake, control becomes much more difficult and efforts to do so may be more detrimental to the system than no management at all. The costs of early detection and rapid response efforts are typically far less than those of long-term invasive species management programs needed when an AIS becomes established.

It is recommended that the Town of Barnes and Friends of the Eau Claire Lakes continue to implement a proactive and consistent AIS monitoring program. At least three times during the open water season, trained volunteers should patrol the shoreline and littoral zone looking for EWM and other species like purple loosestrife, Japanese knotweed, giant reed grass, and zebra mussels. Free support for this kind of monitoring program is provided as part of the UW-Extension Lakes/WDNR CLMN AIS Monitoring Program. Any monitoring data collected should be recorded annually and submitted to the WDNR SWIMS database.

Providing education, outreach opportunities, and materials to the lake community will improve general knowledge and likely increase participation in lake protection and restoration activities. It is further recommended that the Town of Barnes and Friends of the Eau Claire Lakes continue to cultivate an awareness of the problems associated with AIS and enough community knowledge about certain species to aid in detection, planning, and implementation of management alternatives within their lake community. It is also recommended that the Town of Barnes and Friends of the Eau Claire Lakes continue to strive to foster greater understanding and appreciation of the entire aquatic ecosystem including the important role plants, animals, and people play in that system.

Understanding how their activities impact the aquatic plants and water quality of the lakes is crucial in fostering a responsible community of lakeshore property owners. To accomplish this, the Town of Barnes and Friends of the Eau Claire Lakes should distribute or redistribute informational materials and provide educational opportunities on aquatic invasive species and other factors that affect the lakes. At least one annual activity (picnic at the lake, public workshop, guest speakers, etc.) should be sponsored and promoted by the Town of Barnes and Friends of the Eau Claire Lakes that is focused on AIS. Results of water quality monitoring should be shared with the lake community at the annual meeting, or another event, to promote a greater understanding of the lake ecosystem and potentially increase participation in planning and management.

5.4 Goal 4. Research and Monitoring

Long-term data can be used to identify the factors leading to changes in water quality. Such factors include aquatic plant management activities, changes in the watershed land use, and the response of the lakes to environmental changes. The CLMN Water Quality Monitoring Program supports volunteer water quality monitors across the state following a clearly defined schedule. Volunteers collected several years of water quality data on Shunenberg, but little to no data on Smith or Sweet. Several years of water quality monitoring that includes water clarity, total phosphorus, and chlorophyll-a should again be collected from Shunenberg. Long-term trend monitoring should be started on Sweet Lake and continued for multiple years. Identifying a volunteer from Sweet Lake to collect data over 10 years or more would help to determine if there are any trends related to water quality. As the smallest and most downstream lake before entering Upper Eau Claire Lake, collecting long-term trend data on Smith Lake may not be necessary as it generally reflects the conditions in Shunenberg.

Mapping and monitoring for CLP and other non-native, aquatic, invasive plants should be completed annually. If management becomes a larger issue due to the expansion of CLP or because of a new AIS, it is recommended that whole lake point intercept aquatic plant surveys be completed at five-year intervals. This will allow managers to adjust the APM Plan as needed in response to how the plant community changes because of management and/or natural factors.

The Town of Barnes and Friends of the Eau Claire Lakes should continue to support efforts to improve/restore native shoreland around the lakes that lead to healthier habitat and less polluted runoff from properties immediately adjacent to the lake. These efforts should continue and can be supported by the Wisconsin Healthy Lakes and Rivers Initiative. In addition, the Town of Barnes and Friends of the Eau Claire Lakes should continue to work with the Bayfield County Soil and Water Conservation Department to address runoff concerns in the greater watershed.

5.5 Goal 5. Adaptive Management

This APM Plan is a working document guiding management actions on the Headwater lakes for the next five years. This plan will follow a scenario-based, adaptive management approach by adjusting actions as the results of management and data obtained deem fit following IPM strategy. This plan is therefore a living document, progressively evolving and improving to meet environmental, social, and economic goals, to increase scientific knowledge, and to foster good relations among stakeholders. Annual and end of project assessment reports are necessary to monitor progress and justify changes to the management strategy, with or without state grant funding. Project reporting will meet the requirements of all stakeholders, gain proper approval, allow for timely reimbursement of expenses, and provide the appropriate data for continued management success. Success will be measured by the efficiency and ease in which these actions are completed.

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