Note: Methodology, explanation of analysis and biological background on Little Star Lake studies are contained within the Manitowish Waters Chain of Lakes-wide Management Plan document.

8.9 Little Star Lake

An Introduction to Little Star Lake

Little Star Lake, Vilas County, is a deep, headwater drainage lake with a maximum depth of 67 feet, a mean depth of 31 feet, and a surface area of approximately 260 acres. Little Star Lake is considered to be oligotrophic and its watershed encompasses approximately 859 acres. In 2016, 32 native aquatic plant species were found in the lake, of which slender naiad (*Najas flexilis*) the most common. One non-native shoreland plants, pale-yellow iris, was found during surveys.

Field Survey Notes

Little Star Lake was found to have the lowest Simpson's Diversity Index value of all the Manitowish Chain Lakes, as well as the lowest acreage of emergent and floating-leaf vegetation.

Photo 8.9. Little Star Lake, Vilas County

Lake at a Glance* – Little Star Lake

Morphology	
Acreage	260
Maximum Depth (ft)	67
Mean Depth (ft)	32
Volume (acre-feet)	8,098
Shoreline Complexity	3.5
Vegetation	
Curly-leaf Survey Date	June 29, 2016
Comprehensive Survey Date	July 19, 2016
Number of Native Species	31
Threatened/Special Concern Species	-
Exotic Plant Species	Pale-yellow iris
Simpson's Diversity	0.83
Average Conservatism	6.5
Water Quality	
Wisconsin Lake Classification	Deep, Headwater Drainage
Trophic State	Oligotrophic
Limiting Nutrient	Phosphorus
Watershed to Lake Area Ratio	2:1

**These parameters/surveys are discussed within the Chain-wide portion of the management plan.*

8.9.1 Little Star Lake Water Quality

Water quality data was collected from Little Star Lake on six occasions in 2016/2017. Onterra staff sampled the lake for a variety of water quality parameters including total phosphorus, chlorophyll-*a*, Secchi disk clarity, temperature, and dissolved oxygen. Please note that the data in these graphs represent concentrations and depths taken during the growing season (April-October), summer months (June-August) or winter (February-March) as indicated with each dataset. Furthermore, unless otherwise noted the phosphorus and chlorophyll-*a* data represent only surface samples. In addition to sampling efforts completed in 2016/2017, any historical data was researched and are included within this report as available.

In 2016, average summer phosphorus concentrations (11.1 µg/L) were less than the median value (17.0 µg/L) for other deep, headwater drainage lakes in the state (Figure 8.9.1-1). This value is also lower than the value for other lakes within the Northern Lakes and Forests ecoregion. A weighted summer value from all available data ranks as *Excellent* for a deep, lowland drainage lake, except for one year, 1997.

Total phosphorus surface values from 2016-2017 are compared with bottom-lake samples collected during this same time frame in Figure 8.9.1-2. Concentrations within the hypolimnion were found to be slightly higher than those measured from the epilimnion during stratification. As explained in the Chainwide Report (Water Quality Section Primer), sediments within a lake often release phosphorus under anoxic conditions. When mixing occurs in the lake, these nutrients may be transported to the upper water column for use by algae or aquatic plants. The near-bottom total phosphorus concentrations indicate that internal nutrient loading occurs to some degree in Little Star Lake, but that it is not a significant source of phosphorus to the lake.

Similar to what has been observed with the total phosphorus dataset, summer average chlorophyll-*a* concentrations (0.6 µg/L) were lower than the median value (5.0 µg/L) for other lakes of this type (Figure 8.8.1-3), as well as lower than the median for all lakes in the ecoregion. Both of these parameters, total phosphorus and chlorophyll-*a*, rank within a TSI category of *Excellent*, indicating the lake has enough nutrients for production of aquatic plants, algae, and other organisms but not so much that a water quality issue is present. During 2016 visits to the lake, Onterra ecologists recorded field notes describing stained water but good conditions overall.

The clarity of Little Star Lake's water can be described as *Excellent* during the summer months in which data has been collected, except for in 1979 (Figure 8.9.1-4). A weighted average over this timeframe is greater than the median value for other deep, headwater drainage lakes in the state and is also larger than the regional median. Secchi disk clarity is influenced by many factors, including plankton production and suspended sediments, which themselves vary due to several environmental conditions such as precipitation, sunlight, and nutrient availability. The Manitowish Waters Chain of Lakes displays a natural staining of the water which plays a role in light penetration, and thus water clarity, as well.

True color measures the dissolved organic materials in water. Water samples collected in May and July of 2016 were measured for this parameter, and were found to be 5 Platinum-cobalt units (Pt-co units, or PCU) in May and not detectable in July. Lillie and Mason (1983) categorized lakes with 0-40 PCU as having low color, 40-100 PCU as medium color, and >100 PCU as high color.

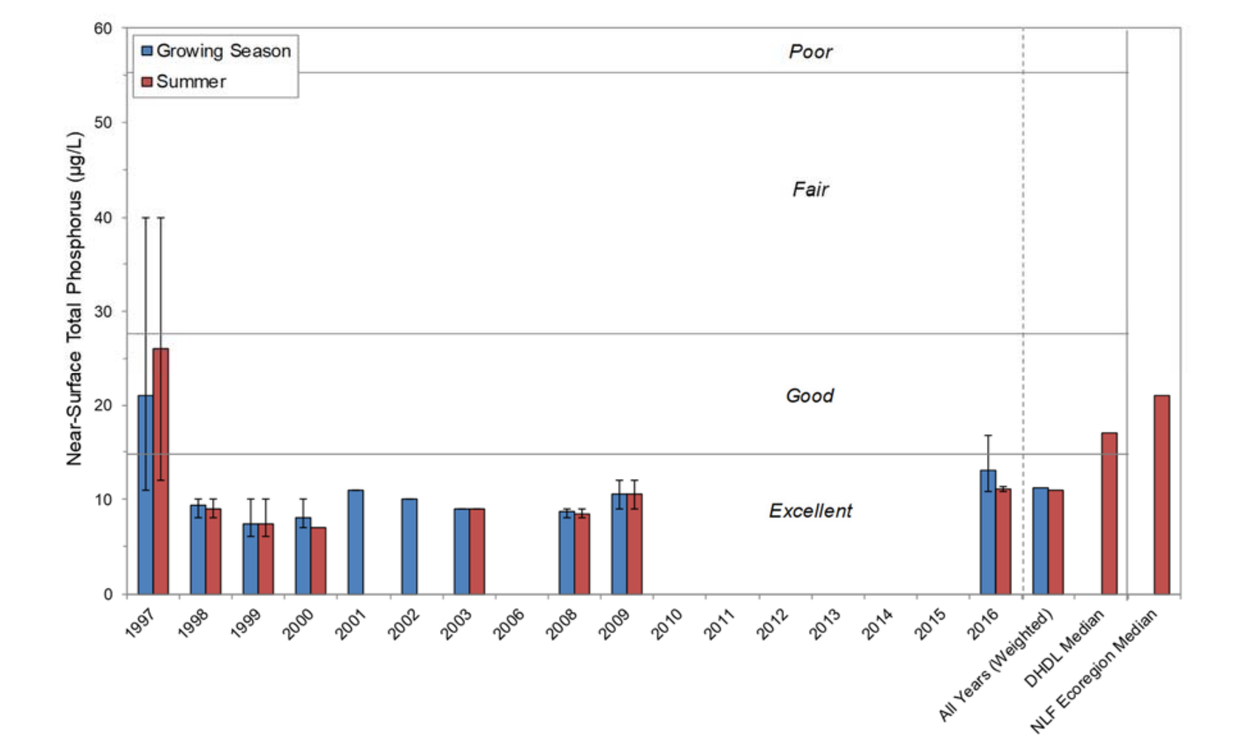


Figure 8.9.1-1. Little Star Lake, state-wide deep, headwater drainage lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

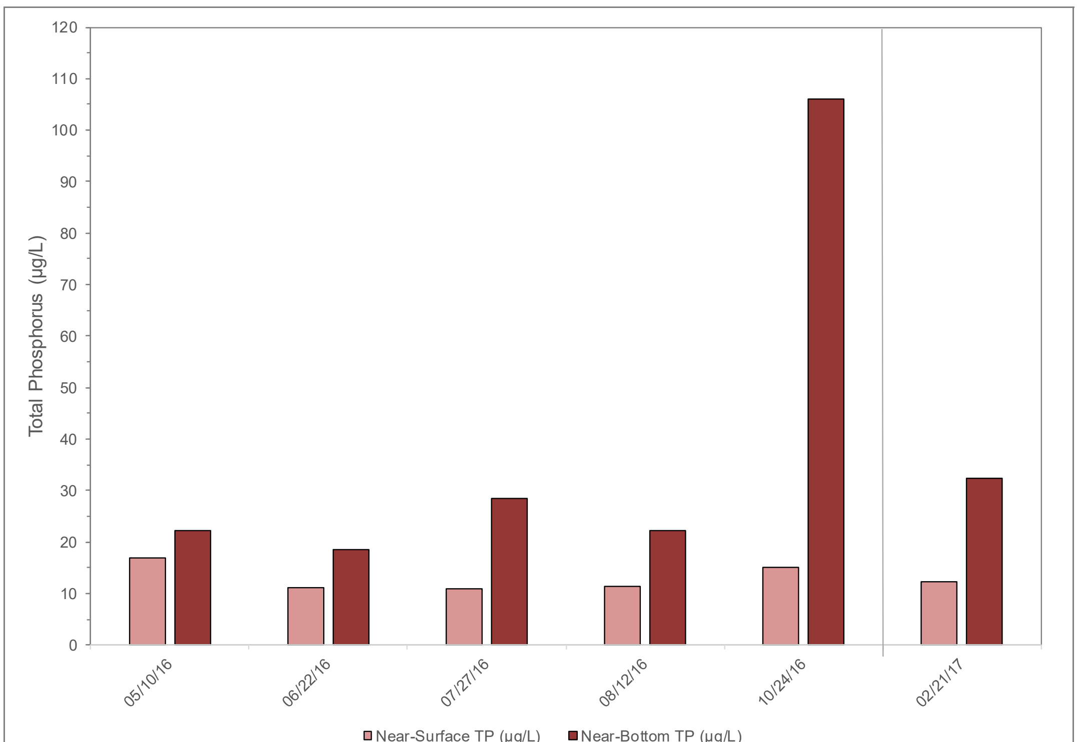


Figure 8.9.1-2. Little Star Lake surface and bottom total phosphorus values, 2016-2017.

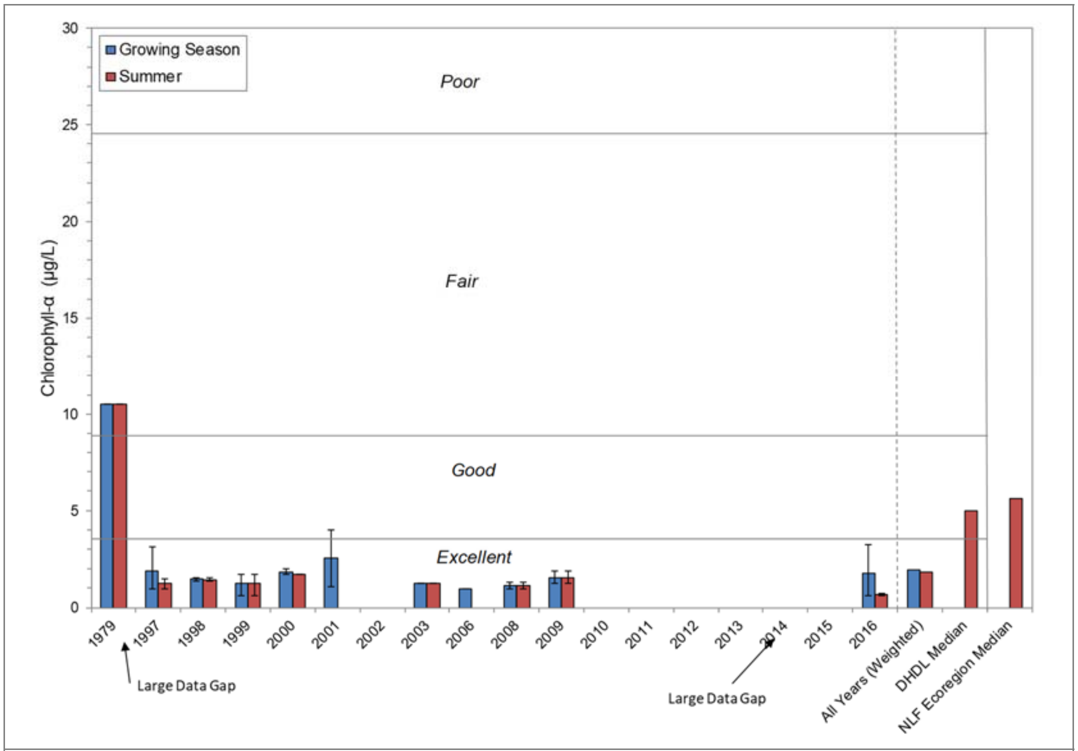


Figure 8.9.1-3. Little Star Lake, state-wide deep, headwater drainage lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

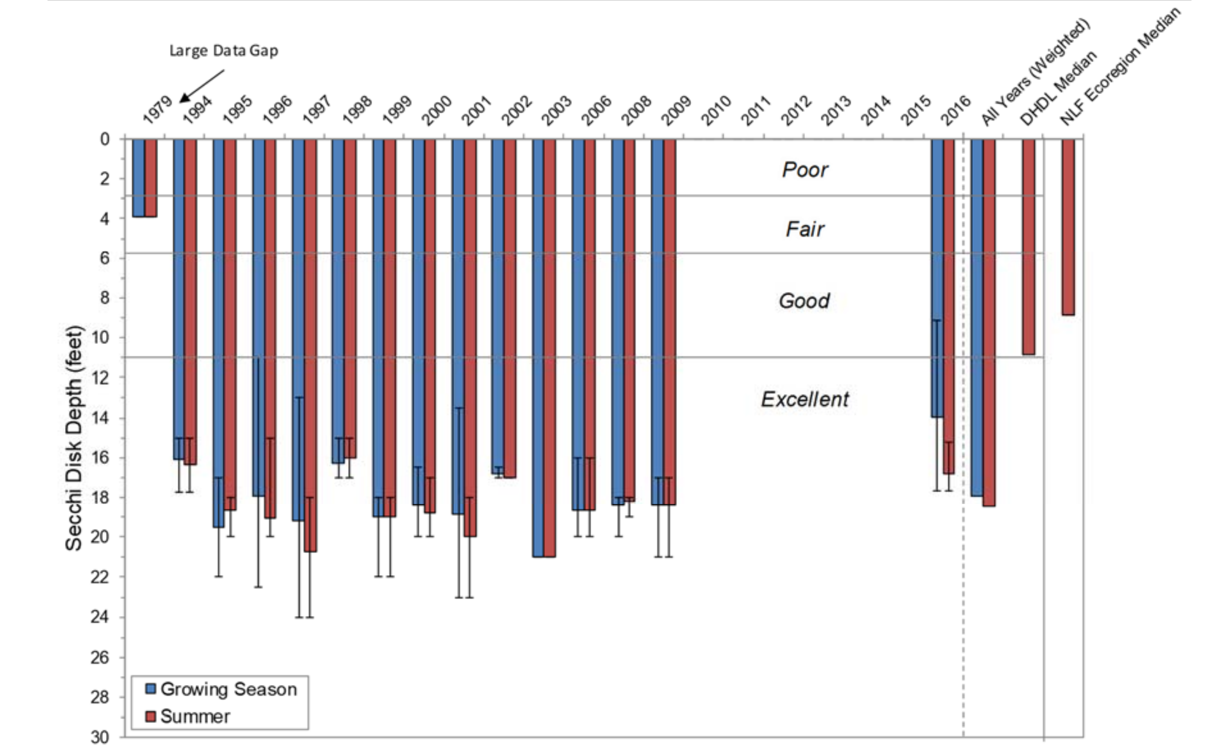


Figure. 8.9.1-4. Little Star Lake, state-wide deep, headwater drainage lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Little Star Lake Trophic State

The TSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from lower mesotrophic to eutrophic (Figure 8.9.1-5). In general, the best values to use in judging a lake's trophic state are the biological parameters; therefore, relying primarily on total phosphorus and chlorophyll-*a* TSI values, it can be concluded that Little Star Lake is in an oligotrophic state.

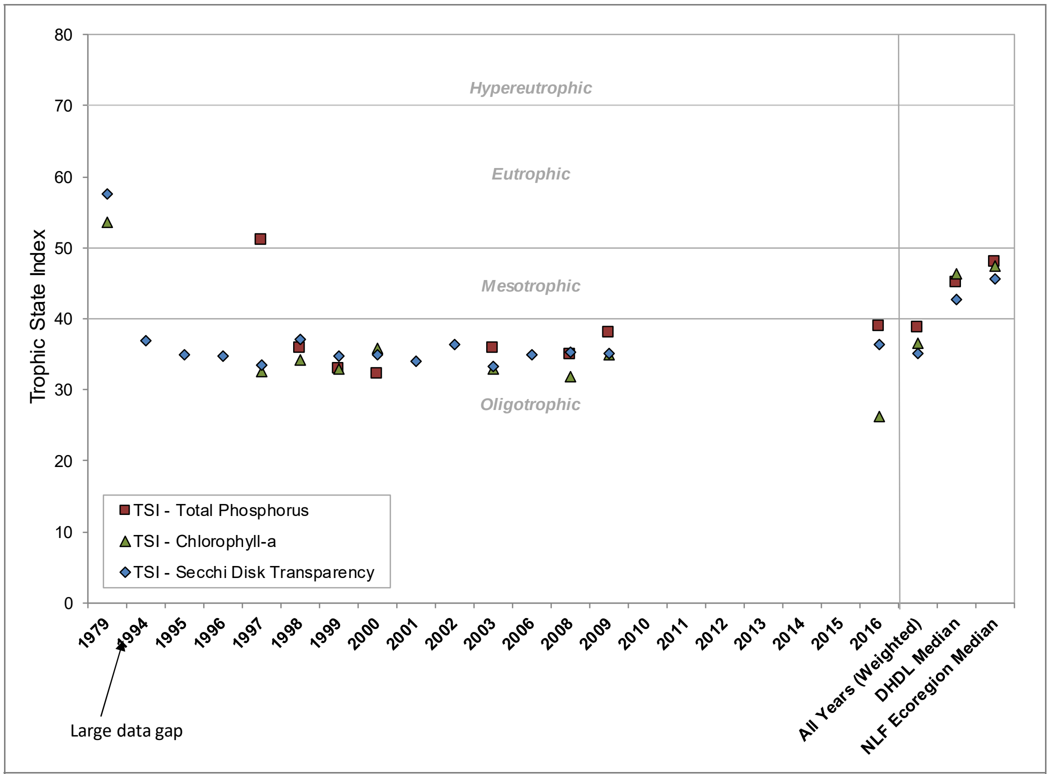


Figure 8.9.1-5. Little Star Lake, state-wide deep, headwater drainage lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Little Star Lake

Dissolved oxygen and temperature profiles were created during each water quality sampling trip made to Little Star Lake by Onterra staff. Graphs of those data are displayed in Figure 8.9.1-6 for all sampling events.

Little Star Lake mixes thoroughly during the spring, when changing air temperatures and gusty winds help to mix the water column. During the summer months, the lake was not observed to mix completely. The bottom of the lake was found to become void of oxygen (anoxic) only during August and October. This occurrence is slightly uncommon in Wisconsin lakes because usually bacteria break down organic matter that has collected at the bottom of the lake and in doing so utilize any available oxygen. When oxygen is available deep down in the water column, during the summer, a different phenomenon is occurring.

Little Star Lake is exhibiting metalimnetic oxygen maxima during the summer months. This type of profile occurs because there is a large algal community in the metalimnion. Lakes that exhibit this profile need to have good water clarity in the epilimnion so that sufficient light reaches the metalimnion to support photosynthesis. Algae thrive in this deeper water because there is sufficient light and higher amounts of nutrients, e.g. phosphorus, in these deeper waters. If there is sufficient light reaching the metalimnion, but there is not a large algal community, this indicates that nutrient levels are low in this part of the water column. If lakes have a greater metalimnetic oxygen maxima now compared with earlier years, it is an indication that nutrient levels are higher at the present time in the deeper waters.

During the winter months, the coldest temperatures are found just under the overlying ice, while oxygen gradually diminishes once again towards the bottom of the lake. In February of 2017, oxygen levels remained sufficient throughout most of the water column to support most aquatic life in northern Wisconsin lakes.

Additional Water Quality Data Collected at Little Star Lake

The water quality section is centered on lake eutrophication. However, parameters other than water clarity, nutrients, and chlorophyll-*a* were collected as part of the project. These other parameters were collected to increase the understanding of Little Star Lake's water quality and are recommended as a part of the WDNR long-term lake trends monitoring protocol. These parameters include; pH, alkalinity, and calcium.

As the Chain-wide Water Quality Section explains, the pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is thus an index of the lake's acidity. Little Star Lake's surface water pH was measured at roughly 7.9 during May and 7.8 in July of 2016. These values are slightly above neutral and falls within the normal range for Wisconsin lakes. Fluctuations in pH with respect to seasonality is common; in-lake processes such as photosynthesis by plants act to reduce acidity by carbon dioxide removal while decomposition of organic matter adds carbon dioxide to water, thereby increasing acidity.

A lake's pH is primarily determined by the amount of alkalinity that is held within the water. Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. Lakes with low alkalinity have higher amounts of the bicarbonate compound (HCO_3^-) while lakes with a higher alkalinity have more of the carbonate compound of alkalinity ($CO_3^=$). The carbonate form is better at buffering acidity, so lakes with higher alkalinity are less sensitive to acid rain than those with lower alkalinity. The alkalinity in Manitowish Lake was measured at 38.2 and 37.5 mg/L as $CaCO_3$ in May and July of 2016, respectively. This indicates that the lake has a substantial capacity to resist fluctuations in pH and has a low sensitivity to acid rain.

Samples of calcium were also collected from Little Star Lake during 2016. Calcium is commonly examined because invasive and native mussels use the element for shell building and in reproduction. Invasive mussels typically require higher calcium concentrations than native mussels. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so Little Star Lake's pH of 7.85 falls within this range. Lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The calcium concentration of Little Star Lake was found to be 11.8 mg/L in July of 2016, which is just below the optimal range for zebra mussels. Plankton tows were completed by Onterra staff during the summer of 2016 and these samples were processed by the WDNR for larval zebra mussels. No veligers (larval zebra mussels) were found within these samples.

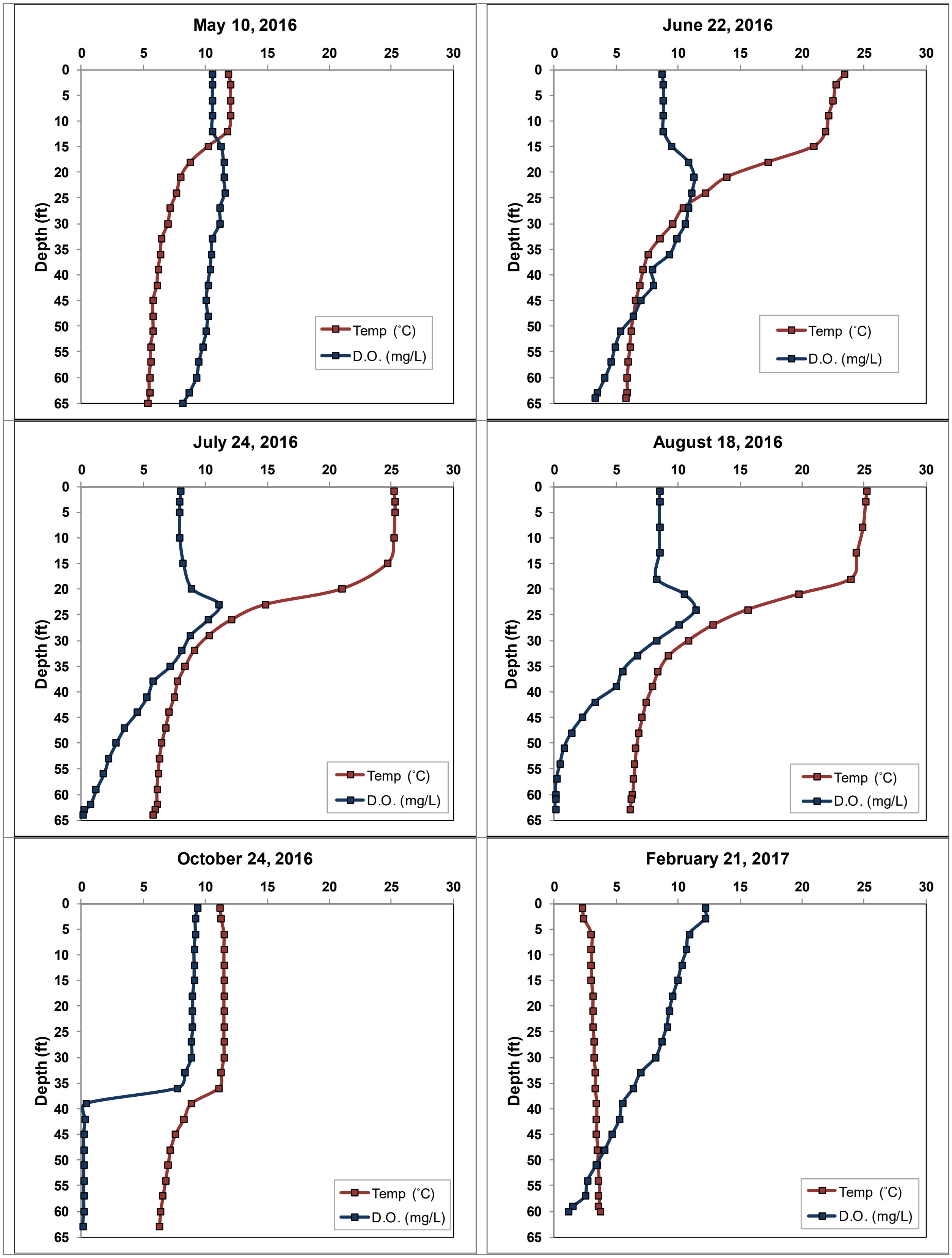


Figure 8.9.1-6. Little Star Lake dissolved oxygen and temperature profiles.

8.9.2 Little Star Lake Watershed Assessment

Little Star Lake's watershed is 859 acres in size. Compared to Little Star Lake's size of 261 acres, this makes for a small watershed to lake area ratio of 2:1. The watershed is comprised of land cover types including forest (53%), the lake surface itself (19%), wetlands (16%), pasture/grass/rural open space (12%), rural residential areas (<1%), and urban-medium density (<1%), (Figure 8.9.2-1). Wisconsin Lakes Modeling Suite (WiLMS) modeling indicates that Little Star Lake's residence time is approximately 9.9 years, or the water within the lake is completely replaced 0.1 times per year.

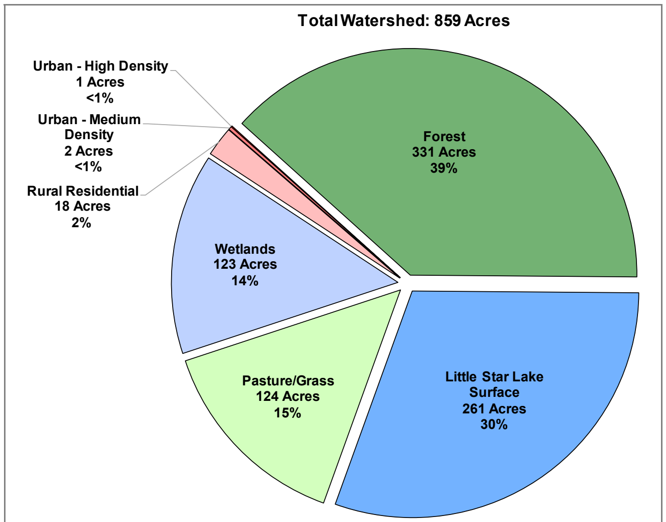


Figure 8.9.2-1. Little Star Lake watershed proportion of land cover types. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

Of the estimated 423 pounds of phosphorus being delivered to Little Star Lake on an annual basis, approximately 152 pounds (36%) originates through direct atmospheric deposition onto the lake, 130 pounds (31%) from forests, 97 pounds (23%) from areas of pasture/grass/rural open space, and 44 pounds (10%) from wetlands (Figure 8.9.2-2). Using the estimated annual potential phosphorus load, WiLMS predicted an in-lake growing season average total phosphorus concentration of 14 µg/L, which is essentially the same as the measured growing season average total phosphorus concentration of 11 µg/L. This means the model works reasonably well for Little Star Lake and that there are no significant, unaccounted sources of phosphorus entering the lake.

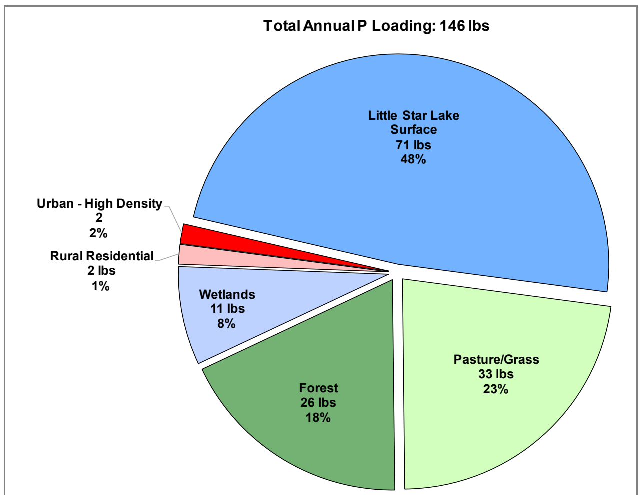


Figure 8.9.2-2. Little Star Lake estimated potential annual phosphorus loading. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

Using the WiLMS model for Little Star Lake's watershed, scenarios can be run to determine how Little Star Lake's water quality would change given alterations to its watershed. For example, if 25% of the forests within Little Star Lake's watershed were converted to row crop agriculture, phosphorus concentrations would be predicted to increase from the current growing season concentration of 11 µg/L to 14 µg/L. This increase in total phosphorus would result in chlorophyll-*a* concentrations increasing from the current growing season average of 3 µg/L to 4 µg/L, and Secchi disk transparency is predicted to decline from the current growing season average of 14.8 feet to 11.9 feet. This modelling illustrates the importance of the natural land cover types within Little Star Lake's watershed in maintaining the lake's excellent water quality.

8.9.3 Little Star Lake Shoreland Condition

Shoreland Development

As mentioned previously in the Chain-wide Shoreland Condition Section, one of the most sensitive areas of the watershed is the immediate shoreland area. This area of land is the last source of protection for a lake against surface water runoff, and is also a critical area for wildlife habitat. In fall of 2016, Little Star Lake's immediate shoreline was assessed in terms of its development. Little Star Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 3.1 miles of natural/undeveloped and developed-natural shoreline were observed during the survey (Figure 8.9.3-1). This constitutes about 50% of Little Star Lake's shoreline. These shoreland types provide the most benefit to the lake and should be left in their natural state if at all possible. During the survey, 1.6 miles of urbanized and developed–unnatural shoreline (37%) was observed. If restoration of the Little Star Lake shoreline is to occur, primary focus should be placed on these shoreland areas as they currently provide little benefit to, and actually may harm, the lake ecosystem. Little Star Lake Map 1 displays the location of these shoreline lengths around the entire lake.

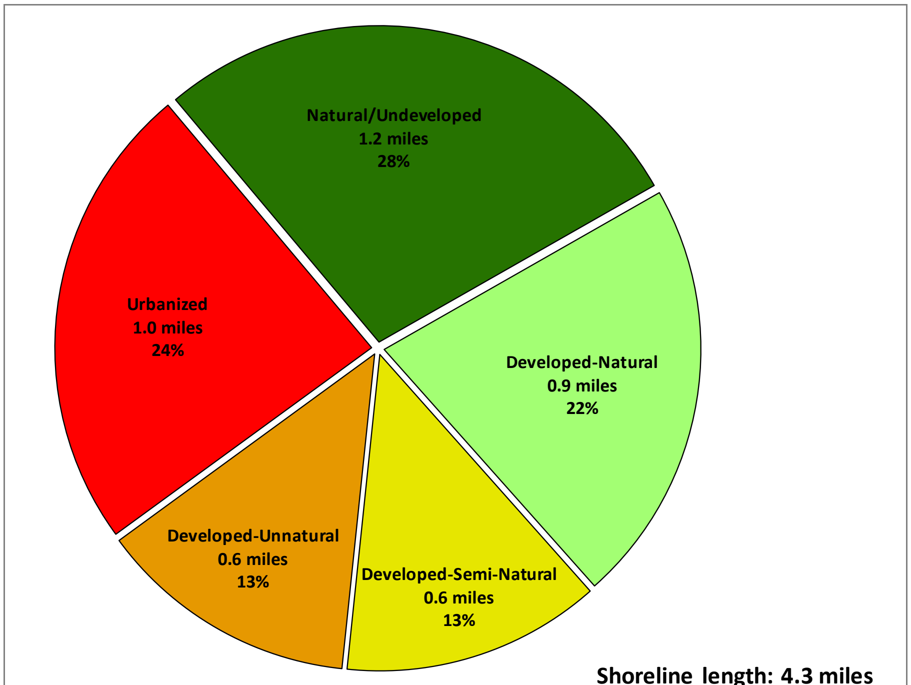


Figure 8.9.3-1. Little Star Lake shoreland categories and total lengths. Based upon a fall 2016 survey. Locations of these categorized shorelands can be found on Little Star Lake Map 1.

Coarse Woody Habitat

As part of the shoreland condition assessment, Little Star Lake was also surveyed to determine the extent of its coarse woody habitat. Coarse woody habitat was identified and classified in three size categories (2-8 inches in diameter, 8+ inches in diameter, or clusters of pieces) as well as four branching categories: no branches, minimal branches, moderate branches, and full canopy. As discussed earlier, research indicates that fish species prefer some branching as opposed to no branching on coarse woody habitat, and increasing complexity is positively correlated with higher fish species richness, diversity and abundance (Newbrey et al. 2005).

During this survey, 110 total pieces of coarse woody habitat were observed along 4.3 miles of shoreline (Little Star Lake Map 2), which gives Little Star Lake a coarse woody habitat to shoreline mile ratio of 26:1 (Figure 8.9.3-2). Only instances where emergent coarse woody habitat extended from shore into the water were recorded during the survey. One hundred and six pieces of 2-8 inches in diameter pieces of coarse woody habitat were found, four pieces of 8+ inches in diameter pieces of coarse woody habitat were found, and no instances of clusters of coarse woody habitat were found.

To put this into perspective, Wisconsin researchers have found that in completely undeveloped lakes, an average of 345 coarse woody habitat structures may be found per mile (Christensen et al. 1996). Please note the methodologies between the surveys done on Little Star Lake and those cited in this literature comparison are much different, but still provide a valuable insight into what undisturbed shorelines may have in terms of coarse woody habitat.

Onterra has completed coarse woody habitat surveys on 98 lakes throughout Wisconsin since 2012, with the majority occurring in the NLF ecoregion on lakes with public access. The number of coarse woody habitat pieces per shoreline mile in Little Star Lake falls near the median of these 98 lakes (Figure 8.9.3-2).

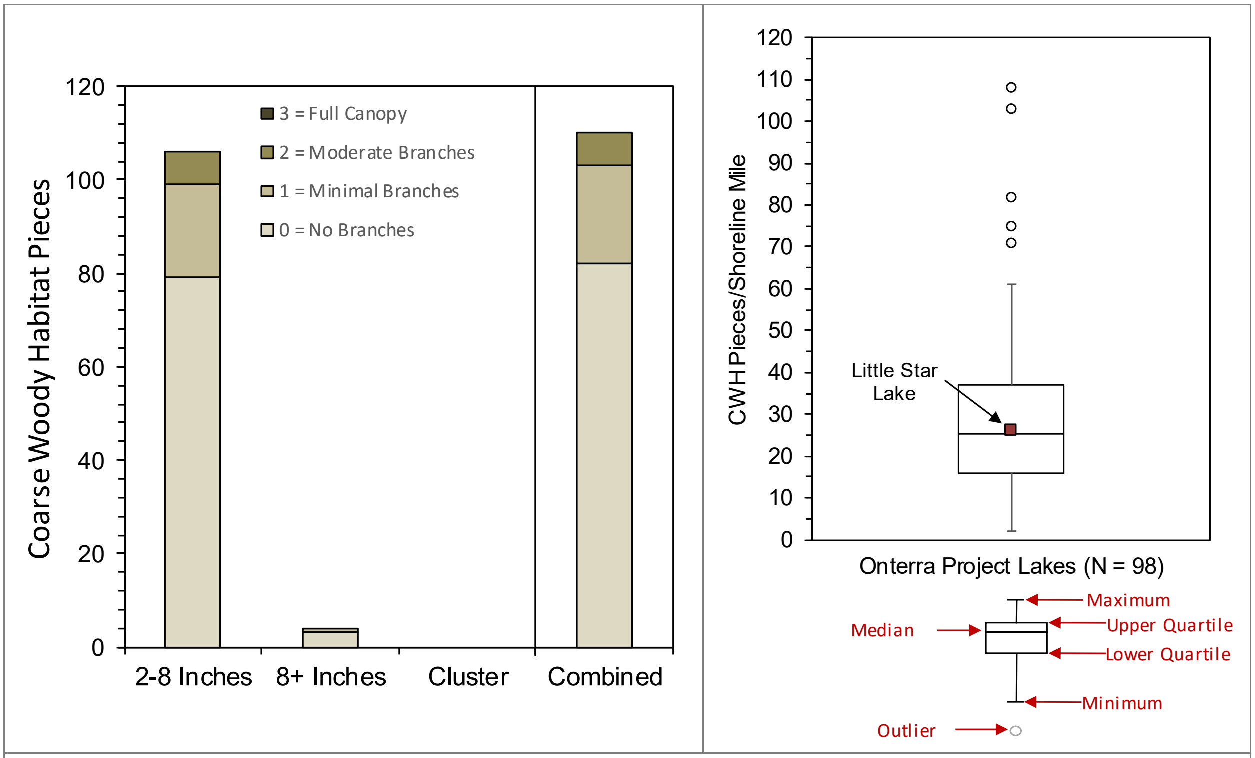


Figure 8.9.3-2. Little Star Lake coarse woody habitat survey results. Based upon a fall 2016 survey. Locations of the Little Star Lake coarse woody habitat can be found on Little Star Lake Map 2.

8.9.4 Little Star Lake Aquatic Vegetation

An early season aquatic invasive species survey was conducted on Little Star Lake on June 29, 2016. While the intent of this survey is to locate any potential non-native species within the lake, the primary focus is to locate occurrences of curly-leaf pondweed which should be at or near its peak growth at this time. During this meander-based survey of the littoral zone, Onterra ecologists did not locate any occurrences of curly-leaf pondweed or any other submersed non-native aquatic plant species.

The aquatic plant point-intercept survey was conducted on Little Star Lake on July 19, 2016 by Onterra. The floating-leaf and emergent plant community mapping survey was completed on that same day to map these community types. During all surveys, 33 species of aquatic plants were located in Little Star Lake (Table 8.9.4-1). Nineteen of these species were sampled directly during the point-intercept survey and are used in the analysis that follows, while 14 species were observed incidentally during visits to Little Star Lake. One non-native species, pale-yellow iris (*Iris pseudacorus*) was observed along the Little Star Lake shoreline.

Aquatic plants were found growing to a depth of 13 feet. As discussed later on within this section, many of the plants found in this survey indicate that the overall community is healthy, diverse and in one species case somewhat rare. Of the 189 point-intercept locations sampled within the littoral zone, roughly 54% contained aquatic vegetation. Little Star Lake Map 3 indicates that most of the point-intercept locations that contained aquatic vegetation are located in shallow bays and near shore; areas that are more likely to hold organic substrates. Approximately 83% of the point-intercept sampling locations where sediment data was collected at were sand, 3% consisted of a fine, organic substrate (muck) and 13% were determined to be rocky (Chain-wide Fisheries Section, Table 3.5-5).

Table 8.9.4-1. Aquatic plant species located in Little Star Lake during 2016 plant surveys.

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2016 (Onterra)
Emergent	*Carex utriculata*	Common yellow lake sedge	7	I
	Glyceria canadensis	Rattlesnake grass	7	I
	Iris pseudacorus	Pale yellow iris	Exotic	I
	Juncus effusus	Soft rush	4	I
	Mimulus ringens	Monkey-flower	6	I
	Sagittaria rigida	Stiff arrowhead	8	I
	Schoenoplectus acutus	Hardstem bulrush	5	I
	Typha spp.	Cattail spp.	1	I
	Zizania spp.	Wild rice sp.	8	I
FL	*Nuphar variegata*	Spatterdock	6	I
	Nymphaea odorata	White water lily	6	I
	Sparganium fluctuans	Floating-leaf bur-reed	10	I
Submergent	*Bidens beckii*	Water marigold	8	X
	Ceratophyllum demersum	Coontail	3	X
	Chara spp.	Muskgrasses	7	X
	Elodea canadensis	Common waterweed	3	X
	Isoetes spp.	Quillwort spp.	8	X
	Myriophyllum farwellii	Farwell's watermilfoil	9	I
	Myriophyllum sibiricum	Northern watermilfoil	7	X
	Najas flexilis	Slender naiad	6	X
	Nitella spp.	Stoneworts	7	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X
	Potamogeton berchtoldii	Slender pondweed	7	I
	Potamogeton gramineus	Variable-leaf pondweed	7	X
	Potamogeton praelongus	White-stem pondweed	8	X
	Potamogeton pusillus	Small pondweed	7	X
	Potamogeton robbinsii	Fern-leaf pondweed	8	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X
	Ranunculus flammula	Creeping spearwort	9	I
	Sagittaria sp. (rosette)	Arrowhead sp. (rosette)	N/A	X
	Vallisneria americana	Wild celery	6	X
S/E	*Eleocharis acicularis*	Needle spikerush	5	X
	Juncus pelocarpus	Brown-fruited rush	8	X

FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submergent and Emergent; FF = Free Floating
X = Located on rake during point-intercept survey; I = Incidental Species

Figure 8.9.4-1 shows that slender naiad, muskgrasses and variable-leaf pondweed were the most frequently encountered plants within Little Star Lake. Slender naiad, a common annual species in Wisconsin, is considered to be one of the most important food sources for a number of migratory waterfowl species (Borman et al. 1997). Their numerous seeds, leaves, and stems all provide sources of food. The small, condensed network of leaves provide excellent habitat for aquatic invertebrates. Muskgrasses, a genus of macroalgae, are not true vascular plants, and are often abundant in waterbodies that are clear with higher alkalinity. While several species of muskgrasses occur in Wisconsin, the muskgrasses in Little Star Lake were not identified to the species level. Often growing in dense beds, muskgrasses stabilize bottom sediments, provide excellent structural habitat for aquatic organisms, and are sources of food for fish, waterfowl, and other wildlife (Borman et al. 2007). Variable-leaf pondweed is one of several pondweed species found in Wisconsin. Variable-leaf pondweed produces long, slender stems with alternating lance-shaped leaves. As its name indicates, this plant can look very different from lake to lake, with some populations having larger leaves and others possessing smaller leaves.

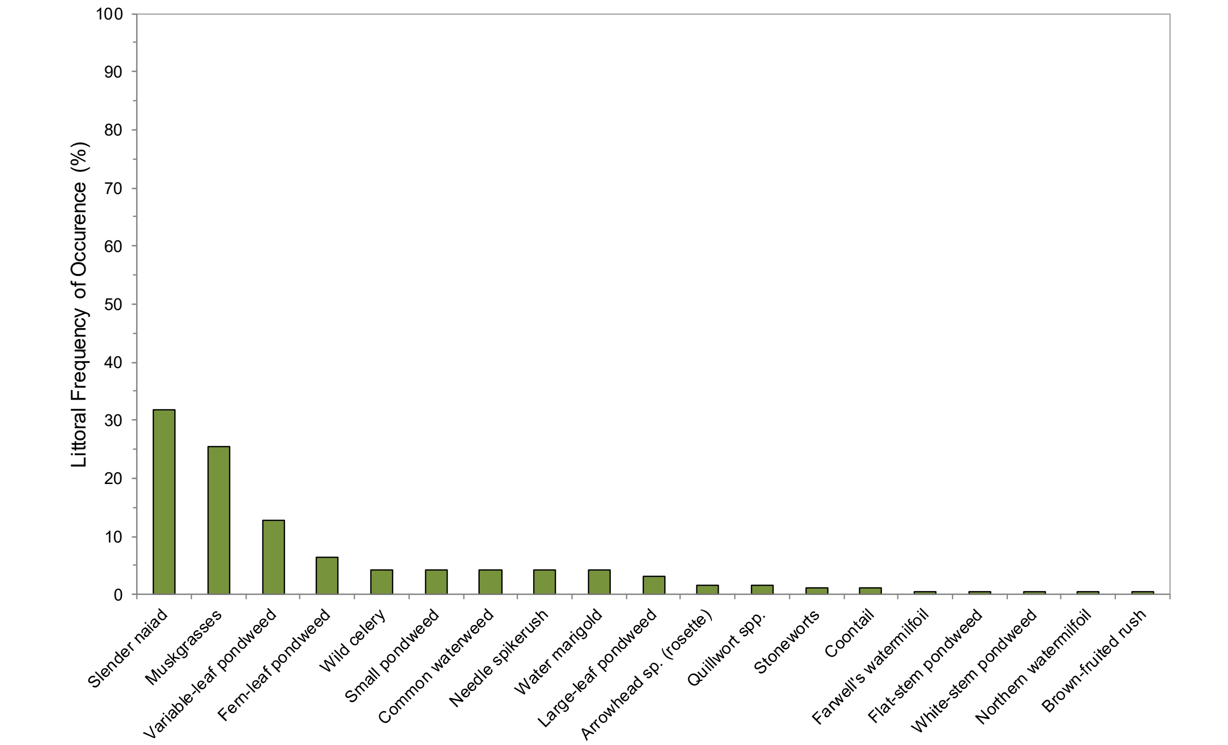


Figure 8.9.4-1. Little Star Lake aquatic plant littoral frequency of occurrence analysis. Created using data from a 2016 point-intercept survey. .

During aquatic plant inventories, 32 species of native aquatic plants (including incidentals) were found in Little Star Lake. Because of this, one may assume that the system would also have a high diversity. As discussed earlier, how evenly the species are distributed throughout the system also influence the diversity. The diversity index for Little Star Lake's plant community (0.83) lies below the Northern Lakes and Forest Lakes ecoregion value (0.86), indicating the lake holds diversity similar to the lakes in the same ecoregion.

As explained earlier in the Manitowish Waters Chain of Lakes-wide document, the littoral frequency of occurrence analysis allows for an understanding of how often each of the plants is located during the point-intercept survey. Because each sampling location may contain numerous plant species, relative frequency of occurrence is one tool to evaluate how often each plant species is found in relation to all other species found (composition of population). For instance, while slender naiad was found at 32% of the sampling locations, its relative frequency of occurrence is 29%. Explained another way, if 100 plants were randomly sampled from Little Star Lake, 29 of them would be slender naiad. This distribution can be observed in Figure 8.9.4-2, where together 3 native species account for 64% of the aquatic plant population within Little Star Lake, while the other 16 species account for the remaining 36%. Thirteen additional native species were found incidentally from the lake but not from of the point-intercept survey, and are indicated in Table 8.9.4-1 as incidentals.

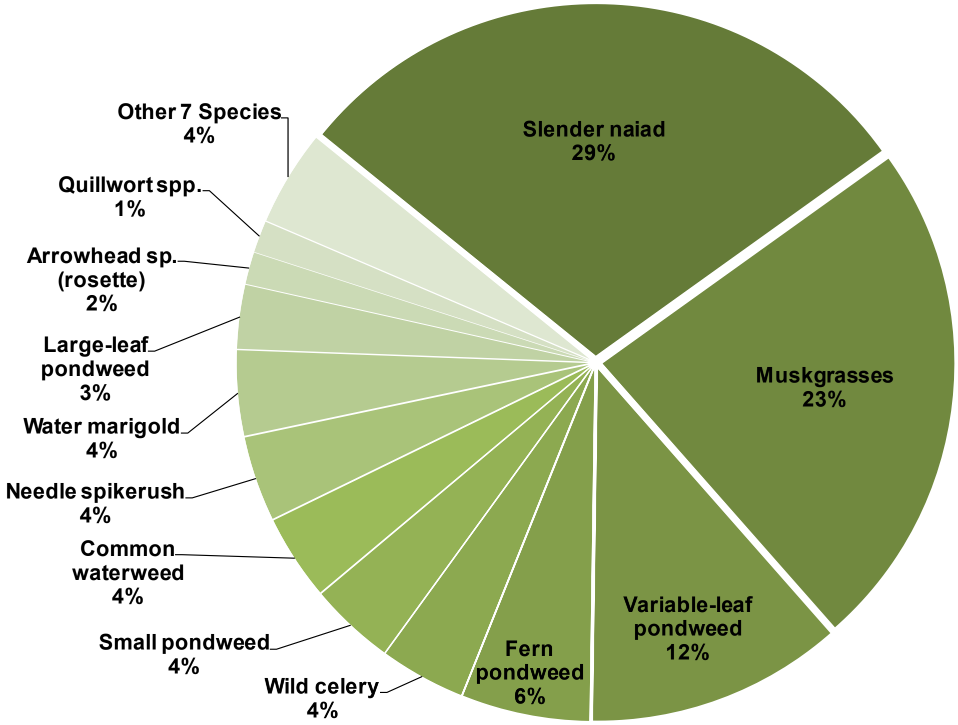


Figure 8.9.4-2. Little Star Lake aquatic plant relative frequency of occurrence analysis. Created using data from 2016 point-intercept survey.

Little Star Lake's average conservatism value (6.6) is higher than the state median (6.3) but slightly lower than the Northern Lakes and Forests ecoregion median (6.7). This indicates that the plant community of Little Star Lake is indicative of an average system within Wisconsin. Combining Little Star Lake's species richness and average conservatism values to produce its Floristic Quality Index (FQI) results in a value of 37.2 which is above the median values of the ecoregion and state.

Little Star Lake was found to have few emergent and floating-leaf aquatic plant communities. The 2016 community map indicates that approximately 0.8 acres of the lake contains these types of plant communities (Little Star Lake Map 4, Table 8.8.4-2). Twelve floating-leaf and emergent species were located on Little Star Lake (Table 8.8.4-1), all of which provide valuable wildlife habitat.

Table 8.9.4-2. Little Star Lake acres of emergent and floating-leaf plant communities from the 2016 community mapping survey.

Plant Community	Acres
Emergent	0.4
Floating-leaf	0.0
Mixed Floating-leaf and Emergent	0.4
Total	0.8

The community map represents a ‘snapshot’ of the emergent and floating-leaf plant communities, replications of this survey through time will provide a valuable understanding of the dynamics of these communities within Little Star Lake. This is important, because these communities are often negatively affected by recreational use and shoreland development. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota Lakes. Furthermore, they also found a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelines.

Non-Native Aquatic Plants in Little Star Lake

Pale-yellow iris

Pale-yellow iris (*Iris pseudacorus*) is a large, showy iris with bright yellow flowers. Native to Europe and Asia, this species was sold commercially in the United States for ornamental use and has since escaped into Wisconsin’s wetland areas forming large monotypic colonies and displacing valuable native wetland species. This species was observed flowering along the shoreline areas on the lake during the early-season aquatic invasive species survey. The locations of pale-yellow iris on Little Star Lake can be viewed on Little Star Lake Map 4. This exotic plant is typically controlled with hand-removal and in cases of heavy infestations, the use of herbicides.

8.9.5 Little Star Lake Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here as a reference. The following section is not intended to be a comprehensive plan for the lake's fishery, as those aspects are currently being conducted by the fisheries biologists overseeing Little Star Lake. The goal of this section is to provide an overview of some of the data that exists. Although current fish data were not collected as a part of this project, the following information was compiled based upon data available from the Wisconsin Department of Natural Resources (WDNR) the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) and personal communications with DNR Fisheries Biologist Hadley Boehm (WDNR 2018 & GLIFWC 2017).

Fish Stocking

To assist in meeting fisheries management goals, the WDNR may stock fry, fingerling or adult fish in a waterbody that were raised in nearby permitted hatcheries (Photograph 8.9.5-1). Stocking of a lake may be done to assist the population of a species due to a lack of natural reproduction in the system, or to otherwise enhance angling opportunities. Little Star Lake has been stocked from 1974 to 1989 with muskellunge (Table 8.9.5-1).

Photograph 8.9.5-1. Fingerling Muskellunge.

Table 8.9.5-1. Stocking data available for Muskellunge in Little Star Lake (1974-1989).

Lake	Year	Strain (Stock)	Age Class	# Fish Stocked	Avg Fish Length (in)
Little Star Lake	1974	Unspecified	Fingerling	250	11
Little Star Lake	1974	Unspecified	Fingerling	500	11
Little Star Lake	1976	Unspecified	Fingerling	100	13
Little Star Lake	1976	Unspecified	Fingerling	596	5
Little Star Lake	1989	Unspecified	Fingerling	160	9

Little Star Lake Spear Harvest Records

Walleye open water spear harvest records are provided in Figure 8.9.5-1 from 1999 to 2017. As many as 114 walleye have been harvested from the lake in the past (2003), but the average harvest is roughly 35 fish in a given year. Spear harvesters on average have taken 67% of the declared quota. Additionally, on average 9% of walleye harvested have been female.

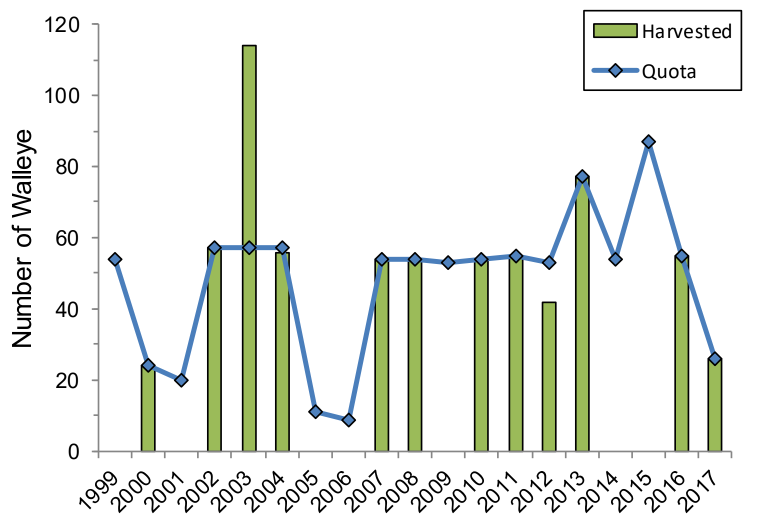


Figure 8.9.5-1. Little Star Lake walleye spear harvest data. (GLIFWC 1999-2017).

Muskellunge open water spear harvest records are provided in 8.9.5-2 from 1999 to 2017. As many as one muskellunge have been harvested from the lake in the past (2013 and 2017), however the average harvest is zero fish in a given year. Spear harvesters on average have taken 3% of the declared quota.

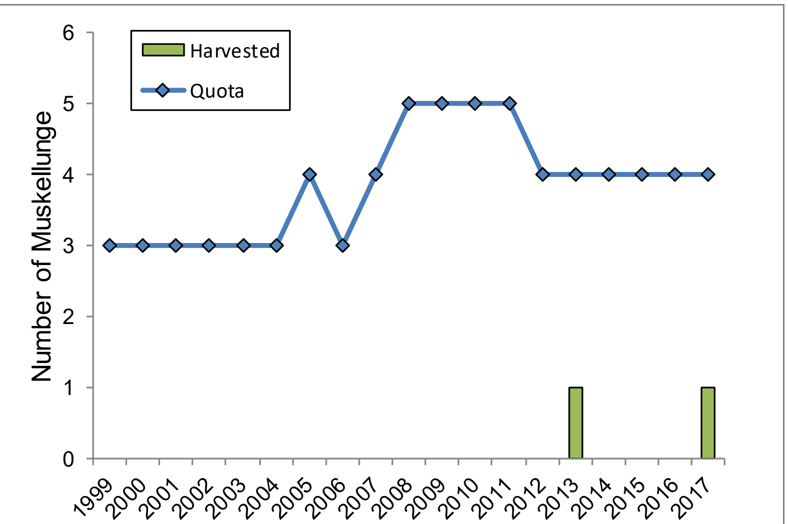
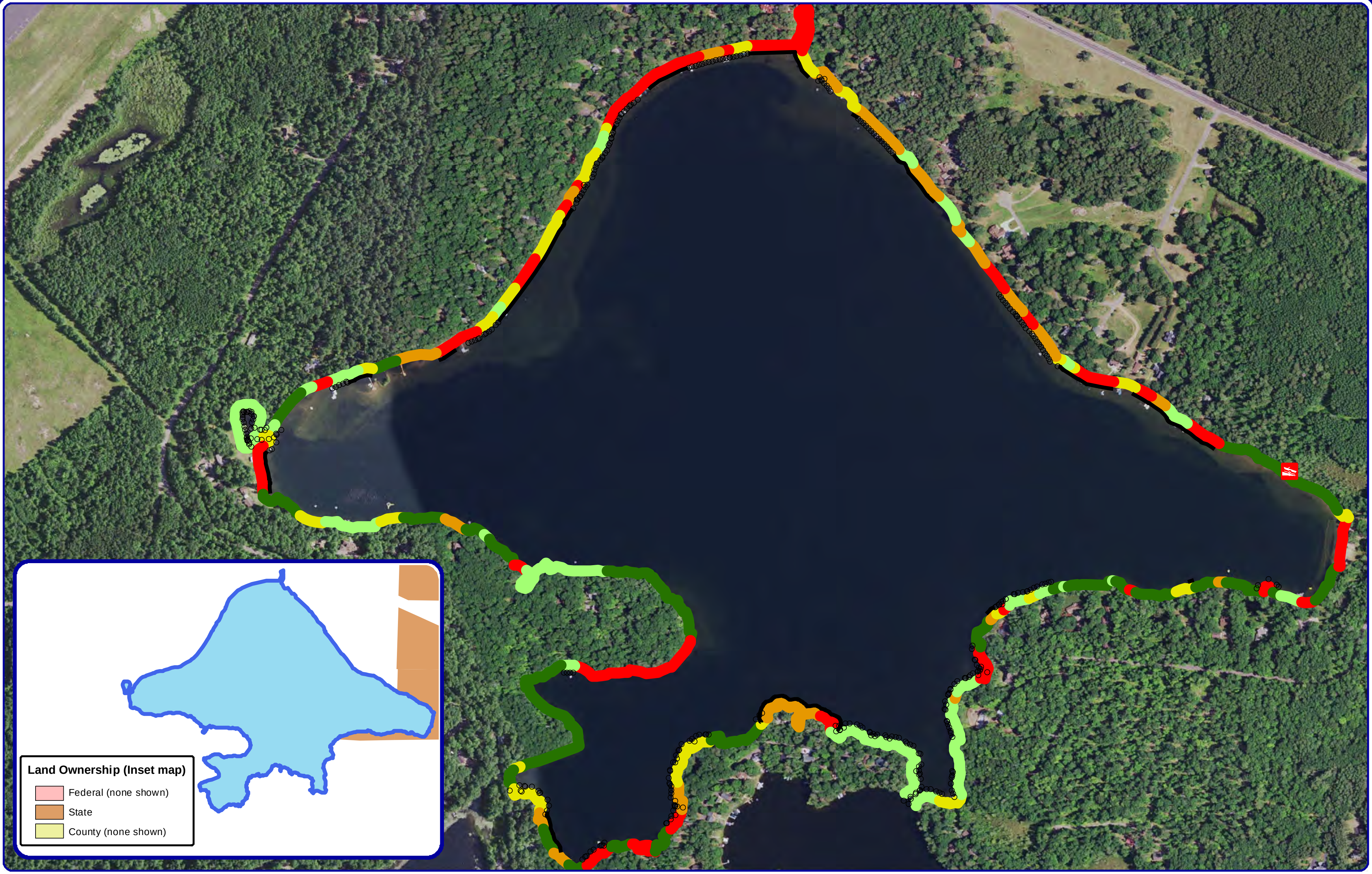


Figure 8.9.5-2. Little Star Lake muskellunge spear harvest data. (GLIFWC 1999-2017).



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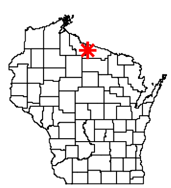
700
Feet

Onterra, LLC
Lake Management Planning
815 Prosper Road
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Hydro: WDNR
Orthophotography: NAIP, 2015
Shoreline Assessment: Onterra, 2016
Map Date: December 8, 2016
Filename:LittleStar_Map1_ShorelandCondition_2016.mxd



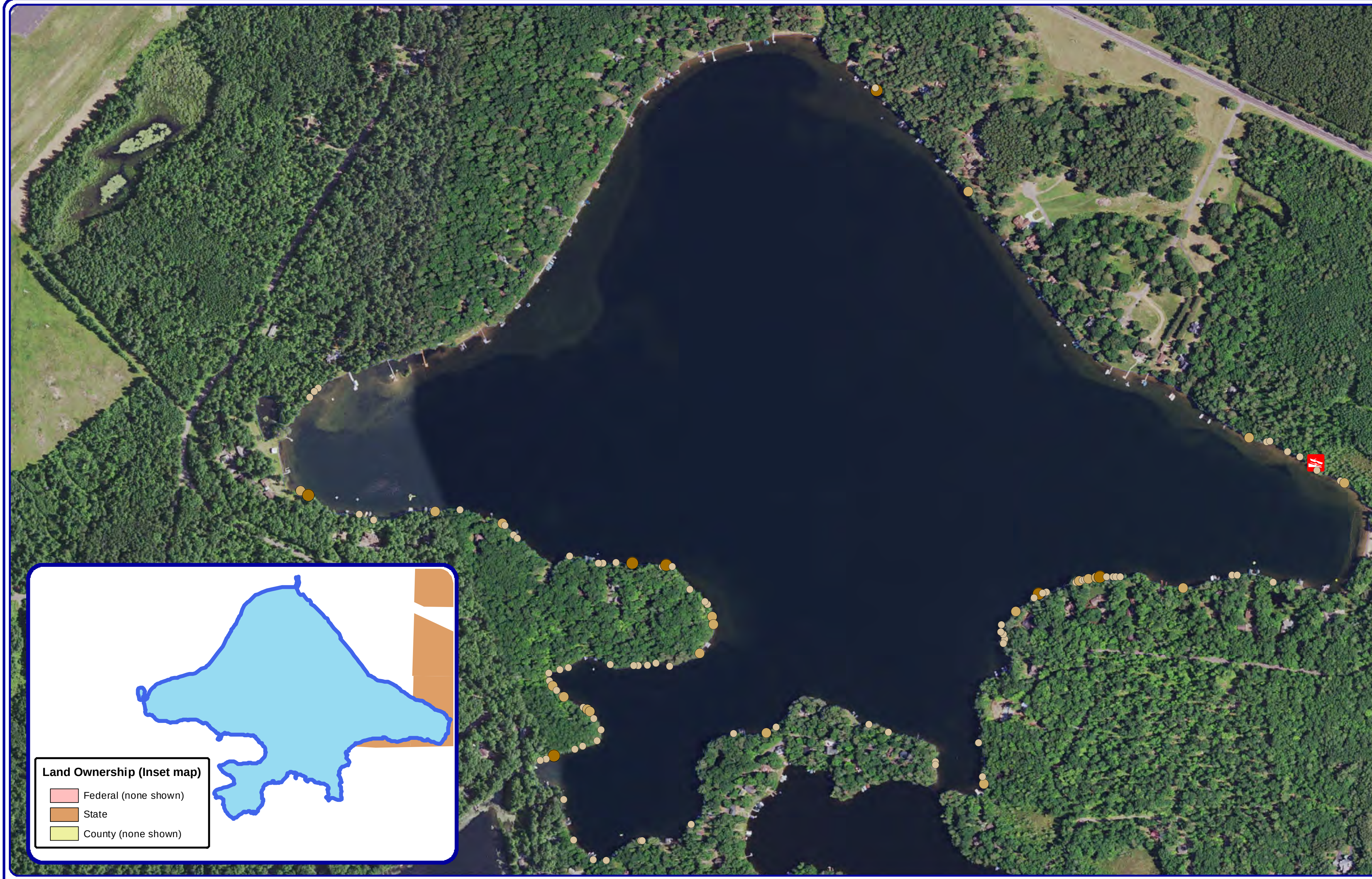
Project Location in Wisconsin

Legend

Natural/Undeveloped
Developed-Natural
Developed-Semi-Natural
Developed-Unnatural
Urbanized

Seawall
Rip-Rap
Wood/Masonary/Metal

Map 1
Little Star Lake
Vilas County, Wisconsin
2016 Shoreland Condition



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Onterra, LLC
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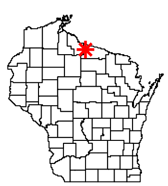
815 Prosper Road
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Hydro: WDNR
Orthophotography: NAIP, 2015
Shoreline Assessment: Onterra, 2016
Map Date: December 9, 2016
Filename: LittleStar_Map2_CWH_2016.mxd

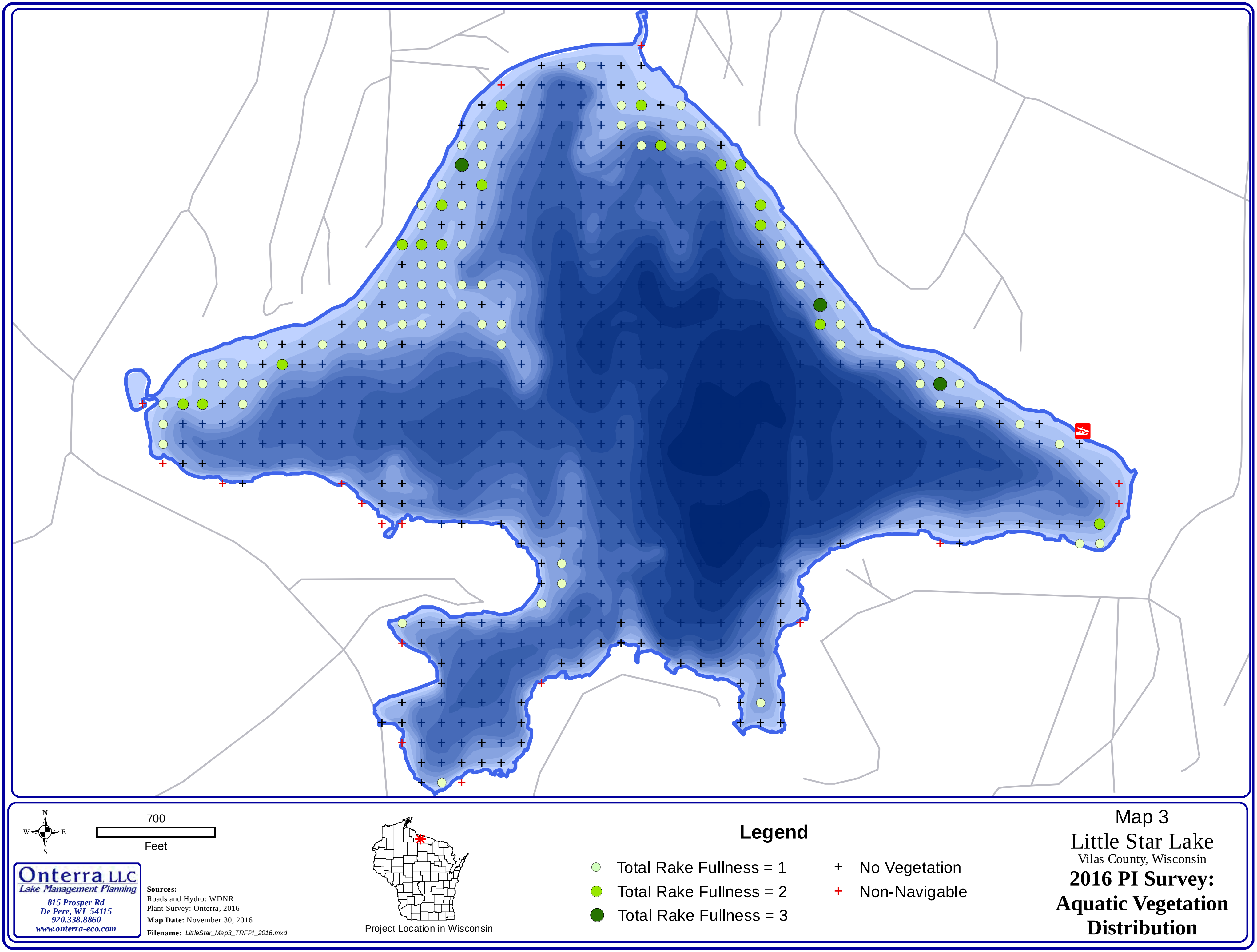


Project Location in Wisconsin

Legend

2-8 Inch Pieces	8+ Inch Pieces	Cluster of Pieces
No Branches	No Branches	No Branches (none)
Minimal Branches	Minimal Branches	Minimal Branches (none)
Moderate Branches	Moderate Branches (none)	Moderate Branches (none)
Full Canopy (none)	Full Canopy (none)	Full Canopy (none)

Map 2
Little Star Lake
Vilas County, Wisconsin
Coarse Woody Habitat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700
Feet
Onterra, LLC
Lake Management Planning
815 Prosper Rd
De Pere, WI 54115
920.338.8860
www.onterra-eco.com
Sources:
Roads and Hydro: WDNR
Plant Survey: Onterra, 2016
Map Date: November 30, 2016
Filename: LittleStar_Map3_TRFPI_2016.mxd
Project Location in Wisconsin
Legend
Total Rake Fullness = 1
Total Rake Fullness = 2
Total Rake Fullness = 3
No Vegetation
Non-Navigable
Map 3
Little Star Lake
Vilas County, Wisconsin
2016 PI Survey:
Aquatic Vegetation
Distribution

N W E S

700

Feet

Onterra, LLC
Lake Management Planning

815 Prosper Road
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Aquatic Plants: Onterra, 2016
Orthophotography: NAIP, 2015
Map date: October 27, 2016
Filename: LittleStar_Map4_Comm_2016.mxd

Legend

Small Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Large Plant Communities
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Exotic Plant Communities
- Pale yellow iris

Little Star Lake - Map 4

Manitowish Waters
Chain of Lakes
Vilas County, Wisconsin

Emergent & Floating-leaf Aquatic Plant Communities