Please note that study methods and explanations of analyses for West Plum Lake can be found within the Town of Plum Lake Town-wide Management Plan document.

8.2 West Plum Lake

An Introduction to West Plum Lake

West Plum Lake, Vilas County, is a 71-acre shallow headwater, eutrophic drainage lake with a maximum depth of 5 feet and a mean depth of 3 feet (West Plum Lake – Map 1). Its watershed encompasses approximately 770 acres within the St. Germain River Watershed and is comprised mainly of intact forests and wetlands. Water leaves West Plum Lake to the northeast and flows into Plum Lake. In 2017, 32 native aquatic plant species were located within the lake, of which common waterweed (*Elodea canadensis*) was the most common. Two non-native plants, pale yellow iris and narrow-leaved cattail, were found during the surveys.

Lake at a Glance - West Plum Lake

Morphometry	
Lake Type	Shallow Headwater Drainage Lake
Surface Area (Acres)	71
Max Depth (feet)	5
Mean Depth (feet)	3
Perimeter (Miles)	1.8
Shoreline Complexity	2.3
Watershed Area (Acres)	770
Watershed to Lake Area Ratio	10:1

Water Quality	
Trophic State	Eutrophic
Limiting Nutrient	Phosphorus
Avg Summer P (µg/L)	32
Avg Summer Chl-α (µg/L)	8
Avg Summer Secchi Depth (ft)	-
Summer pH	-
Alkalinity (mg/L as $CaCO_3$)	-

Vegetation	
Number of Native Species	32
NHI-Listed Species	-
Exotic Species	Pale yellow iris (*Iris pseudacorus*), Narrow-leaved cattail (*Typha angustifolia*)
Average Conservatism	6.8
Floristic Quality	27.8
Simpson's Diversity (1-D)	0.7

Descriptions of these parameters can be found within the town-wide portion of the management plan

8.2.1 West Plum Lake Water Quality

Water quality data was collected from Plum Lake on four occasions in 2017 with reduced water quality monitoring due to the size of the lake, depth of the lake, the level of development. Onterra staff sampled the lake for 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. No historical data was available on West Plum Lake.

Near-surface total phosphorus data was collected from West Plum Lake in 2017 (Figure 8.2.1-1). The 2017 summer average total phosphorus concentration is 32 µg/L and falls into the *good* category for shallow headwater drainage lakes in Wisconsin. West Plum Lake's 2017 summer average total phosphorus concentration is higher than the median values for both shallow headwater drainage lakes in the state and all lake types in the Northern Lakes and Forests (NLF) ecoregion.

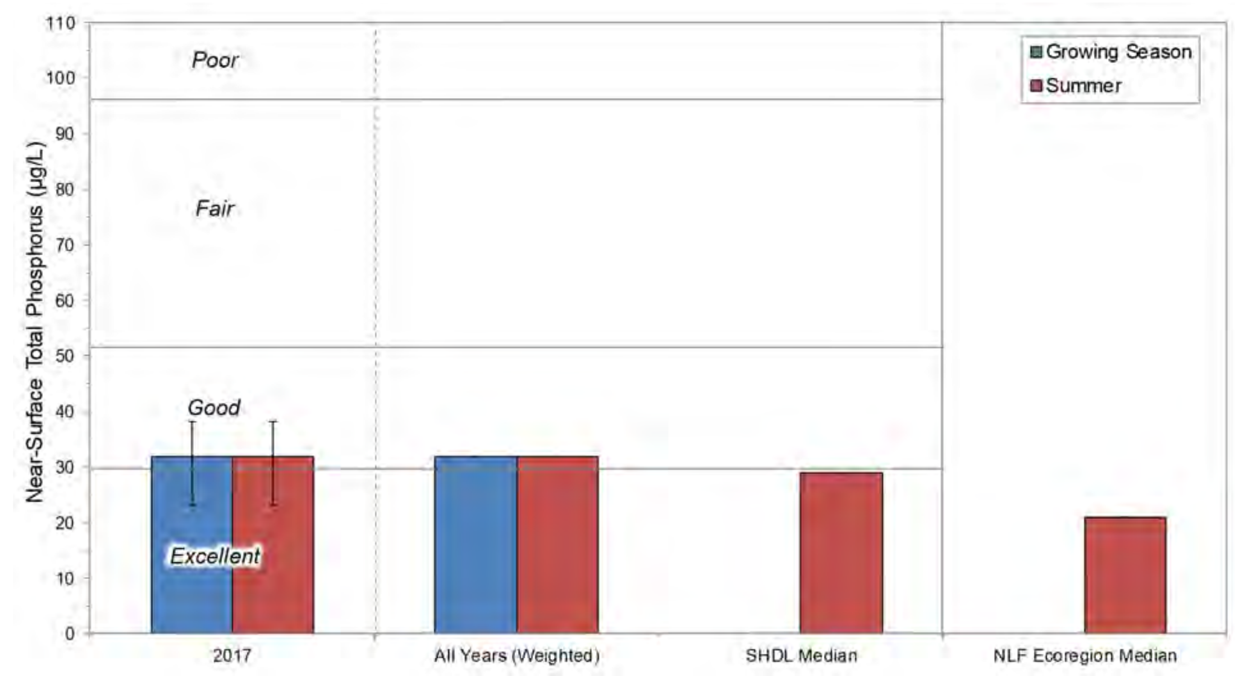


Figure 8.2.1-1. West Plum Lake, statewide shallow headwater drainage lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Chlorophyll-*a* data was collected from West Plum Lake in 2017 (Figure 8.2.1-2). The 2017 summer average chlorophyll-*a* concentration is 8 µg/L and falls into the *excellent* category for shallow headwater drainage lakes in Wisconsin. West Plum Lake's 2017 summer average chlorophyll-*a* concentration is higher than the median values for both shallow headwater drainage lakes in the state and all lake types in the Northern Lakes and Forests (NLF) ecoregion.

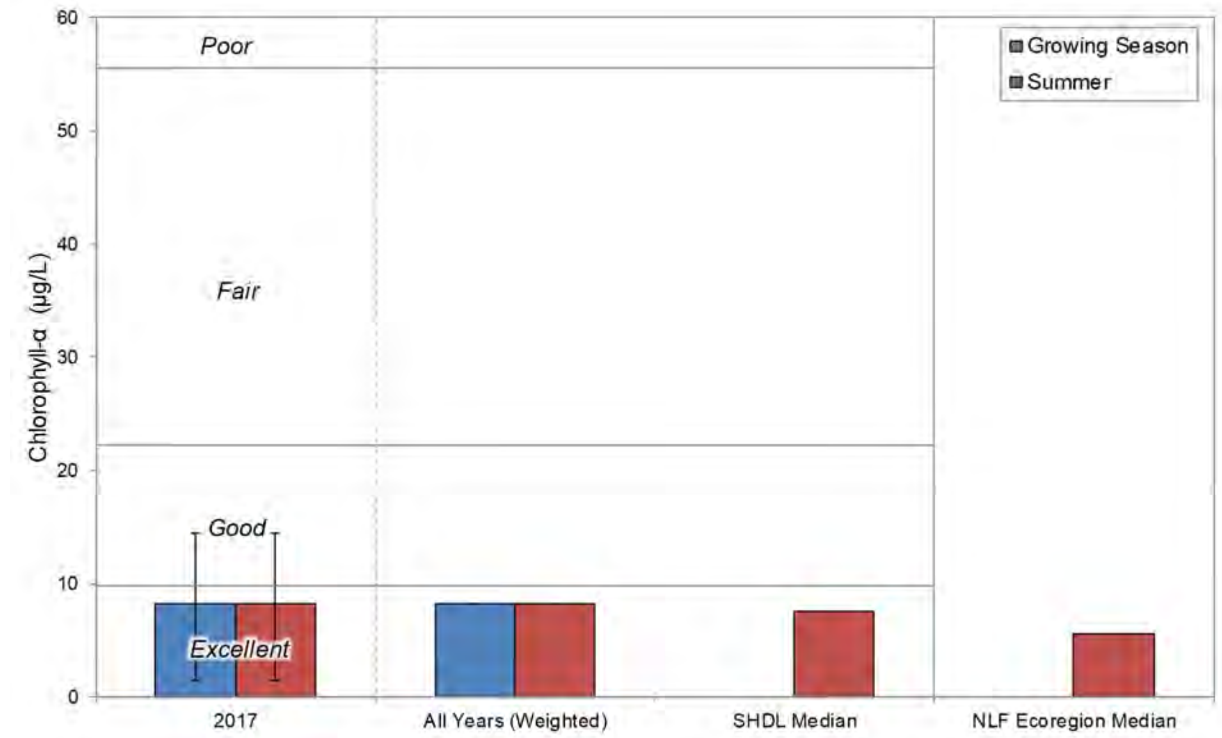


Figure 8.2.1-2. West Plum Lake, statewide shallow headwater drainage lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Secchi disk transparency was measured in West Plum Lake in 2017; however, the Secchi disk measurement hit bottom during every sampling event, indicating that water clarity exceeded the maximum depth of the sampling location. Because these measurements hit bottom, they cannot be included within the seasonal average and cannot be compared against median values for other shallow headwater drainage lakes in the state.

Limiting Plant Nutrient of West Plum Lake

Using midsummer nitrogen and phosphorus concentrations from West Plum Lake, a nitrogen:phosphorus ratio of 18:1 was calculated. This finding indicates that West Plum Lake is indeed phosphorus limited as are the vast majority of Wisconsin lakes. In general, this means that cutting phosphorus inputs may limit plant growth within the lake.

West Plum Trophic State

Figure 8.2.1-3 contains the Trophic State Index (TSI) values for West Plum Lake. These TSI values are calculated using summer near-surface total phosphorus and chlorophyll-*a* data collected as part of this project. All of the Secchi disk measurements his bottom during every sampling event in West Plum Lake; therefore, they cannot be used to calculate a TSI value for the lake. In general, the best values to use in assessing a lake's trophic state are chlorophyll-*a* and total phosphorus, as water clarity can be influenced by other factors other than phytoplankton such as dissolved organic compounds. Closer TSI values for these three parameters indicate a higher degree of correlation between the parameters.

The weighted TSI values for total phosphorus and chlorophyll-*a* in West Plum Lake indicate the lake is at present in a lower eutrophic state. West Plum Lake's productivity is slightly higher than other deep lowland drainage lakes in Wisconsin and all lake types within the NLF ecoregion.

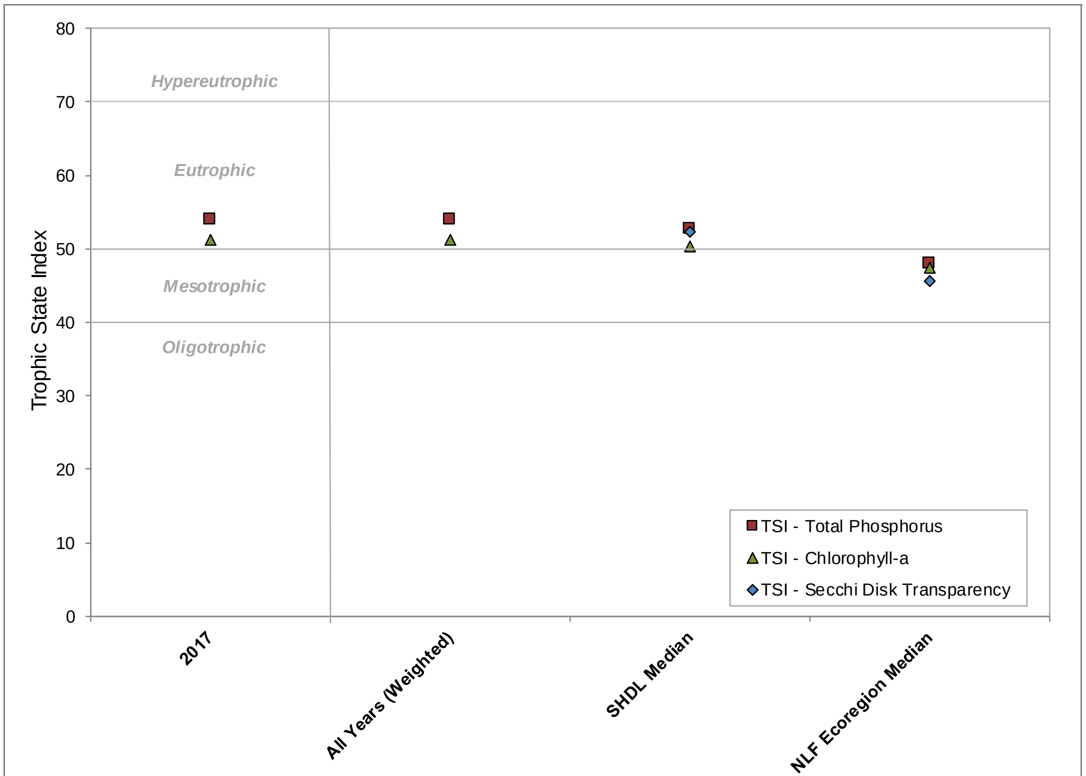


Figure 8.2.1-3. West Plum Lake, statewide shallow headwater drainage lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in West Plum Lake

Dissolved oxygen and temperature were measured during water quality sampling visits to West Plum Lake by Onterra staff. Profiles depicting these data are displayed in Figure 8.2.1-4.

West Plum Lake is *polymictic* [lakes that are too shallow to thermally stratify and can mix throughout the growing season] and the temperature at the bottom was over 20°C in July 2017, indicating that the lake frequently mixes (Figure 8.2.1-4).

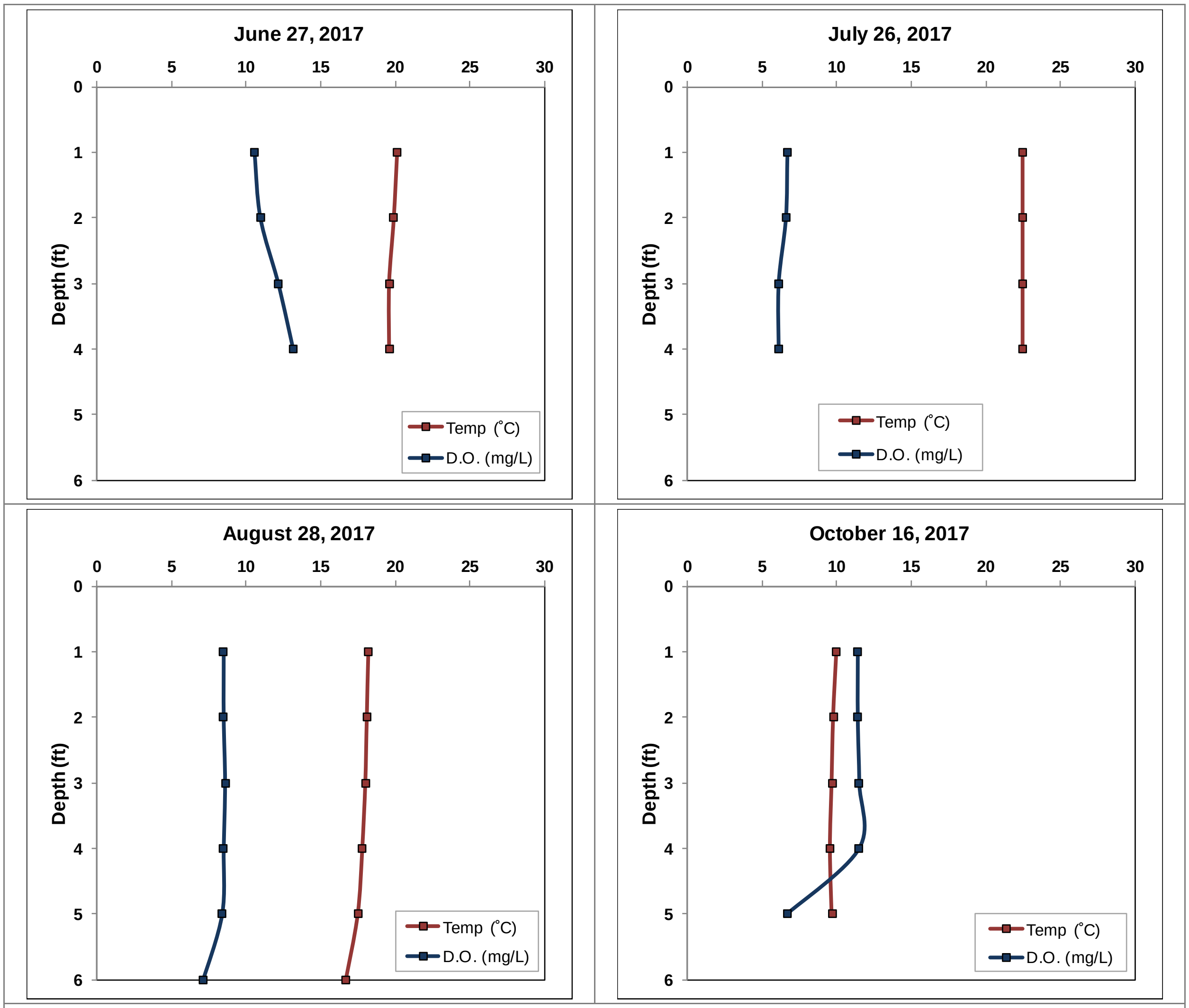


Figure 8.2.1-4. West Plum Lake 2017 dissolved oxygen and temperature profiles.

8.2.2 West Plum Lake Watershed Assessment

West Plum Lake's watershed encompasses an area of approximately 770 acres, yielding a watershed to lake area ratio of 10:1 (Figure 8.2.2-1, West Plum Lake – Map 2). According to WiLMS modeling, the lake's water is completely replaced every 76 days (residence time) or approximately 4.8 times per year (flushing rate).

Approximately 60% of West Plum Lake's watershed is composed of forest, 19% of wetlands, 12% of pasture/grass, and 9% of the lake's surface (Figure 8.2.2-1). The remaining portions of the watershed are composed of rural residential areas.

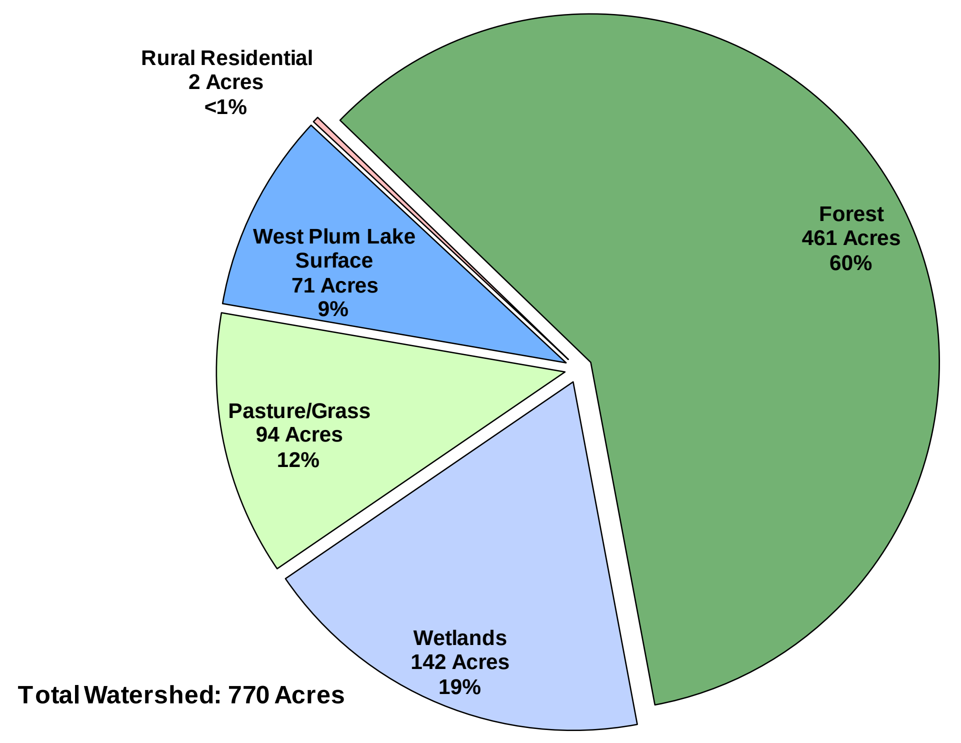


Figure 8.2.2-1. West Plum Lake watershed land cover types in acres. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

Using the land cover data described above, WiLMS was utilized to estimate the annual potential phosphorus load from West Plum Lake's watershed. It was estimated that approximately 95 pounds of phosphorus is delivered to West Plum Lake from its watershed on an annual basis (Figure 8.2.2-2).

Of the estimated 95 pounds of phosphorus being delivered annually to West Plum Lake, 39% is estimated to originate from forest, 26% from pasture/grass, 21% from direct atmospheric deposition into the lake, and 14% from wetlands (Figure 8.2.2-2).

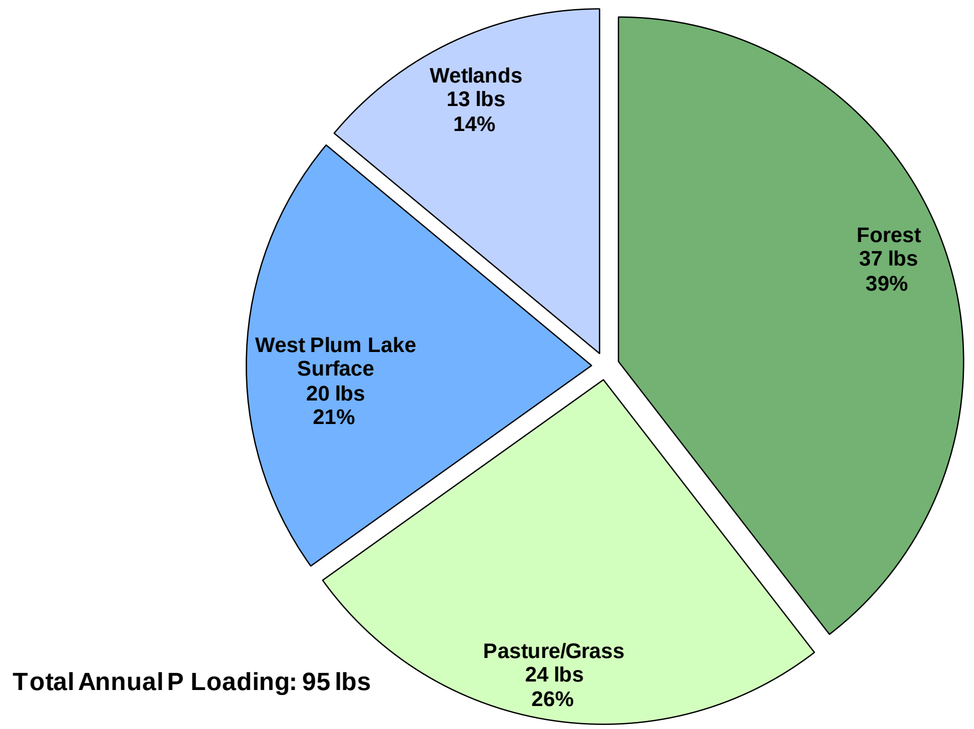


Figure 8.2.2-2. West Plum Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

Using predictive equations, WiLMS estimated that based on the 95 pounds of phosphorus which are estimated to be loaded to West Plum Lake annually, the lake should have an in-lake growing season mean (GSM) total phosphorus concentration of approximately 30 µg/L. This predicted GSM total phosphorus concentration is similar to the measured GSM concentration of 31.8 µg/L. This indicates the lake's watershed and phosphorus inputs were modeled fairly accurately and the measured phosphorus concentrations in West Plum Lake are near expected levels based on the lake's watershed size and land cover composition. There are no indications that significant sources of unaccounted phosphorus are being loaded to the lake.

8.2.3 West Plum Lake Shoreland Condition

Shoreland Development

As mentioned previously in the Town-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 the fall of 2017, West Plum Lake's immediate shoreline was assessed in terms of its development. West Plum Lake has stretches of shoreland that fit four of the five shoreland assessment categories. In all, 1.7 miles of natural/undeveloped and developed-natural shoreline were observed during the survey (Figure 8.2.3-1). This constitutes almost all (99%) of West Plum 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, less than 0.2 miles of urbanized and developed–unnatural shoreline (<1%) was observed. If restoration of the West Plum 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. West Plum Lake - Map 3 displays the location of these shoreline lengths around the entire lake.

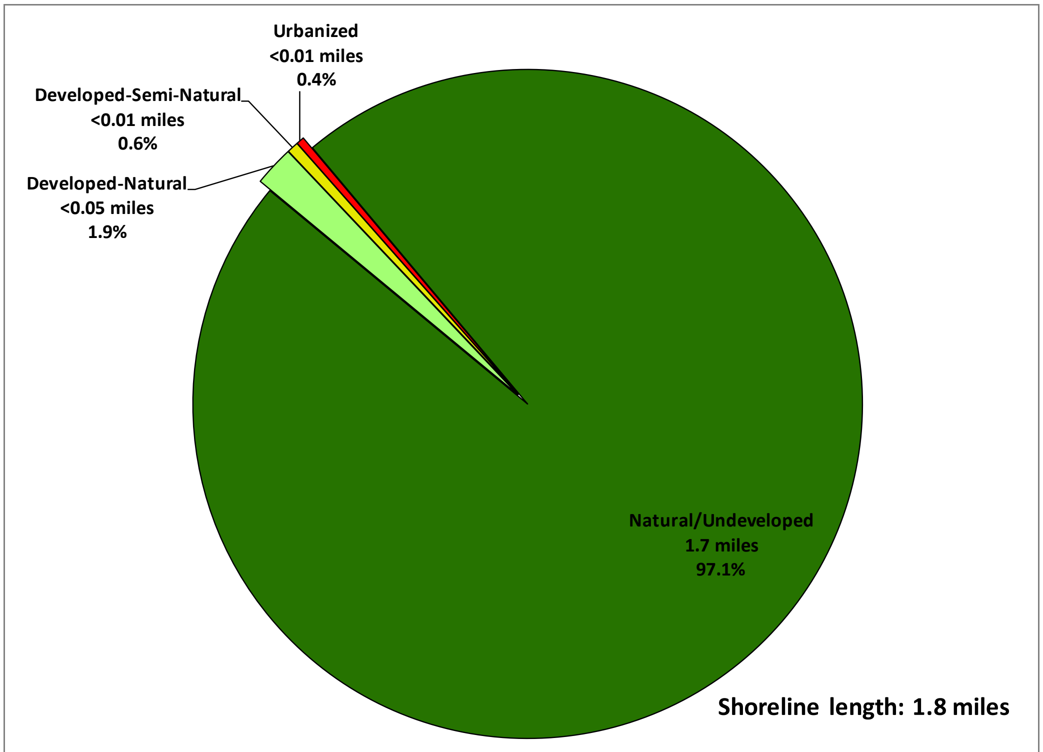


Figure 8.2.3-1. West Plum Lake shoreland categories and total lengths. Based upon a fall 2017 survey. Locations of these categorized shorelands can be found on West Plum Lake - Map 3.

Coarse Woody Habitat

A survey for coarse woody habitat was conducted in conjunction with the shoreland assessment (development) survey. Coarse woody habitat was identified, and classified in three size categories (2-8 inches in diameter, >8 inches in diameter, and cluster 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, 146 total pieces of coarse woody habitat were observed along 1.8 miles of shoreline (West Plum Lake - Map 4), which gives West Plum Lake a coarse woody habitat to shoreline mile ratio of 82:1 (Figure 8.2.3-2). Only instances where emergent coarse woody habitat extended from shore into the water were recorded during the survey. Of the 146 total pieces of coarse woody habitat observed during the survey, 126 pieces were 2-8 inches in diameters, 20 were 8 inches in diameter or greater, and no clusters of pieces 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 West Plum 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 75 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 West Plum Lake fell well above the 75th percentile of these 75 lakes (Figure 8.2.3-2).

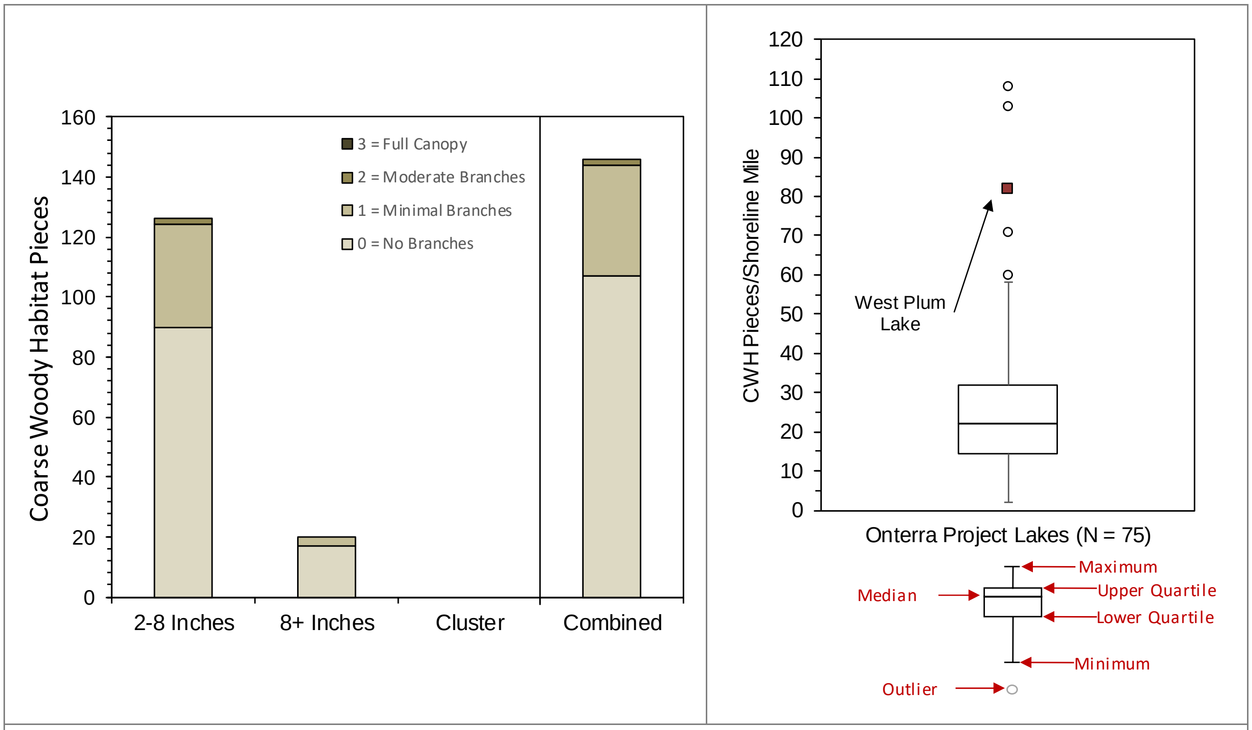


Figure 8.2.3-2. West Plum Lake coarse woody habitat survey results. Based upon a fall 2017 survey. Locations of West Plum Lake coarse woody habitat can be found on West Plum Lake - Map 4.

8.2.4 West Plum Lake Aquatic Vegetation

An Early-Season Aquatic Invasive Species (ESAIS) Survey was conducted by Onterra ecologists on West Plum Lake on June 29, 2017. While the intent of this survey is to locate any potential non-native species within the lake, the primary focus is to locate potential occurrences of the non-native curly-leaf pondweed, which should be at or near its peak growth at this time. No curly-leaf pondweed was located during the survey but pale-yellow iris was located during the ESAIS survey in 2017.

Photograph 8.2.4-1. West Plum Lake

The whole-lake aquatic plant point-intercept survey and emergent and floating-leaf aquatic plant community mapping survey were conducted on West Plum by Onterra ecologists on August 8, 2017. During these surveys, a total of 34 aquatic plant species were located, two of which are considered to be non-native, invasive species: pale-yellow iris and narrow-leaved cattail (Table 8.2.4-1).

As discussed in the primer section, sediment data were collected at each sampling location within the littoral zone during the point-intercept survey. Approximately 94% of the point-intercept locations within littoral areas contained fine, organic sediments (muck), 3% contained sand, and 3% contained rock (Figure 8.2.4-1). The majority of the shallow, near-shore areas contained sand and/or rock, while the deeper areas of the littoral zone were comprised of muck (West Plum Lake - Map 5). Like terrestrial plants, different aquatic plant species are adapted to grow in certain substrate types; some species are only found growing in mucky substrates, others only in sandy areas, and some can be found growing in either. Lakes that have varying substrate types generally support a higher number of plant species because the different habitat types that are available.

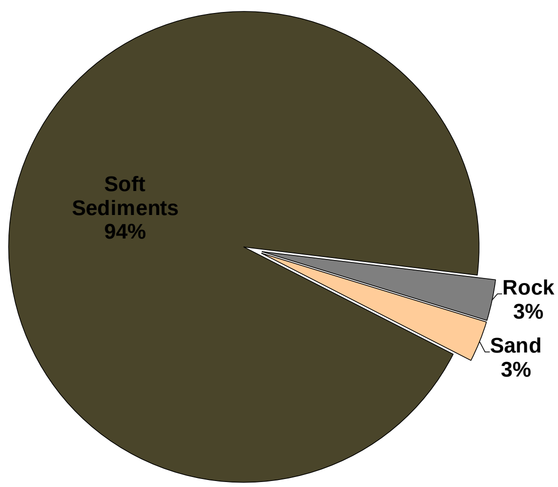


Figure 8.2.4-1. West Plum 2017 proportion of substrate types. Created from data collected during the 2017 whole-lake point-intercept survey (N = 178).

Table 8.2.4-1. List of aquatic plant species located in West Plum during Onterra 2017 aquatic plant surveys.

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2017 (Onterra)
Emergent	*Decodon verticillatus*	Water-willow	7	I
	Equisetum fluviatile	Water horsetail	7	I
	Iris pseudacorus	Pale yellow iris	Exotic	I
	Iris versicolor	Northern blue flag	5	I
	Pontederia cordata	Pickerelweed	9	X
	Sagittaria latifolia	Common arrowhead	3	I
	Schoenoplectus acutus	Hardstem bulrush	5	X
	Sparganium americanum	American bur-reed	8	I
	Sparganium eurycarpum	Common bur-reed	5	I
	Typha angustifolia	Narrow-leaved cattail	Exotic	I
	Zizania spp.	Wild rice sp.	8	X
FL	*Brasenia schreberi*	Watershield	7	X
	Nuphar variegata	Spatterdock	6	I
	Nymphaea odorata	White water lily	6	X
	Persicaria amphibia	Water smartweed	5	I
Submergent	*Ceratophyllum demersum*	Coontail	3	I
	Chara spp.	Muskgrasses	7	X
	Elodea canadensis	Common waterweed	3	X
	Myriophyllum sibiricum	Northern watermilfoil	7	X
	Najas flexilis	Slender naiad	6	X
	Potamogeton friesii	Fries' pondweed	8	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X
	Potamogeton robbinsii	Fern-leaf pondweed	8	X
	Potamogeton strictifolius	Stiff pondweed	8	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X
	Sagittaria sp. (rosette)	Arrowhead sp. (rosette)	N/A	X
	Stuckenia pectinata	Sago pondweed	3	I
	Utricularia geminiscapa	Twin-stemmed bladderwort	9	X
	Vallisneria americana	Wild celery	6	X
S/E	*Eleocharis acicularis*	Needle spikerush	5	I
FF	*Lemna trisulca*	Forked duckweed	6	I
	Lemna turionifera	Turion duckweed	2	I
	Riccia fluitans	Slender riccia	7	I
	Spirodela polyrhiza	Greater duckweed	5	I

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

Of the 178 point-intercept sampling locations that fell at or below the maximum depth of plant growth in 2017, approximately 81% contained aquatic vegetation. West Plum Lake – Map 6 displays the point-intercept locations that contained aquatic vegetation in 2017, and the total rake fullness ratings at those locations. The aquatic vegetation found in 2017 was found lake-wide. Forty-four percent of the point-intercept locations had a total rake fullness (TRF) rating of 1, 19% had a total rake fullness rating of 2, and 19% had the highest total rake fullness rating of 3 (Figure 8.2.4-2). Even though 81% of the littoral zone has vegetation, the aquatic plants in West Plum Lake can be considered relatively sparse, lake-wide.

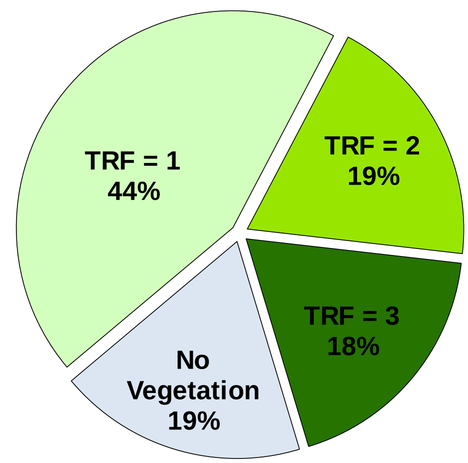


Figure 8.2.4-2. West Plum Lake 2017 aquatic vegetation total rake fullness ratings (TRF). Created from data collected during the 2017 whole-lake point-intercept survey (N = 178).

Of the 34 native aquatic plant species located in West Plum in 2017, 17 were encountered directly on the rake during the whole-lake point-intercept survey (Figure 8.2.4-3). The remaining 17 plants were located incidentally, meaning they were observed by Onterra ecologists while on the lake but they were not directly sampled on the rake at any of the point-intercept sampling locations. Incidental species typically include emergent and floating-leaf species that are often found growing on the fringes of the lake and submersed species that are relatively rare within the plant community. Of the 17 species directly sampled with the rake during the point-intercept survey, common waterweed, Fries' pondweed, northern watermilfoil, and fern-leaf pondweed were the four-most frequently encountered plants, respectively (Figure 8.2.4-3).

Common waterweed was the most abundant aquatic plant encountered in West Plum in 2017, with a littoral occurrence of approximately 64% (Figure 8.2.4-3). Common waterweed is found throughout lakes in Wisconsin and North America, and is often dominant in areas with soft sediments. Its dense foliage provides valuable aquatic habitat while its ability to derive nutrients directly from the water aids in improving water quality.

Fries' pondweed was the second-most abundant aquatic plant encountered in West Plum in 2017, with a littoral occurrence of approximately 38% (Figure 8.2.4-3). Fries' pondweed is a common thin-leaved pondweed throughout the state of Wisconsin. It is easily distinguishable from other thin-leaved pondweeds by the juxtaposition fan that it displays in its winter bud. It also differs from other thin-leaved pondweeds with its leaves containing 5-7 veins and coming to an abrupt point at the tip.

Northern watermilfoil, the third-most encountered species in 2017 had a littoral occurrence of 9% (Figure 8.2.4-3), is arguably the most common milfoil species in Wisconsin lakes and is frequently found growing in soft sediments and higher water clarity. Northern watermilfoil is often falsely identified as Eurasian watermilfoil, especially since it is known to take on the reddish appearance of Eurasian watermilfoil as the plant reacts to sun exposure as the growing season progresses. The feathery foliage of northern watermilfoil traps filamentous algae and detritus, providing valuable invertebrate habitat. Because northern watermilfoil prefers high water clarity, its populations are declining state-wide as lakes are becoming more eutrophic.

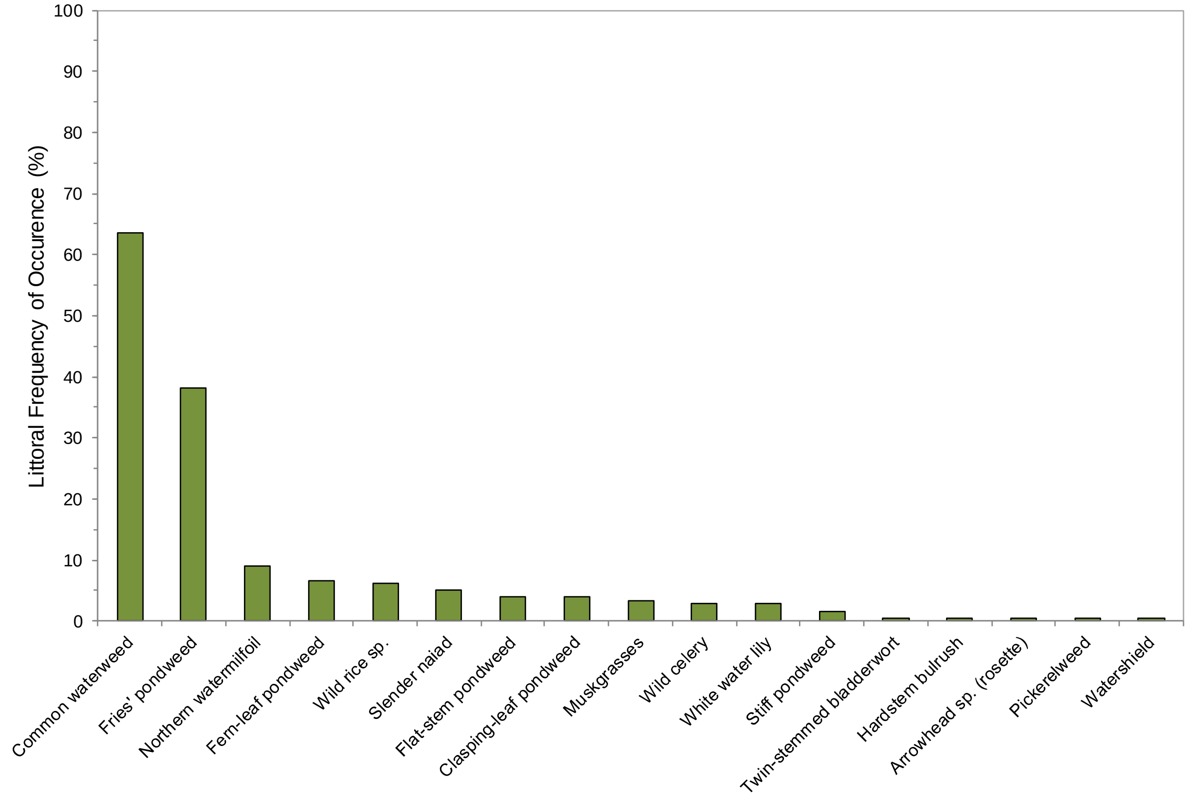


Figure 8.2.4-3. West Plum 2017 littoral frequency of occurrence of aquatic plant species. Created using data from 2017 whole-lake point-intercept survey.

Fern-leaf pondweed was the fourth-most abundant plant in West Plum Lake in 2017 with a littoral occurrence of approximately 7% (Figure 8.2.4-3). As its name suggests, it has the appearance of a fern's leaf and is a common pondweed found in lakes in northern Wisconsin. This plant generally grows in dense beds which creep along the bottom of the lake, where they provide excellent structural habitat for aquatic invertebrates and fish.

As discussed in the Town-wide section, the calculations used to create the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were encountered on the rake during the point-intercept survey and do not include incidental species. The native species encountered on the rake during the 2017 point-intercept survey and their conservatism values were used to calculate the FQI of West Plum's aquatic plant community (equation shown below).

$$FQI = \text{Average Coefficient of Conservatism} * \sqrt{\text{Number of Native Species}}$$

Figure 8.2.4-4 compares 2017 FQI components of West Plum to median values of lakes within the Northern Lakes and Forests (NLF) ecoregion and lakes throughout Wisconsin. The number of native aquatic plant species encountered on the rake, or native species richness, was 17 for the 2017 survey. West Plum's species richness is below the median value for lakes within the ecoregion and the state.

West Plum's average conservatism in 2017 was 6.8 (Figure 8.2.4-4). This value exceeds the median for lakes in the ecoregion and for lakes throughout Wisconsin, which indicates West Plum's aquatic plant community contains a higher number of aquatic plants that are considered to be sensitive to environmental degradation and require high-quality habitats. Given West Plum's high native species richness and average conservatism values from 2017, West Plum has a higher Floristic Quality Index value of 27.8. This FQI value is below the median values for lakes in the ecoregion but above the median value for the state, and indicates that West Plum's aquatic plant community is of higher quality than the majority of lakes throughout Wisconsin.

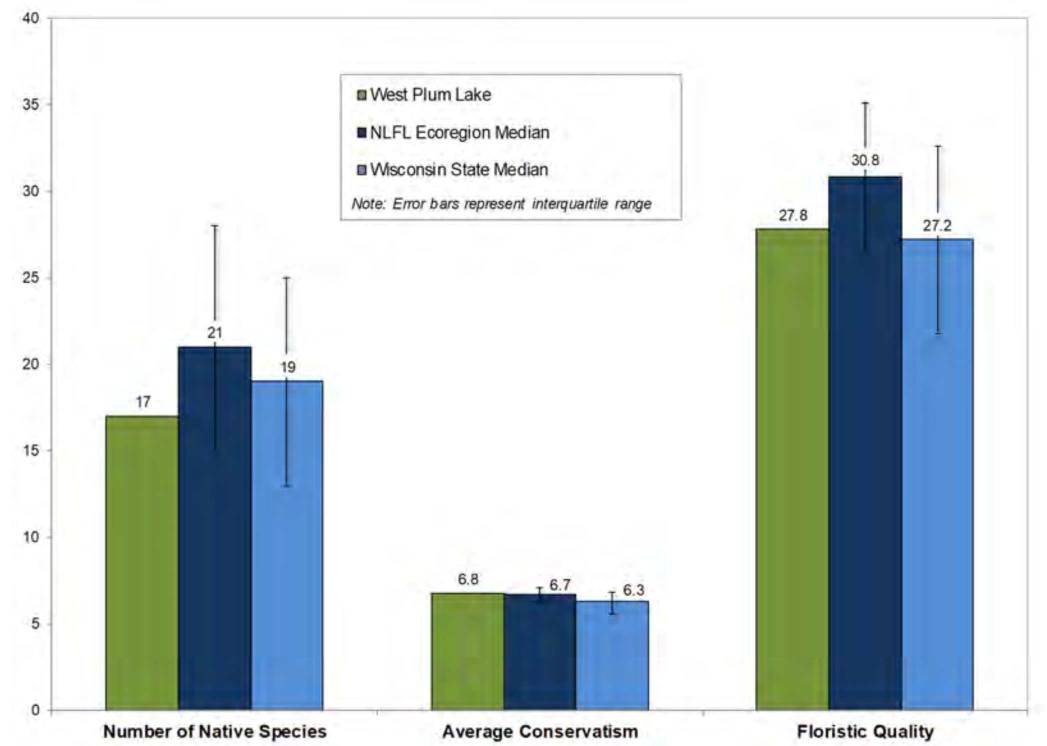


Figure 8.2.4-4. West Plum Floristic Quality Assessment. Created using data from Onterra 2017 whole-lake point-intercept survey. Analysis follows Nichols (1999).

As explained in the Town-wide section, lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. In addition, a plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish, and other wildlife with diverse structural habitat and various sources of food. Because West Plum Lake contains a high number of native aquatic plant species, one may assume the aquatic plant community has high species diversity. However, species diversity is also influenced by how evenly the plant species are distributed within the community.

While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how West Plum's diversity value ranks. Using data collected by Onterra and WDNR Science Services, quartiles were calculated for 212 lakes within the NLF ecoregion (Figure 8.2.4-5). Using the data collected from the 2017 point-intercept survey, West Plum's aquatic plant community is shown to have low species diversity with a Simpson's Diversity Index value of 0.74. In other words, if two individual aquatic plants were randomly sampled from West Plum Lake in 2017, there would be a 74% probability that they would be different species. This diversity value falls below the lower quartile value for lakes in the ecoregion and the state.

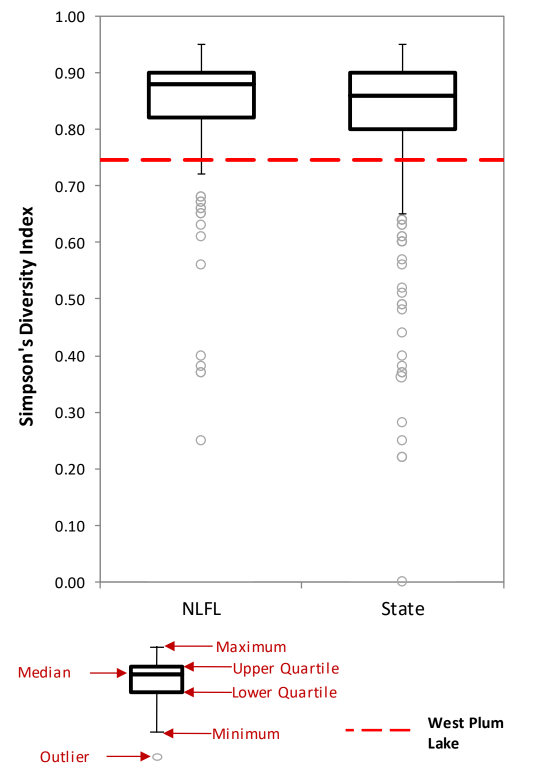


Figure 8.2.4-5. West Plum species diversity index. Created using data from the Onterra 2017 point-intercept survey.

One way to visualize West Plum Lake's lower species diversity is to look at the relative occurrence of aquatic plant species. Figure 8.2.4-6 displays the relative frequency of occurrence of aquatic plant species created from the 2017 whole-lake point-intercept survey and illustrates the relatively uneven distribution of aquatic plant species within the community. A plant community that is dominated by just a few species yields lower species diversity. 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 common waterweed was found at 64% of the littoral sampling locations in West Plum in 2017, its relative frequency of occurrence is 42%. Explained another way, if 100 plants were randomly sampled from West Plum in 2017, 42 of them would be common waterweed. When a lake is dominated by just a few species, the diversity is affected, which would cause the lake to have a lower Simpson's diversity index.

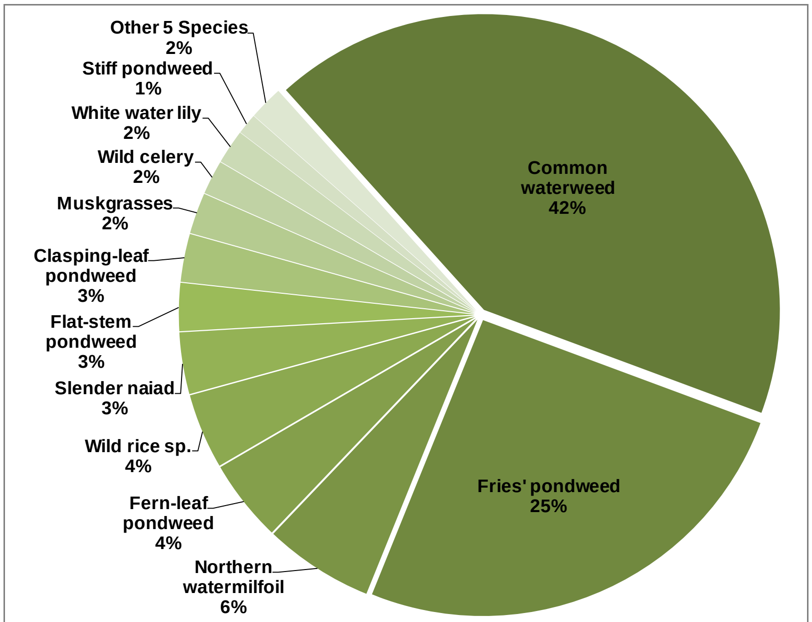


Figure 8.2.4-6. West Plum 2017 relative frequency of occurrence of aquatic plant species. Created using data from 2017 point-intercept survey.

In 2017, Onterra ecologists also conducted a survey aimed at mapping emergent and floating-leaf aquatic plant communities in West Plum Lake. This survey revealed West Plum contains approximately 65 acres of these communities comprised of 15 different aquatic plant species (West Plum Lake – Map 7 and Table 8.2.4-2). These native emergent and floating-leaf plant communities provide valuable fish and wildlife habitat that is important to the ecosystem of the lake. These areas are particularly important during times of fluctuating water levels, since structural habitat of fallen trees and other forms of course-woody habitat can be quite sparse along the shores of receding water lines.

Table 8.2.4-2. West Plum 2017 acres of emergent and floating-leaf aquatic plant communities. Created using data from 2017 aquatic plant community mapping survey.

Plant Community	Acres
Emergent	18.7
Floating-leaf	4.0
Mixed Emergent & Floating-leaf	42.1
Total	**64.8**

The community map represents a 'snapshot' of the important emergent and floating-leaf plant communities, and a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within West Plum. This is important, because these communities are often negatively affected by recreational use and shoreland development.

Non-native Aquatic Plants in West Plum

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. Pale-yellow iris was observed growing in shoreline areas of West Plum in 2017 (West Plum Lake – Map 7). Control of pale-yellow iris on the Town of West Plum project lakes will be discussed in the Implementation Plan Section.

Narrow-leaved Cattail

Narrow-leaved cattail (*Typha angustifolia*) is a non-native wetland plant introduced to North America from Europe and is widespread throughout wetland areas across Wisconsin. Like other non-native, invasive species, narrow-leaved cattail is aggressive and often forms dense monotypic stands which displace native wetland plants. Current control methods for narrow-leaved cattail include maintaining higher water levels to flood the plants, hand or mechanical harvesting followed by flooding, controlled burning, and chemical control using 2,4-D or glyphosate. Narrow-leaved cattail was found on the northern shore of West Plum Lake (West Plum Lake – Map 7).

8.2.5 Aquatic Invasive Species in West Plum Lake

As is discussed in section 2.0 Stakeholder Participation, the lake stakeholders were asked about aquatic invasive species (AIS) and their presence in West Plum Lake within the anonymous stakeholder survey. Onterra and the WDNR have confirmed that there are three AIS present (Table 8.2.5-1).

Table 8.2.5-1. AIS present within West Plum Lake

Type	Common name	Scientific name	Location within the report
Plants	Pale-yellow iris	*Iris pseudacorus*	Section 8.2.4 – West Plum Lake Aquatic Plants
	Narrow-leaved cattail	*Typha angustifolia*	Section 8.2.4 – West Plum Lake Aquatic Plants
Invertebrates	Chinese mystery snail	*Cipangopaludina chinensis*	Section 8.2.5 – Aquatic Invasive Species in West Plum Lake

More information on these invasive species or any other AIS can be found at the following links:

- http://dnr.wi.gov/topic/invasives/
- https://nas.er.usgs.gov/default.aspx
- https://www.epa.gov/greatlakes/invasive-species

Aquatic Animals

Mystery snails

There are two types of mystery snails found within Wisconsin waters, the Chinese mystery snail (*Cipangopaludina chinensis*) and the banded mystery snail (*Viviparus georgianus*). Both snails can be identified by their large size, thick hard shell and hard operculum (a trap door that covers the snail's soft body). These traits also make them less edible to native predators. These species thrive in eutrophic waters with very little flow. They are bottom-dwellers eating diatoms, algae and organic and inorganic bottom materials. One study conducted in northern Wisconsin lakes found that the Chinese mystery snail did not have strong negative effects on native snail populations (Solomon et al. 2010). However, researchers did detect negative impacts to native snail communities when both Chinese mystery snails and the rusty crayfish were present (Johnson et al. 2009).

8.2.6 West Plum 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 West Plum 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 2017 & GLIFWC 2017).

West Plum Lake Fishery

Energy Flow of a Fishery

When examining the fishery of a lake, it is important to remember what drives that fishery, or what is responsible for determining its mass and composition. The gamefish in West Plum Lake are supported by an underlying food chain. At the bottom of this food chain are the elements that fuel algae and plant growth – nutrients such as phosphorus and nitrogen, and sunlight. The next tier in the food chain belongs to zooplankton, which are tiny crustaceans that feed upon algae and plants, and insects. Smaller fish called planktivores feed upon zooplankton and insects, and in turn become food for larger fish species. The species at the top of the food chain are called piscivores, and are the larger gamefish that are often sought after by anglers, such as bass and walleye.

A concept called energy flow describes how the biomass of piscivores is determined within a lake. Because algae and plant matter are generally small in energy content, it takes an incredible amount of this food type to support a sufficient biomass of zooplankton and insects. In turn, it takes a large biomass of zooplankton and insects to support planktivorous fish species. And finally, there must be a large planktivorous fish community to support a modest piscivorous fish community. Studies have shown that in natural ecosystems, it is largely the amount of primary productivity (algae and plant matter) that drives the rest of the producers and consumers in the aquatic food chain. This relationship is illustrated in Figure 8.2.6-1.

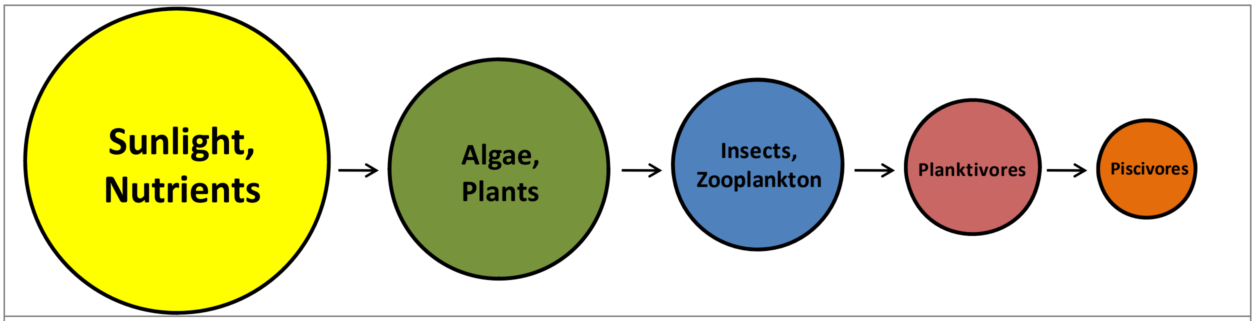


Figure 8.2.6-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality section, West Plum Lake is a eutrophic system, meaning it has high nutrient content and thus relatively high primary productivity. Simply put, this means West Plum Lake should be able to support sizable populations of predatory fish (piscivores) because the supporting food chain is relatively robust.

Survey Methods

In order to keep the fishery of a lake healthy and stable, fisheries biologists must assess the current fish populations and trends. To begin this process, the correct sampling technique(s) must be selected to efficiently capture the desired fish species. A commonly used passive trap is a fyke net (Photograph 8.2.6-1). Fish swimming towards this net along the shore or bottom will encounter the lead of the net, be diverted into the trap and through a series of funnels which direct the fish further into the net. Once reaching the end, the fisheries technicians can open the net, record biological characteristics, mark (usually with a fin clip), and then release the captured fish.

The other commonly used sampling method is electroshocking (Photograph 8.2.6-1). This is done, often at night, by using a specialized boat fit with a generator and two electrodes installed on the front touching the water. Once a fish comes in contact with the electrical current produced, the fish involuntarily swims toward the electrodes. When the fish is in the vicinity of the electrodes, they become stunned making them easy for fisheries technicians to net and place into a livewell to recover. Contrary to what some may believe, electroshocking does not kill the fish and after being placed in the livewell fish generally recover within minutes. As with a fyke net survey, biological characteristics are recorded and any fish that has a mark (considered a recapture from the earlier fyke net survey) are also documented before the fish is released.

The mark-recapture data collected between these two surveys is placed into a statistical model to calculate the population estimate of a fish species. Fisheries biologists can then use this data to make recommendations and informed decisions on managing the future of the fishery.

Photograph 8.2.6-1. Fyke net positioned in the littoral zone of a Wisconsin Lake (left) and an electroshocking boat (right).

Fish Stocking

To assist in meeting fisheries management goals, the WDNR may permit the stocking of fry, fingerling or adult fish in a waterbody that were raised in permitted hatcheries (Photograph 8.2.6-2). 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. West Plum Lake has not been stocked in recent years.

West Plum Lake Spear Harvest Records

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842 (Figure 8.2.6-2). West Plum Lake falls within the ceded territory based on the Treaty of 1842. This allows for a regulated open water spear fishery by Native Americans on lakes located within the Ceded Territory.

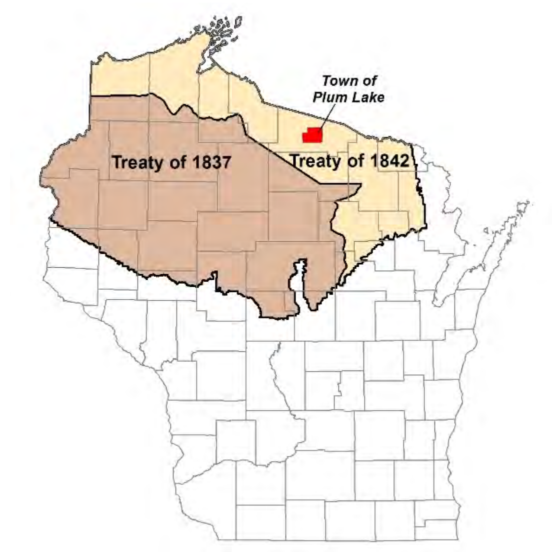


Figure 8.2.6-2. Location of West Plum Lake within the Native American Ceded Territory (GLIFWC 2017). This map was digitized by Onterra; therefore, it is a representation and not legally binding.

Although West Plum Lake has been declared as a spear harvest lake, it has not historically seen a harvest. It is possible spearing efforts have been concentrated on other larger lakes in the region, which would potentially have a higher estimated safe harvest for both walleye and muskellunge.

West Plum Lake Fish Habitat

Substrate Composition

Just as forest wildlife require proper trees and understory growth to flourish, fish require certain substrates and habitat types to nest, spawn, escape predators, and search for prey. Lakes with primarily a silty/soft substrate, many aquatic plants, and coarse woody debris may produce a completely different fishery than lakes that are largely sandy/rocky, and contain few aquatic plant species or coarse woody habitat.

Substrate and habitat are critical to fish species that do not provide parental care to their eggs. Northern pike is one species that does not provide parental care to its eggs (Becker 1983). Northern pike broadcast their eggs over woody debris and detritus, which can be found above sand or muck. This organic material suspends the eggs above the substrate, so the eggs are not buried in sediment and suffocate as a result. Walleye are another species that does not provide parental care to its eggs. Walleye preferentially spawn in areas with gravel or rock in places with moving water or wave action, which oxygenates the eggs and prevents them from getting buried in sediment. Fish that provide parental care are less selective of spawning substrates. Species such as bluegill tend to prefer a harder substrate such as rock, gravel or sandy areas if available, but have been found to spawn and care for their eggs in muck as well.

According to the point-intercept survey conducted by Onterra in 2017, 94% of the substrate sampled in the littoral zone of West Plum Lake were soft sediments, 3% was composed of rock and 3% were composed of sand sediments.

Woody Habitat

As discussed in the Shoreland Condition Section, the presence of coarse woody habitat is important for many stages of a fish's life cycle, including nesting or spawning, escaping predation as a juvenile, and hunting insects or smaller fish as an adult. Unfortunately, as development has increased on Wisconsin lake shorelines in the past century, this beneficial habitat has often been the first to be removed from the natural shoreland zone. Leaving these shoreland zones barren of coarse woody habitat can lead to decreased abundances and slower growth rates in fish (Sass 2006). A fall 2017 survey documented 146 pieces of coarse woody along the shores of West Plum Lake, resulting in a ratio of approximately 82 pieces per mile of shoreline.

Fish Habitat Structures

Some fisheries managers may look to incorporate fish habitat structures on the lakebed or littoral areas extending to shore for the purpose of improving fish habitats. These projects are typically conducted on lakes lacking significant coarse woody habitat in the shoreland zone. The "Fish sticks" program, outlined in the WDNR best practices manual, adds trees to the shoreland zone restoring fish habitat to critical near shore areas. Typically, every site has 3 – 5 trees which are partially or fully submerged in the water and anchored to shore (Photograph 8.2.6-2). The WDNR recommends placement of the fish sticks during the winter on ice when possible to prevent adverse impacts on fish spawning or egg incubation periods. The program requires a WDNR permit and can be funded through many different sources including the WDNR, County Land & Water Conservation Departments or partner contributions.


Photograph 8.2.6-2. Examples of fish sticks (left) and half-log habitat structures. (Photos by WDNR)

Fish cribs are a fish habitat structure that is placed on the lakebed. Installing fish cribs may be cheaper than fish sticks; however, some concern exists that fish cribs can concentrate fish, which in turn leads to increased predation and angler pressure.

Half-logs are another form of fish spawning habitat placed on the bottom of the lakebed (Photograph 8.2.6-2). Smallmouth bass specifically have shown an affinity for overhead cover when creating spawning nests, which half-logs provide (Wills 2004). If the waterbody is exempt from a permit or a permit has been received, information related to the construction, placement and maintenance of half-log structures are available online.

An additional form of fish habitat structure is spawning reefs. Spawning reefs typically consist of small rubble in a shallow area near the shoreline for mainly walleye habitat. Rock reefs are sometimes utilized by fisheries managers when attempting to enhance spawning habitats for some fish species. However, a 2004 WDNR study of rock habitat projects on 20 northern Wisconsin lakes offers little hope the addition of rock substrate will improve walleye reproduction (Neuswanger and Bozek 2004).

Placement of a fish habitat structure in a lake does not require a permit if the project meets certain conditions outlined by the WDNR's checklists available online:

(https://dnr.wi.gov/topic/waterways/Permits/Exemptions.html)

If a project does not meet all of the conditions listed on the checklist, a permit application may be sent in to the WDNR and an exemption requested. The TPL should work with the local WDNR fisheries biologist to determine if the installation of fish habitat structures should be considered in aiding fisheries management goals for West Plum.

Regulations and Management

Regulations for West Plum Lake gamefish species as of April 2018 are displayed in Table 8.2.6-1. For specific fishing regulations on all fish species, anglers should visit the WDNR website (*www.http://dnr.wi.gov/topic/fishing/regulations/hookline.html)* or visit their local bait and tackle shop to receive a free fishing pamphlet that contains this information.

Table 8.2.6-1. WDNR fishing regulations for West Plum Lake (As of April 2018).

Species	Daily bag limit	Length Restrictions	Season
Panfish (bluegill, pumpkinseed, sunfish, crappie and yellow perch)	25	None	Open All Year
Smallmouth bass (Early Season)	Catch and release only	None	May 5, 2018 to June 15, 2018
Smallmouth bass	1	18"	June 16, 2018 to March 3, 2019
Largemouth bass	1	18"	May 5, 2018 to March 3, 2019
Muskellunge and hybrids	1	40"	May 26, 2018 to November 30, 2018
Northern pike	5	None	May 5, 2018 to March 3, 2019
Walleye, sauger, and hybrids	3	The minimum length is 15", but walleye, sauger, and hybrids from 14" to 18" may not be kept, and only 1 fish over 18" is allowed.	May 5, 2018 to March 3, 2019
Bullheads	Unlimited	None	Open All Year

General Waterbody Restrictions: Motor Trolling is allowed with 1 hook, bait, or lure per angler, and 2 hooks, baits, or lures maximum per boat.

Mercury Contamination and Fish Consumption Advisories

Freshwater fish are amongst the healthiest of choices you can make for a home-cooked meal. Unfortunately, fish in some regions of Wisconsin are known to hold levels of contaminants that are harmful to human health when consumed in great abundance. The two most common contaminants are polychlorinated biphenyls (PCBs) and mercury. These contaminants may be found in very small amounts within a single fish, but their concentration may build up in your body over time if you consume many fish. Health concerns linked to these contaminants range from poor balance and problems with memory to more serious conditions such as diabetes or cancer. These contaminants, particularly mercury, may be found naturally to some degree. However, the majority of fish contamination has come from industrial practices such as coal-burning facilities, waste incinerators, paper industry effluent and others. Though environmental regulations have reduced emissions over the past few decades, these contaminants are greatly resistant to breakdown and may persist in the environment for a long time. Fortunately, the human body is able to eliminate contaminants that are consumed however this can take a long time depending upon the type of contaminant, rate of consumption, and overall diet. Therefore, guidelines are set upon the consumption of fish as a means of regulating how much contaminant could be consumed over time.

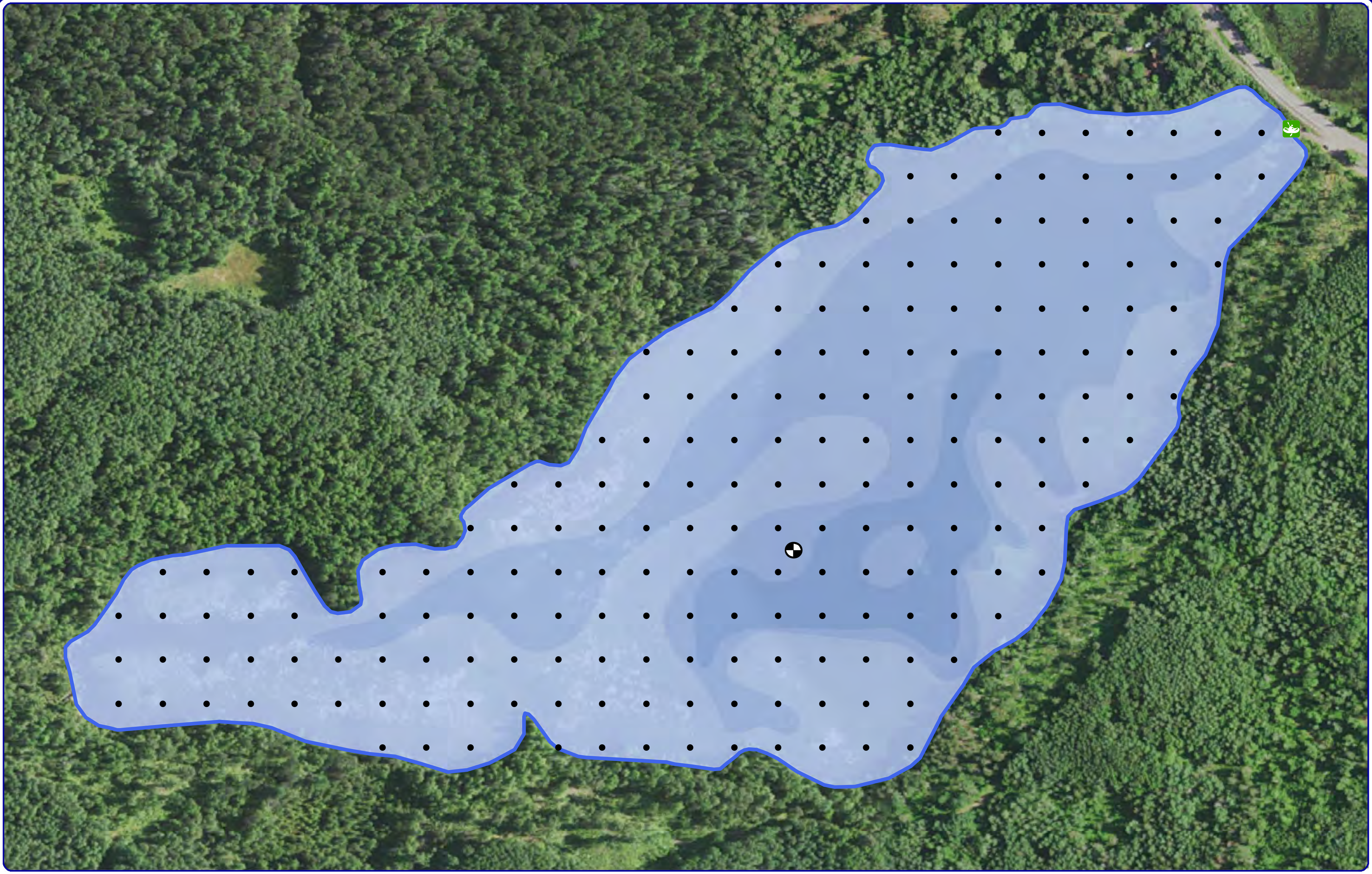
General fish consumption guidelines for Wisconsin inland waterways are presented in Figure 8.2.6-3. There is an elevated risk for children as they are in a stage of life where cognitive development is rapidly occurring. As mercury and PCB both locate to and impact the brain, there are greater restrictions on women who may have children or are nursing children, and also for children under 15.

Fish Consumption Guidelines for Most Wisconsin Inland Waterways

	Women of childbearing age, nursing mothers and all children under 15	Women beyond their childbearing years and men
Unrestricted*	-	Bluegill, crappies, yellow perch, sunfish, bullhead and inland trout
1 meal per week	Bluegill, crappies, yellow perch, sunfish, bullhead and inland trout	Walleye, pike, bass, catfish and all other species
1 meal per month	Walleye, pike, bass, catfish and all other species	Muskellunge
Do not eat	Muskellunge	-

**Doctors suggest that eating 1-2 servings per week of low-contaminant fish or shellfish can benefit your health. Little additional benefit is obtained by consuming more than that amount, and you should rarely eat more than 4 servings of fish within a week.*

Figure 8.2.6-3. Wisconsin statewide safe fish consumption guidelines. Graphic displays consumption guidance for most Wisconsin waterways. Figure adapted from WDNR website graphic (http://dnr.wi.gov/topic/fishing/consumption/)



N W E S

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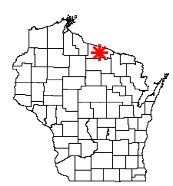
Feet

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

Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR, digitized by Onterra
Orthophotography: NAIP, 2015
Map Date: April 17, 2018
Filename: *Map1_WestPlum_Location.mxd*



Project Location in Wisconsin

Legend

West Plum Lake ~69 acres
WDNR Definition

Carry-In Access

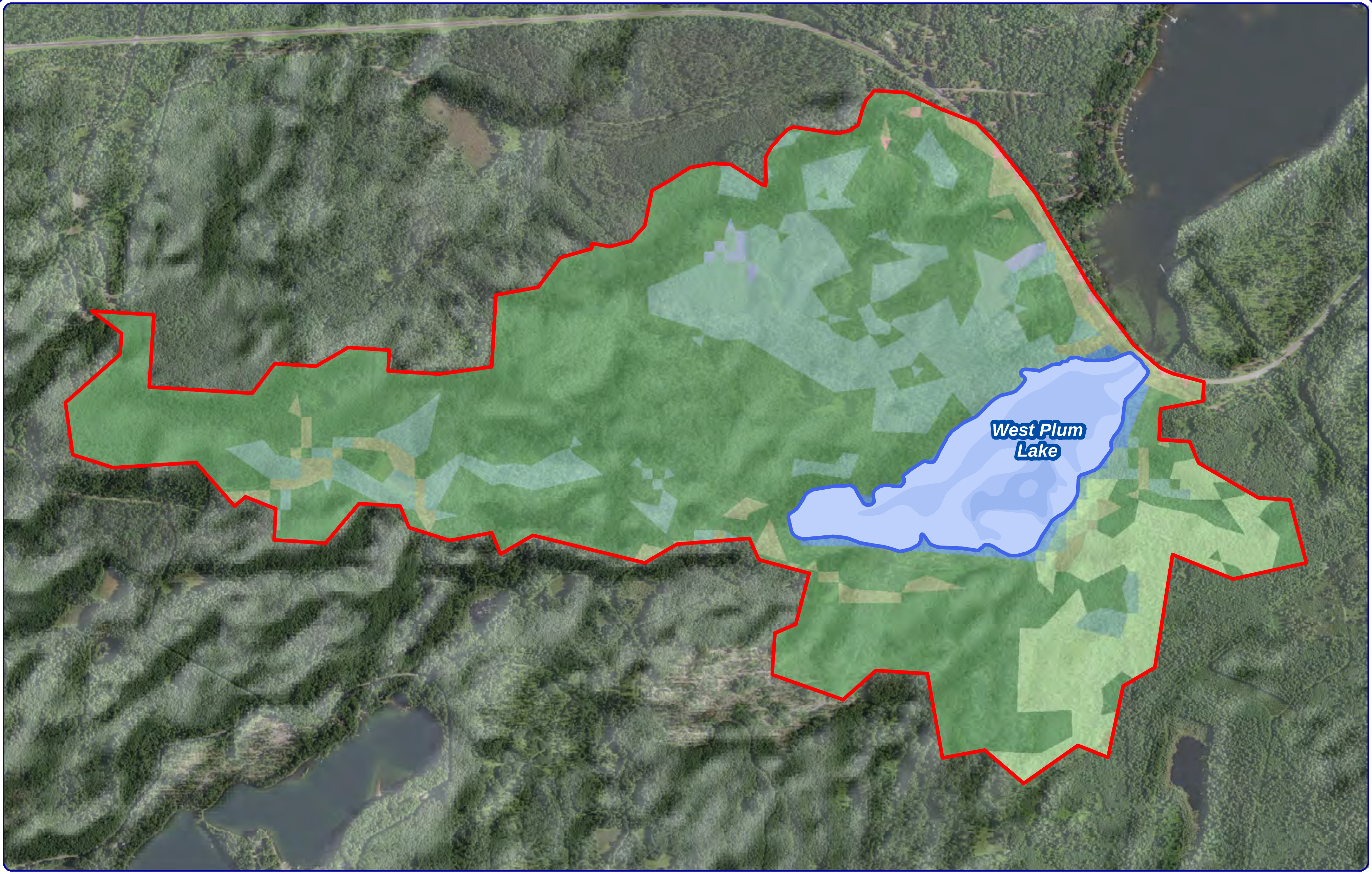
Water Quality
Sampling Location

Point-intercept Sample Location
37 meter points

West Plum Lake - Map 1

Town of Plum Lake
Vilas County, Wisconsin

Project Location & Lake Boundaries



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Feet

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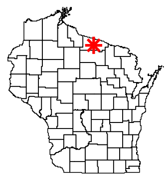
Sources:
Hydro: WDNR
Bathymetry: WDNR, digitized by Onterra
Orthophotography: NAIP 2015
Land Cover: NLCD 2011
Watershed Boundaries: Onterra 2017
Map Date: October 31, 2017
Filename: *Map2_WestPlum_WS.mxd*



Project Location in Wisconsin

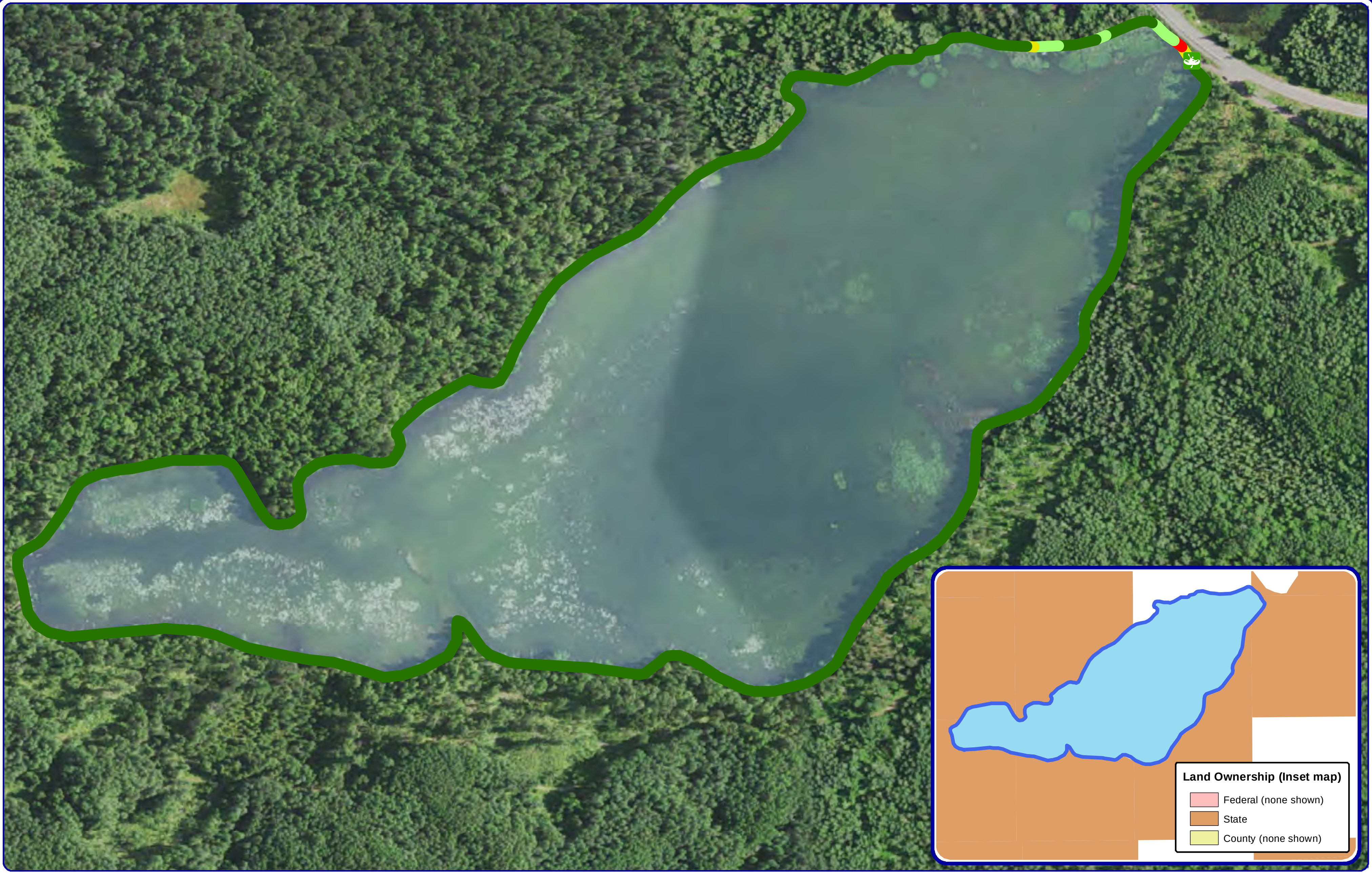
Legend

Land Cover Types

- Forest
- Forested Wetlands
- Wetlands
- Open Water
- Rural Open Space
- Pasture/Grass
- Rural Residential
- West Plum Lake Watershed Boundary
- River/Stream

West Plum Lake - Map 2
Town of Plum Lake
Vilas County, Wisconsin

Watershed Boundaries & Land Cover Types



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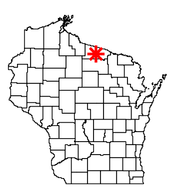
Sources:
Hydro: WDNR
Orthophotography: NAIP, 2015
Shoreline Assessment: Onterra, 2017
Map Date: November 2, 2017
Filename: *Map3_WestPlum_ShorelandCondition_2017.mxd*



Project Location in Wisconsin

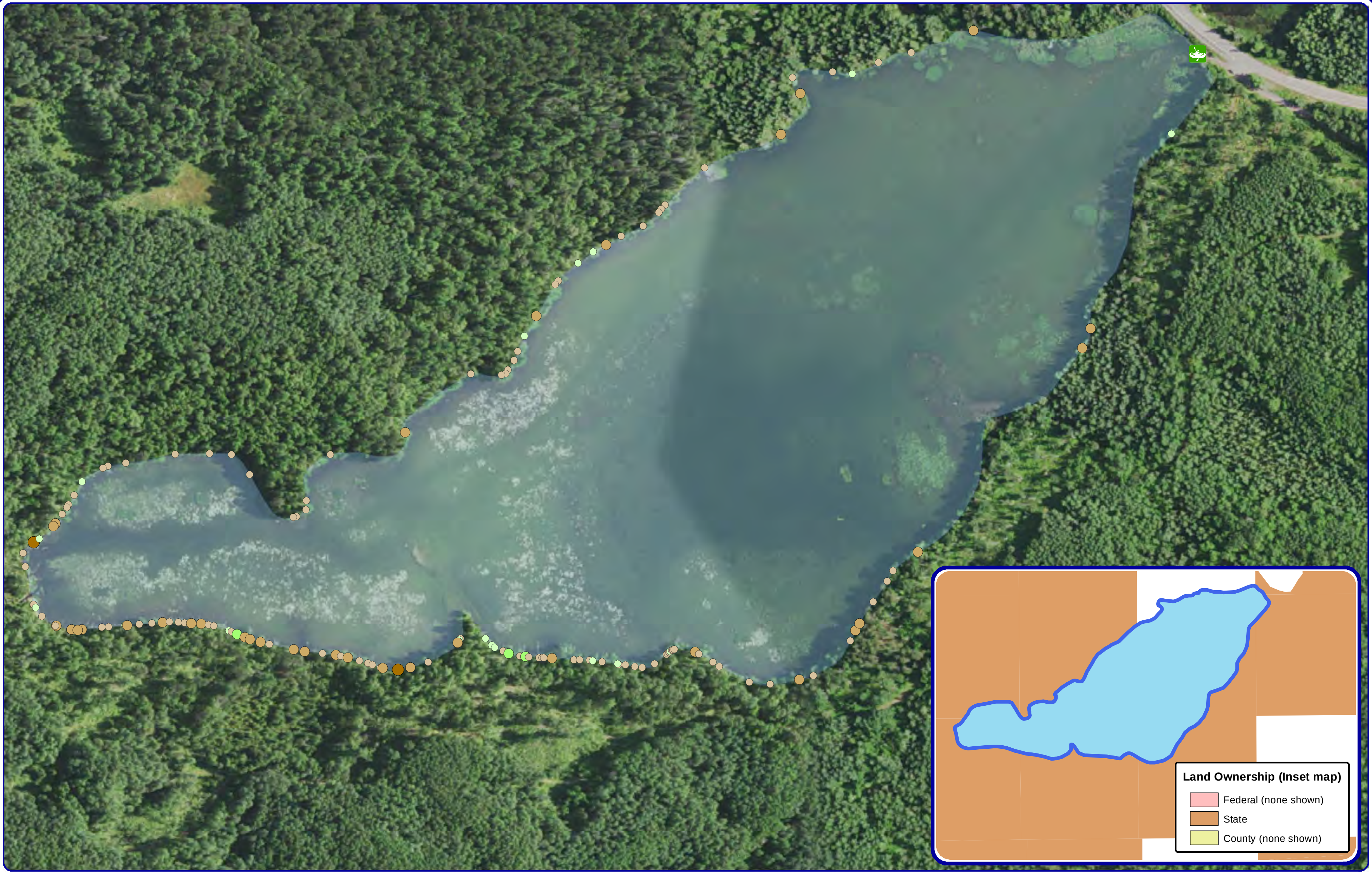
Legend

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

West Plum Lake - Map 3

Town of Plum Lake
Vilas County, Wisconsin

2017 Shoreland Condition



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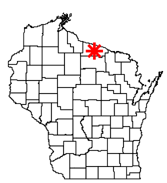
Sources:
Hydro: WDNR
Orthophotography: NAIP, 2015
Coarse Woody Habitat Survey: Onterra, 2017
Map Date: November 2, 2017
Filename: *Map4_WestPlum_CWH_2017.mxd*



Project Location in Wisconsin

Legend

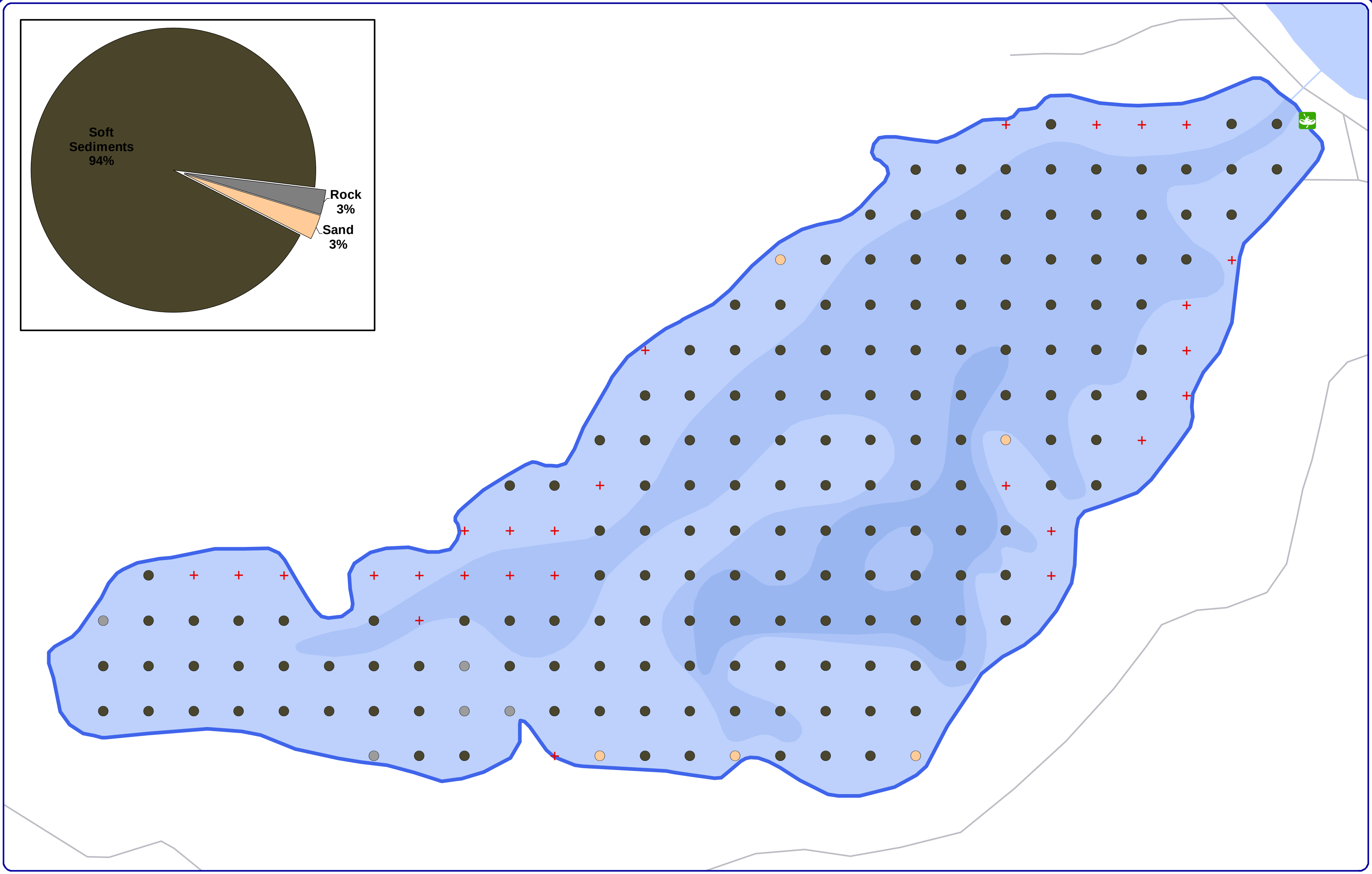
2-8 Inch Pieces	8+ Inch Pieces	Cluster of Pieces
No Branches	No Branches	No Branches (none)
Minimal Branches	Minimal Branches (none)	Minimal Branches (none)
Moderate Branches	Moderate Branches (none)	Moderate Branches (none)
Full Canopy (none)	Full Canopy (none)	Full Canopy (none)

West Plum Lake - Map 4

Town of Plum Lake

Vilas County, Wisconsin

Coarse Woody Habitat



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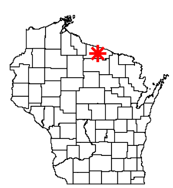
Sources:
Hydro and Roads: WDNR
Bathymetry: WDNR, digitized by Onterra
Aquatic Plant Survey: Onterra, 2017
Map Date: November 17, 2017
Filename: *Map5_WestPlum_SubstratePI_2017.mxd*


Project Location in Wisconsin

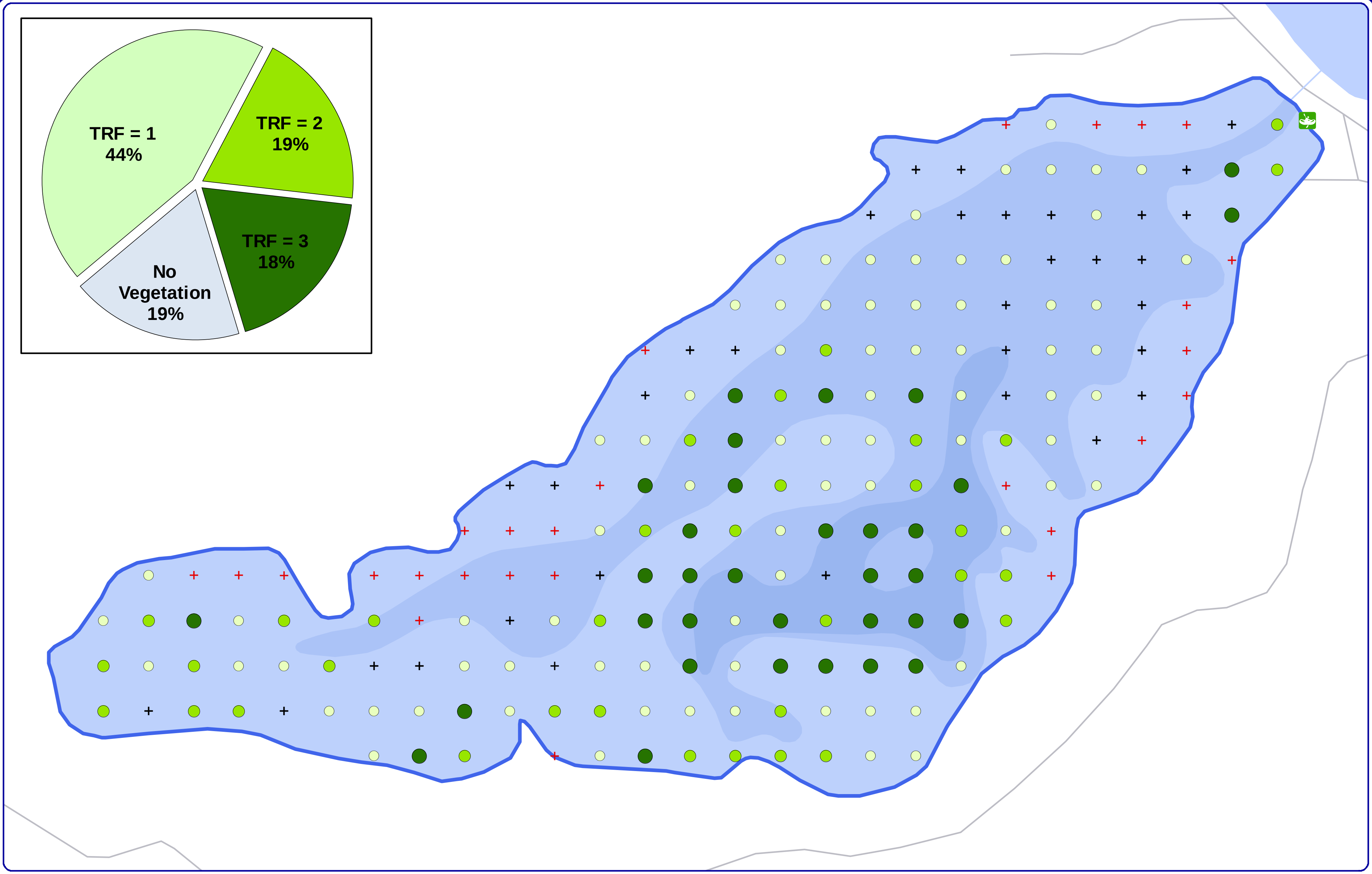
Legend

- Soft/Organic Sediments
- Rock
- Sand
- Too Deep
- Non-navigable

West Plum Lake - Map 5

Town of Plum Lake
Vilas County, Wisconsin

2017 PI Survey:
Substrate Types



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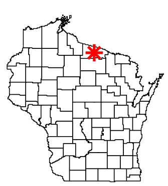

Project Location in Wisconsin

Legend

- Total Rake Fullness = 1
- Total Rake Fullness = 2
- Total Rake Fullness = 3
- + No Vegetation
- + Non-Navigable

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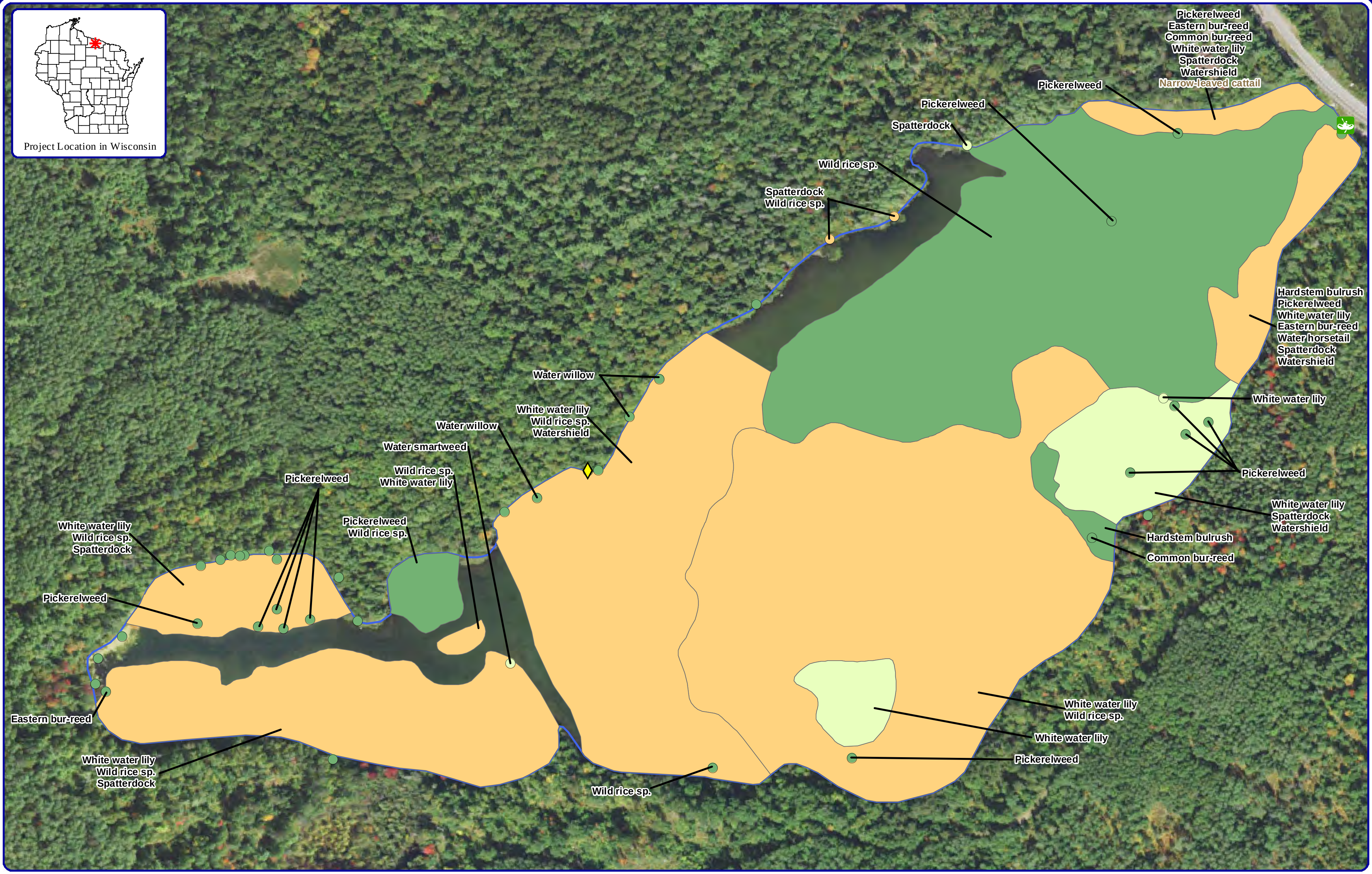
Sources:
Hydro and Roads: WDNR
Bathymetry: WDNR, digitized by Onterra
Aquatic Plant Survey: Onterra, 2017
Map Date: November 17, 2017
Filename: *Map6_WestPlum_TRFPI_2017.mxd*

West Plum Lake - Map 6

Town of Plum Lake
Vilas County, Wisconsin

2017 PI Survey: Aquatic Vegetation Distribution



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www.onterra-eco.com

Sources:
Hydro: WDNR
Aquatic Plants: Onterra, 2017
Orthophotography: NAIP, 2015
Map date: April 24, 2018 EEH
Filename: *Map7_WestPlum_Comm_2017.mxd*

Legend

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

Small Plant Communities
- Emergent *(Northern blue-flag unless otherwise noted)*
- Floating-leaf
- Mixed Floating-leaf & Emergent

Exotic Plant Communities
- Pale Yellow Iris

West Plum Lake - Map 7

Town of Plum Lake
Vilas County, Wisconsin

Emergent & Floating-leaf Aquatic Plant Communities