Stormy Lake
2023 Lake Assessment Report

Prepared by
Vilas County Land & Water Conservation

September 11, 2025

Assessment Type	Metric	Metric Context	Stormy Lake Results
Water Quality	Total Phosphorus	FAL[1] & REC[2]: 15 ug/L in two-story fishery	<10.3 ug/L average July-Sep 2023
	Chlorophyll *a*	FAL[1]: 8 ug/L in two-story fishery REC[2]: more than 5% of days where >20 ug/L	1.43 ug/L average July-Sep 2023 >20 ug/L in 0 of 3 sampling events (0%)
Aquatic Plant Point-Intercept	Floristic Quality Index	24.3 median for Northern Lakes and Forest Lakes Ecoregion	25.69
	Average Value of Conservatism	6.7 median for Northern Lakes and Forest Lakes Ecoregion	7.42
Shoreland Habitat	Docks/Mile	>16 docks/mile density correlated with less fish diversity	27.41

Additional Data		
Water Quality	Secchi Depth	20.17 ft average (July-Sep 2023)
Aquatic Plant Point-Intercept Survey	Max Depth of Plants	37.0 ft
	FOO[3] shallower than max depth	18.72%
	Simpson's Diversity Index	0.83
	Rare Plants	None detected
AIS Early Detection	Previously Verified & **Newly Verified** AIS	Previously verified AIS: Chinese mystery snail, spiny waterflea, and rusty crayfish **New AIS: None**
Shoreland Habitat	% Natural Cover	>58%
	% Impervious	7%
	Parcels With Runoff Concerns	128 of 140 parcels (91%)
	Coarse Woody Habitat	Stormy Lake = 6.43 logs/mile Undeveloped lake average = 345 logs/mile

[1]Fish and aquatic life; [2]Recreation; [3]Frequency of Occurrence
Metrics & Contexts sourced from: WisCALM 2024; Hauxwell et al 2010; Nichols 1999; and Jacobson et. al. 2016.

Summary

Stormy Lake is a two-story fishery lake in Vilas County. Of the 3 water quality sampling events, total phosphorus and chlorophyll a measured within the thresholds set by 2024 WisCALM and combined with Secchi data is indicative of excellent water quality and an oligotrophic system. Globular stonewort (Chara globularis), variable pondweed (Potamogeton gramineus), slender nitella (Nitella flexilis), needle spikerush (Eleocharis acicularis), and dwarf watermilfoil (Myriophyllum tenellum) were the most common aquatic plants in the lake. The lake had a sparse aquatic plant community with only 18.72% of littoral sites having any aquatic plants, and only 14 species of aquatic plants were detected during the survey. Plant growth density was also quite low, with a littoral rake fullness of 0.26. The lake's floristic quality (25.69) is similar to the average for the region (24.3), and its species richness (12) is just below the Northern Lakes and Forests regional average of 13. Verified invasive species from previous events were Chinese mystery snails, rusty crayfish, and spiny waterflea. No new invasive species were documented during the survey. The coarse woody habitat survey resulted in 6.43 logs/mile of shoreline compared to the 345 logs/mile typically found on undeveloped lakes. Over half of the cover within the 35 ft. shoreland buffer area is natural (>58%); 28% is soil or duff; 8% is lawn; and 7% is impervious. The majority of parcels (91%) did present at least some concern for runoff due to any of: point source; channelized flow to the lake; trails or stairs to lake; lawn or soil sloping to lake; or bare soil. Pier density (as a proxy to represent development) is at 27.41 docks/mile, which is greater than the 16.0 docks/mile threshold where negative impacts to fish diversity are seen. Highlighted recommendations include continuing to monitor water quality; monitoring for aquatic invasive species; informing riparian landowners of the benefits of shoreline buffers; continuing a Clean Boats Clean Waters inspection program; and restoring modified or eroded banks and riparian areas where landowners are willing.

Introduction

Figure 1. Stormy Lake Map courtesy of Vilas County Geospatial Online.

Lakes are a vital natural resource to the economy and way of life in Vilas County. With over 75% of property taxes coming from lake front properties (based on 2016 tax roll), it is in the county's best interest to keep these lakes attractive. Vilas County sits at a headwaters region, meaning that this area's lakes and rivers are dependent on precipitation and groundwater. This area does not glean significant water from upstream waterways, so local conservation practices often protect our waters directly as well as maintain the water quality as it heads downstream out of Vilas County. With these ideas in mind, the Vilas County Land & Water Conservation Department continues to assess lake health through the DNR's Directed Lakes program.

The purposes of the study of Stormy Lake are to: 1) fill knowledge gaps by collecting data; and 2) identify any negative lake health issues for future implementation focus. This data can also be used by the Vilas County Land & Water Conservation Department in the future with its planned watershed assessments.

Stormy Lake is a 523-acre two-story fishery lake located in the Town of Conover in Vilas County. Its maximum depth is reported as 63 feet and is made up of 90% sand, 5% gravel, and 5% rock (*Stormy Lake*).

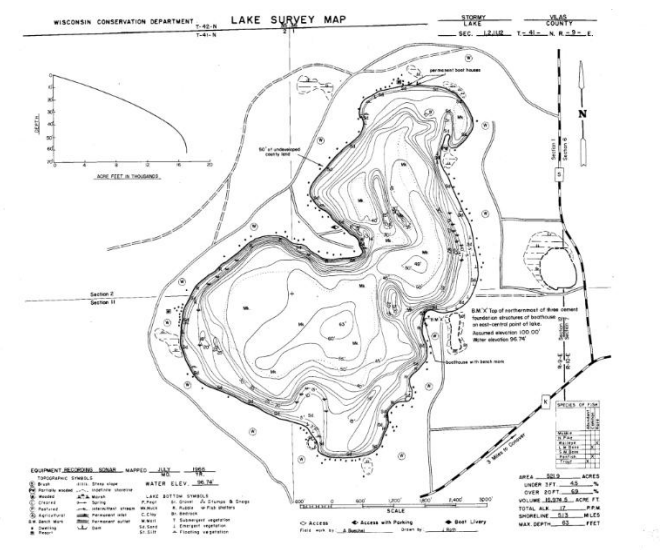


Figure 2. Stormy Lake area topography map with 10 ft contours. Moderately steep slopes exist on the western shoreline. Image courtesy of Vilas County Geospatial Online. The bathymetry map shows steep drop offs around much of littoral area, except for the north bay. Bathymetry map courtesy of WI DNR.

It is a seepage lake and is not considered to have any inlets or outlets. However, Land & Water staff found a small channel connecting Stormy Lake to the nearby 3-acre Pearl Lake. Stormy Lake is fed primarily through precipitation, groundwater exchange, and through runoff into the lake from the adjacent lands. The riparian property owners are all private landowners, with the exception of town road that serves as the boat launch on the western side of the lake.

A topographic map shows that the western shoreline is moderately steep, between 6-15% (Vilas County Geospatial Online). The bathymetry map shows the lake drops off steeply, except for the north bay.

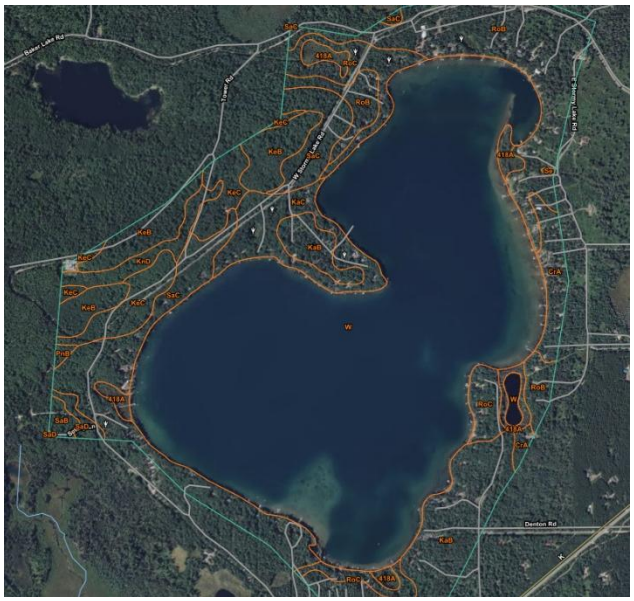


Figure 3. Many different soils occur around Stormy Lake, and about half are greater than a 6% slope. Soils making up more than 5% of the watershed include: Rubicon sand (Ro) with slopes between 0-15%; Sayner-Rubicon complex (Sa) with slopes between 6-15%; Karlin loamy fine sand (Ka) with slopes 0-15%; Siskiwit-Vilas complex (Ke) with slopes 6-15%; Keweenaw-Sayner-Vilas complex (KeC) with slopes 1-15%. Courtesy Web Soil Survey.

Soils with slopes greater than 6% (ie. for every 3 ft change in elevation, there is 50 ft horizontal distance) make up approximately half of the surrounding land; sandy soils up to a 6% slope make up just over 40% of the surrounding land; and level mucks and peats make up the remaining 4% of the surrounding land. The steeper sandy shorelines primarily located on the west and south sides of the lake would be moderately vulnerable to soil erosion (*Web Soil Survey*).

Stormy Lake is represented by the Stormy Lake Association. This report, raw data, and shoreline photos will be shared with this organization as well as DNR.

Results and Discussion

Water Quality

Stormy Lake is a 523 acre and 63 ft deep two-story fishery seepage lake with an estimated lake volume of 16,976 acre-ft. There is no inlet or outlet on the lake with the exception of a channel to 3-acre Pearl Lake. The lake is fed by groundwater, runoff from the adjacent lands, and precipitation. A two-story fishery refers to the lake that has a warm water fishery in the more shallow areas of the lake for fish like bass, pike and panfish; and it has a deep cold-water fishery below the thermocline that supports fish like trout. Stormy Lake's cumulative upstream watershed consists of 951 acres (1.49 sq. miles) including the area of the lake itself. The watershed consists of over 93% natural cover, which allows for less nonpoint phosphorus loading, therefore protecting water quality. Of the land uses that can have higher phosphorus export coefficients, only 6.2% of the watershed is listed as "rural residential" or pasture/grass. The expected likely nonpoint phosphorus load for Stormy Lake is 180 lbs. of phosphorus per year (Wisconsin Water Explorer). For perspective, 1 lb. of phosphorus is capable of producing 500 lbs. of algae (Vallentyne 1974).

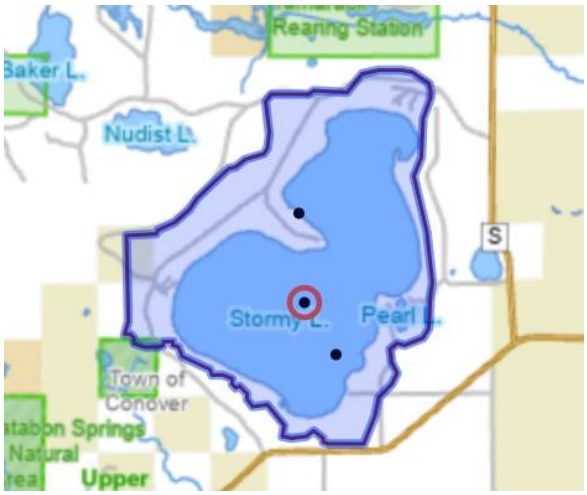


Figure 4. Stormy Lake has a small 1.49 sq. mile watershed (including the lake itself). Image from WI Water Explorer.

Phosphorus is an element needed for plant growth, including aquatic plants. Other nutrients plants need include nitrogen and carbon. Lakes usually have plenty of both carbon and nitrogen, so in roughly 80% of Wisconsin's lakes, phosphorus is the element that limits excessive plant and algae growth. For two-story fishery lakes like Stormy Lake, the total phosphorus criteria for both fish & aquatic life and recreation is 15 ug/L. The total phosphorus sampled on Stormy Lake did not exceed that criteria on any of the 3 sampling events in 2023. The mean total phosphorus reading from the 3 sampling events in 2023 was less than 10.3 ug/L. Two of the samples could not detect phosphorus in the water, but the limit of detection is at 9 ug/L. The remaining sample result was 10.3 ug/L. Historic total phosphorus data between 1989-2023 show that most results were under the WISCALM threshold of 15 ug/L. Total phosphorus does not currently show any statistically significant trends detected for decreasing or increasing total phosphorus on Stormy Lake (Wisconsin Water Explorer). See figure 5.

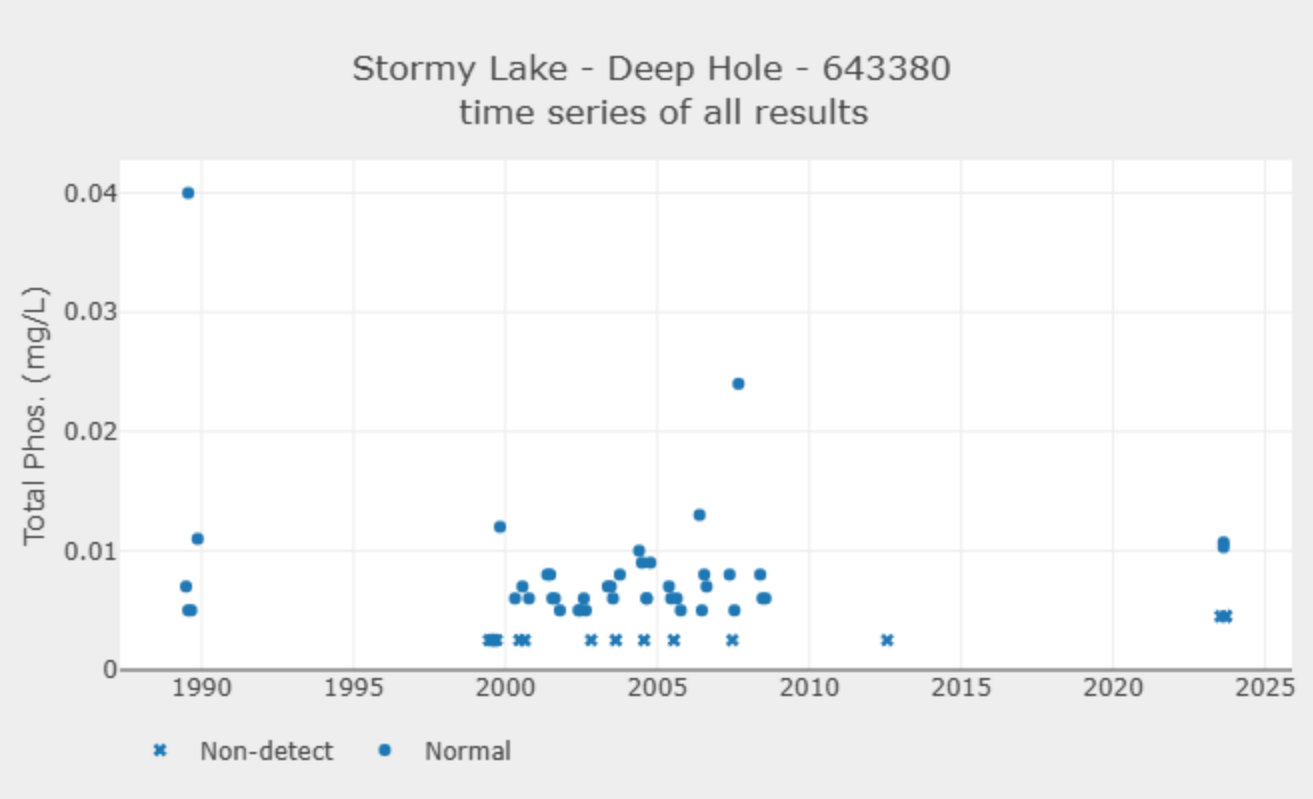


Figure 5. Stormy Lake total phosphorus data from 1989-2023. No statistically significand trend was detected. Notice y-axis lists mg/L, so the two-story fishery lake threshold criteria would be at 0.015 mg/L (vs. 15 ug/L). Plot generated from the Wisconsin Water Explorer.

Chlorophyll *a* refers to the green pigments in planktonic algae in the lake, and is related to lake productivity, or trophic state. Some chlorophyll *a* is essential for aquatic life, but too much can reflect a highly productive or human induced eutrophic state. The chlorophyll *a* criteria for Fish and Aquatic Life for two-story fishery lakes is 8 ug/L (Wisconsin 2024 Consolidated Assessment). This means that typically fish and aquatic life can become affected when chlorophyll *a* levels often exceed 8 ug/L. The chlorophyll *a* results from 3 sampling events on Stormy Lake in 2023 averaged to be 1.43 ug/L, with a minimum reading of 1.28 ug/L and a maximum reading of 1.68 ug/L, well below this threshold. In addition to considering effects on fish & aquatic life, standards for human recreation are also in place. These recreation standards reflect how often chlorophyll *a* exceeds certain concentrations where algae blooms, including blue-green algae blooms, are likely. The recreation standard threshold is 5% of days where chlorophyll *a* is greater than 20 ug/L (Wisconsin 2024 Consolidated Assessment). In 2023 chlorophyll *a* on Stormy Lake never exceeded 20 ug/L (0% of days). Historic data show that chlorophyll *a* has not exceeded 3.5 ug/L. See figures 6 below. While there are no statistically significant chlorophyll *a* trends detected, further monitoring of both total phosphorus and chlorophyll *a* for future trends on Stormy Lake might be useful.

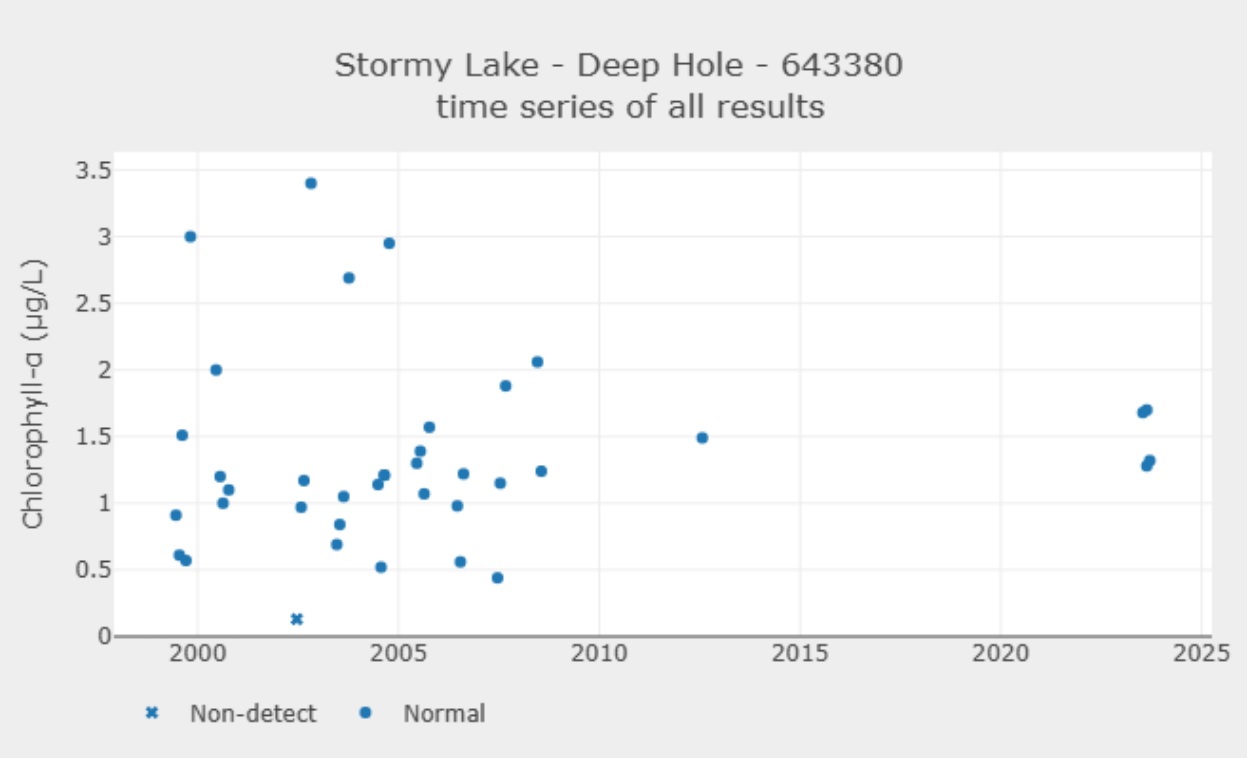


Figure 6. Stormy Lake chlorophyll *a* data from 1999-2023. No statistically significant trend was detected. Sampling shows the 8 ug/L threshold for fish & aquatic life and the 20 ug/L threshold for recreation criteria have not been exceeded. Plot generated from the Wisconsin Water Explorer.

The trophic state of Stormy Lake, based on total phosphorus, chlorophyll *a*, and Secchi depths is generally oligotrophic as sourced from late summer averages. See trophic state graph for historic data below in figure 7.

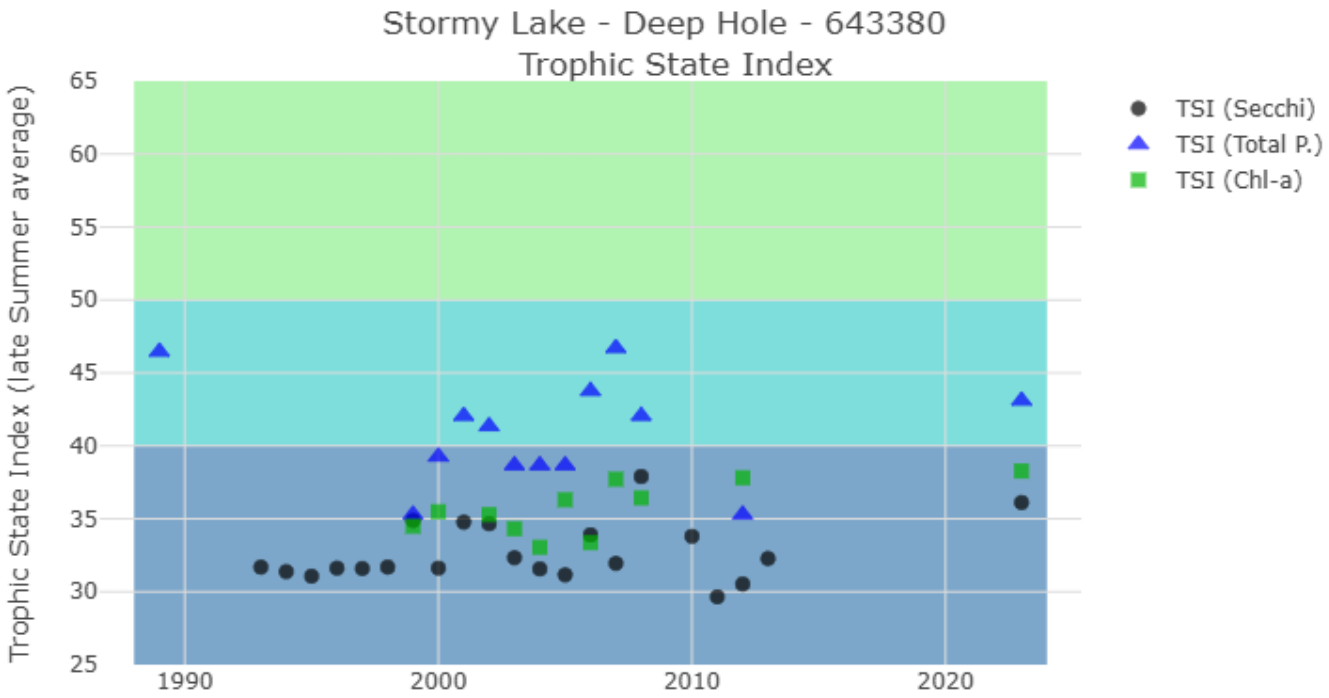


Figure 7. Stormy Lake trophic state from 1989-2023. Data indicate Stomry Lake is oligotrophic. Plot generated from the Wisconsin Water Explorer.

Nitrogen data was collected as nitrate + nitrite and total Kjeldahl nitrogen. Nitrate + nitrite measures inorganic forms of nitrogen. Total Kjeldahl nitrogen (TKN) measures organic nitrogen as well as ammonia. Combining these values gives a total nitrogen measure for the lake. In Stormy Lake, nitrate + nitrite were not detected. TKN measured 0.323 mg/L, so total nitrogen is also 0.323 mg/L.

Most Wisconsin Lakes are phosphorus limited, meaning aside from phosphorus there are enough other nutrients (primarily carbon and nitrogen) to support plant and algae growth. The total nitrogen results can be compared to the total phosphorus results to determine which of phosphorus or nitrogen limits plant and algae growth in the lake. Ratios of N:P of <10:1 indicate a lake is nitrogen limited; between 10:1 – 15:1 indicate a transitional lake; and > 15:1 indicate a phosphorus limited lake (Shaw et.al. 2004). Using the average 2023 water quality data Stormy Lake's N:P ratio is 31:1, so Stormy Lake is phosphorus limited. This means that inputs of phosphorus from soil erosion, garden fertilizers, leaking septics, manure, etc. would be likely increase production of plant and algae growth in Stormy Lake.

Several other parameters were sampled for water quality including color, perception, Secchi depth, pH, conductivity. Water color in Stormy Lake was reported blue & clear on all 3 sampling events. Secchi depths averaged 20.17 ft, which is indicative of excellent water quality. The pH recorded as 7.7 SU indicated basic (vs. acidic) lake water. Alkalinity is a measurement of carbonate and bicarbonate ions in the water. These ions buffer against low pH inputs, such as acid rain resulting from air pollution or even natural fluctuations resulting from photosynthesis cycles with night and day. Stormy Lake's water samples could not detect alkalinity, but the testing limit of detection is at 20 mg/L. Stormy Lake would have little

capacity to buffer acid inputs such as acid rain. Previously sampled calcium concentrations are quite low (3.71 mg/L) as is the 2023 sampled conductivity (39.7 uS/cm), reflecting that Stormy Lake would be quite unlikely to support a reproducing zebra mussel population (Cohen 2018). To add some further perspective, WI DNR recommends zebra mussel monitoring at concentrations of 10 mg/L calcium and above, correlated with a conductivity of 99 uS/cm threshold ("Directed Lake Protocol" 2022).

Two-story fishery lakes have stratified water columns. Water down to about 18 ft is of a similar temperature and dissolved oxygen concentration. Deeper than about 18 ft, the temperature starts to drop. This area is called a thermocline. At the thermocline, there is an increase in dissolved oxygen on Stormy Lake, likely created by certain algae that thrive at the thermocline level and produce oxygen. Cold water fish like trout need both more than 6.0 mg/L dissolved oxygen and temperatures cooler than 73 degrees. Stormy Lake provided this habitat from the surface down to at least 42 ft during the three sampling events. See Appendix 2 for water quality raw data and temperature & dissolved oxygen profiles.

Aquatic Plant Point-Intercept Survey

The Point-Intercept survey was done from July 10-18, 2023. Of the 463 point-intercept (PI) locations 397 were visited. Those that were not visited were skipped primarily because they were too deep for aquatic plant growth as determined during sampling. There was one point skipped because it was located under a dock; and another point skipped because it was terrestrial.

Table 1. Stormy Lake 2023 Aquatic Plant Point-Intercept Statistics. Values sourced from UW-Extension Lakes Aquatic Plant Survey Data Workbook formulas.

Stormy Lake 2023 Point Intercept Summary	
Total number of sites visited	397
Total number of sites with vegetation	41
Total number of sites shallower than maximum depth of plants	219
Frequency of occurrence at sites shallower than maximum depth of plants	18.72
Simpson Diversity Index	0.83
Maximum depth of plants (ft)**	37.00
Number of sites sampled using rake on Rope (R)	172
Number of sites sampled using rake on Pole (P)	101
Average number of all species per site (shallower than max depth)	0.26
Average number of all species per site (veg. sites only)	1.37
Average number of native species per site (shallower than max depth)	0.26
Average number of native species per site (veg. sites only)	1.37
Species Richness	12
Species Richness (including visuals)	12
Floristic Quality Index	25.69
Mean C	7.42

The bulk of the lake bottom was not vegetated, which is typical of oligotrophic lakes. In Stormy Lake, at any given point there is less than a 19% chance of finding aquatic plants growing. Globular stonewort (*Chara globularis*) was the aquatic plant most often captured on a rake; followed closely by variable pondweed (*Potamogeton gramineus*). See Table 2 for a list, and Appendix 3 for photos of highlighted plants. In addition to the species listed in table 1, there were 3 additional species encountered near a survey point but not captured on a rake: northern manna grass (*Glyceria borealis*); creeping spearwort (*Ranunculus flammula*); and Braun's stonewort (*Chara braunii*).

Species Richness is a count of species found on a lake. This figure includes only those species collected with the rake and does not include visual sightings. Stormy Lake's species richness is 12, which is similar to the average species richness for the Northern Lakes and Forests Ecoregion of 13 and the average for the state of Wisconsin which is also 13 (Nichols 1999).

Table 2. Stormy Lake 2023 Aquatic Plant Point-Intercept species collected via rake, coefficients of conservatism, and littoral frequency of occurrence.

Species – Collected via Rake	Common Name	Coefficient of Conservatism	Littoral Frequency of Occurrence
Chara globularis	Globular stonewort	7	6.85%
Potamogeton gramineus	Variable pondweed	7	5.48%
Nitella flexilis	Smooth nitella	7	4.57%
Eleocharis acicularis	Needle spikerush	5	2.74%
Myriophyllum tenellum	Dwarf watermilfoil	10	2.28%
Juncus pelocarpus	Brown fruited rush	8	0.91%
Elatine minima	Waterwort	9	0.46%
Eleocharis palustris	Creeping spikerush	6	0.46%
Eriocaulon aquaticum	Pipewort	9	0.46%
Najas flexilis	Slender naiad	6	0.46%
Potamogeton richardsonii	Clasping-leaf pondweed	5	0.46%
Potamogeton robbinsii	Fern pondweed	8	0.46%

Native aquatic plants are assigned a coefficient of conservatism from 0-10 that describes how likely they are to be part of a stable and undisturbed ecosystem. Higher values reflect more stable and undisturbed systems. The average of these coefficients is reported in the average value of conservatism. Stormy Lake's average value of conservatism of 7.42 is a higher than the Northern Lakes and Forest Lakes Ecoregion average of 6.7 and higher to the state of Wisconsin average of 6.0 (Nichols 1999). This shows that Stormy Lake may be considered a more stable & undisturbed system for the region and for the state.

The Floristic Quality Index weighs both the species richness and the average value of conservatism. The Floristic Quality for Stormy Lake is 25.69. This value is higher than the Northern Lakes and Forest Lakes Ecoregion of 24.3 and the state of Wisconsin of 22.2 (Nichols 1999).

The Simpson Diversity Index describes how diverse and evenly disturbed species are. This figure can range from 0 meaning no diversity to 1 which would mean infinite diversity. Simpson's Diversity Index for Stormy Lake is 0.83. The value of 0.83 indicates a fairly average number of species and average distribution of those species in Stormy Lake compared with other lakes in the Northern Lakes and Forest Lakes Ecoregion.

Most points on Stormy Lake did not have plant growth: of the 397 sites visited, only 56 points had plant growth. When there was plant growth, most sites had only 1 species present. Of all the sampling points on Stormy Lake, the most species rich area occurred in the northern bay and had 4 plant species at a single sampling point. See Appendix 3 for a map of species richness.

Total Rake Fullness is a measure of how dense plant material grows at a particular sampling point. A double headed rake is used to sample points, and the amount of plant material on the rake is recorded from 1 (a few plants) to 3 (rake tines are completely covered with plants). Stormy Lake averaged 1.02 for

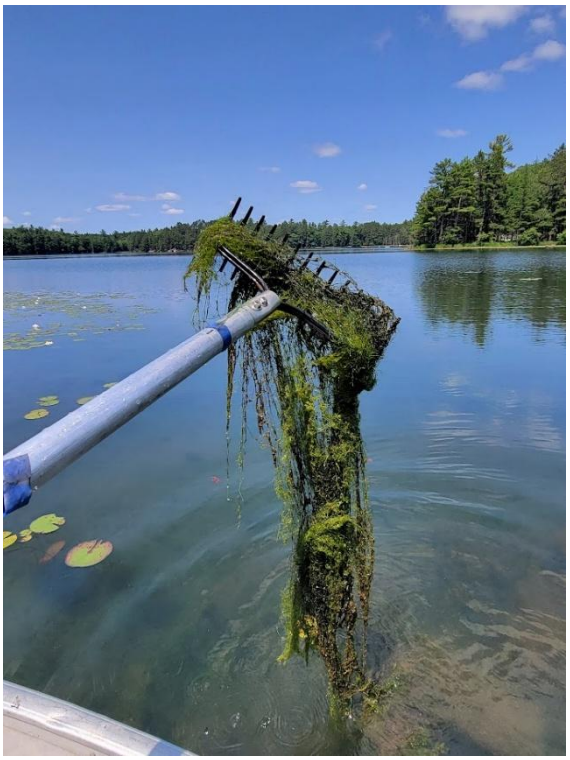


Figure 8. Double headed rake used for aquatic plant sampling. Photo by Cathy Higley on Moccasin Lake.

total rake fullness where plants were found – there was only 1 site in the northern bay that had a total rake fullness of 2, and the rest of the sites where there were plants had a rake fullness of 1.

For Stormy Lake, a sample specimen of most of the plants were collected, photographed, and pressed. Pressed specimens were verified, and some are housed at the Freckmann Herbarium at UW-Steven Point and others are housed at Vilas County Land & Water Conservation.

An aquatic plant point intercept survey was done previously in 2012 and some of the resulting statistics are similar to the 2023 survey: the 2012 survey found a native species richness of 13; the number of species per site was 0.36; and floristic quality was 27.18. Slightly different in 2023 was that the max depth of plant growth with 3 ft deeper (40 ft); and the percent of points that were shallower than the max depth of plants was 59% (vs. 47% from 2023). The other 2012 figures are just slightly less than the 2023 figures. A few more plants were found in 2012 that were not found in 2023: common rush (*Juncus effusus*) golden hedge hyssop (*Gratiola aurea)*, narrow-leaf bur-reed (*Sparganium anguisifolium*), ribbon-leaf pondweed (*Potamogeton epihydrus)*, softstem bulrush (*Schoenoplectus tabernaemontani)*, water lobelia (*Lobelia dortmanna)*, and water celery (*Vallisneria americana).* Data from the 2012 survey was sourced from the WI DNR Aquatic Plant Explorer.

AIS Early Detection Survey

Prior to the survey, Storm Lake had a record of having invasive Chinese mystery snails first verified in 2012; rusty crayfish first verified in 2001; and spiny waterflea first verified in 2007. On August 21, 2023, Vilas County Land & Water staff completed the AIS Early Detection Survey – see Methods in Appendix 1. Since the water clarity was excellent, the public boat landing as well as 5 target sites were selected for timed snorkeling surveys. A boat meander survey around the perimeter of the lake was conducted. Multiple species were searched for - see Methods section in Appendix 1 for species list.

The only aquatic invasive species found during the survey were Chinese mystery snails in low densities along the south shore near an adjacent wetland.

Since historic calcium concentrations on Stormy Lake were less than 10 mg/L, it was not considered suitable for zebra mussels and so no sample for zebra or quagga mussel veligers was taken.

Figure 9. Spiny waterfleas, an invasive plankton, were verified in Stormy Lake in 2007.

Spiny waterfleas (*Bythotrephes longimanus*) were not surveyed in 2023 because they are already verified in the lake. However, Trout Lake Station staff had shared their previous data through 2022 on spiny waterflea density and trends – see figure 10. Spiny waterfleas are an invasive plankton. The main concerns with spiny waterfleas are they have been shown to decrease water clarity in some systems by consuming too many plankton that are algae grazers (Walsh et. al. 2016); and their presence can lead to walleye stunting in their first year of life (Hansen et. al. 2020) as the young fish are not able to consume the spines. While the density of spiny waterflea has been variable since it was quantified in 2008, linear regression from 2008-2022 data does show a decreasing trend (Warden 2022).

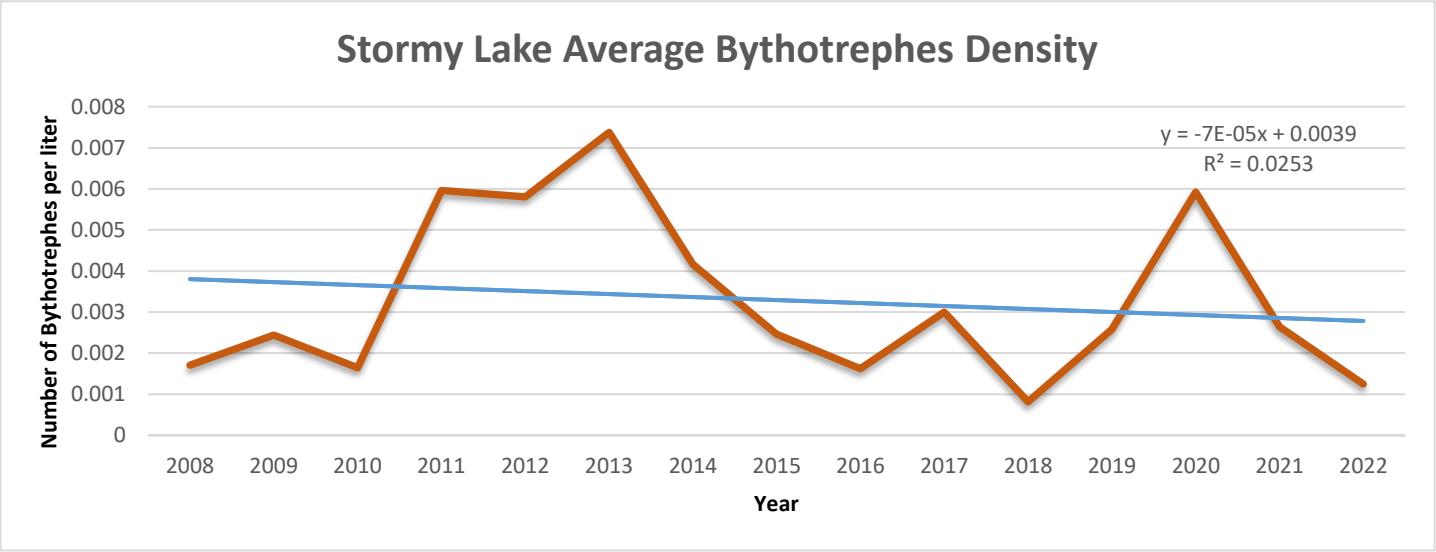


Figure 10. Density of spiny waterfleas as determined by Trout Lake Station staff (Warden 2022).

Coarse Woody Habitat

Coarse woody habitat was mapped on June 12, 2023. The lake water near shore was clear and easy to detect submerged logs. 31 logs were counted between the ordinary high-water mark and the 2 ft depth contour along the 4.82 miles of shoreline, giving the density of 6.43 logs/mile of shoreline – see Appendix 4.

Coarse woody habitat not only offers fish habitat but also offers habitat to the invertebrates that fish eat. Many of these are aquatic insects with terrestrial adult stages (i.e. mayflies). These insects may benefit from the 15 logs (48%) that crossed the ordinary high-water mark, providing a habitat "bridge" between the water and land. Other animals like turtles will also use these. There were 2 logs (6%) submerged with the full tree crown, providing more complex structure to the coarse woody habitat, and likely more abundant and diverse habitat for fish and the insects or macroinvertebrates fish eat.

Figure 11. Wood in the water like these down trees on Stormy Lake provide structure for fish, basking spots for turtles, as habitat for insects and other invertebrates that fish eat.

The density of 6.43 logs/miles can anecdotally be considered very low. For perspective, a study by Christensen et. al. found 345 logs/mile on undeveloped lakes locally (Christensen et. al. 1996). To confirm their findings, one undeveloped lake sampled by Vilas County Land & Water had 341 logs/mile. Wood in the lake offers natural complex fish habitat and a source of ecological carbon. Riparian landowners that are interested in increasing wood in the lake can work with either Vilas County Land & Water Conservation or the DNR Fisheries Biologist for recommendations.

Shoreline Assessment

The shoreline of Stormy Lake consists of 140 privately owned parcels and one town-owned right-of-way serving as the boat launch. All parcels could be surveyed from the water, and navigation did not impact the survey. Within the 35 ft. buffer zone, 69% of the area was covered by a canopy (trees taller than 16 ft.). Around the lake, 44 parcels had canopy percentages within the 35 ft riparian area of 50% or less; and 12 had 25% or less. Of these, most had lower canopy percentages from past tree removals to create lawns, beaches, or for a view of the lake. Some lower percentages were due to wetlands which naturally have little canopy. Canopy provides habitat, diffuses the impact of rain, provides shade, and offers larger and more complex root systems to stabilize banks. See Figure 34 for a map of percent canopy cover by parcel.

Figure 12. Some parcels had lower canopy percentages in the 35 ft riparian area because of wetlands; but most parcels with low canopy percentages occurred from clearing the riparian area for lawns, beaches, or views of the lake.

The width of natural vegetation near the shore, often referred to as shoreline buffers or riparian buffers, needed to meet *biological* or *ecological* targets to provide wildlife habitat and maintain water quality are variable with site conditions. A literature review by Alan Johnson and Diane Ryba found that shoreline buffers often need to be much larger than the required 35 ft through Vilas County Zoning (Johnson & Ryba 1992). The WI Center for Land Use Education located in Stevens Point created a graphic based on the Johnson & Ryba literature review to show how wide shoreline buffers need to be for certain ecological services (Markham 2023).

Wisconsin now allows 100 ft. frontage lake parcels, and each parcel (or each 100 ft.) is allowed a 35 ft. viewing corridor through the 35 ft riparian buffer zone with a max of 100 ft and a minimum of 10 ft (Vilas County Shoreland Zoning Ordinance 2017). Because of this, 65% native vegetation remaining in the Riparian Buffer Zone is the lake-wide standard *compliance* target. This rate does not reflect a *biological* or *ecological* best practice. Stormy Lake's 35 ft riparian area was 56% covered in shrubs or herbaceous plants. The "natural cover" on Stormy Lake would include the shrubs and herbaceous cover as well as the duff cover. Based on survey notes, this would measure greater than 58% of the riparian area. The >58% natural cover seen on Stormy Lake still likely falls short of the 65% target for lakewide shoreline buffer *compliance*; and thus is likely performing at less than optimal levels for meeting the *biological* and *ecological* targets for wildlife habitat, nutrient control, stormwater control, or sediment control.

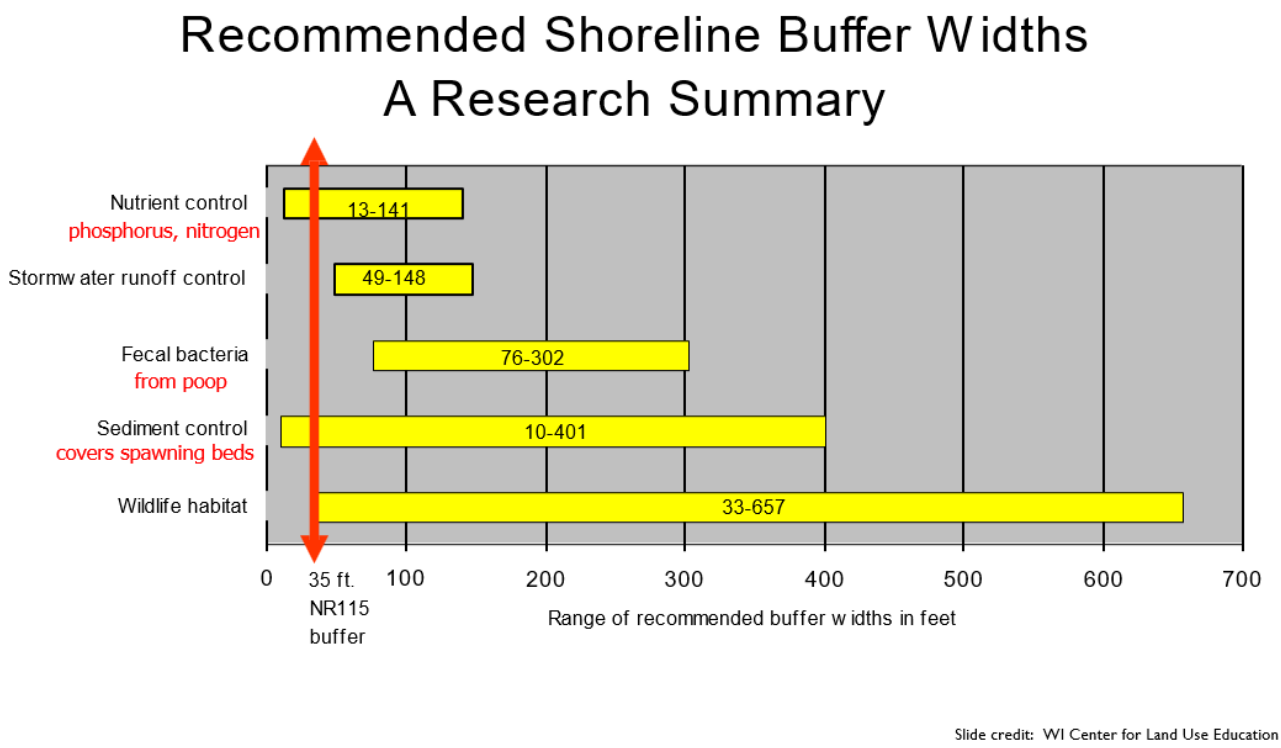


Figure 13. Shoreline buffer (native vegetation adjacent to shore) widths needed to provide ecosystem services of filtering water and providing wildlife habitat. Graphic courtesy of Center for Land Use Education.

Impervious surfaces such as driveways, rocks, roofs, decks, or other surfaces that do not allow rainwater to percolate often exacerbate runoff and erosion problems. If they occur near the lake, they often lead to additional soil erosion into the lake (and thus phosphorus inputs). Generally large percentages of impervious surfaces near the lake are shown to degrade water quality. Stormy Lake has 7% impervious surfaces within the 35 ft riparian area. On Stormy Lake, rock terracing or rock walls in the 35 ft buffer zone were fairly common, and their width would contribute to impervious surface totals. It is also important to note that structures such as rock walls or terracing are typically no longer permitted by Vilas County Zoning within the 35 ft buffer zone; and impervious surfaces outside the 35 ft buffer zone are also regulated.

Manicured lawns typically do not have deep or substantial root systems and are not able to hold soil in place well during large runoff events. This can lead to sediment deposits and therefore nutrient inputs in the lake. Stormy Lake has 8% lawn cover withing the 35 ft riparian buffer zone. Lawns withing the 35 ft buffer zone are no longer permitted with Vilas County Zoning; however existing lawns are typically “grandfathered in”.

Duff (defined as leaf or pine needle litter on the ground) is likely able to offer some function for filtering runoff and providing wildlife habitat, but is categorized with soil in this survey. Conversely, exposed soil generally does present a concern for nutrient inputs into the lake. There were high amounts of both duff and exposed soil in the riparian area of Stormy Lake. Exposed soil was due to multiple factors: erosion along the hillside down to the lake; erosion from foot traffic; and presence of artificial beaches. Soil naturally contains phosphorus, and eroding riparian soil contributes to increased phosphorus concentrations in lakes. Stormy Lake had 28% of the riparian buffer zone covered in either duff or soil.

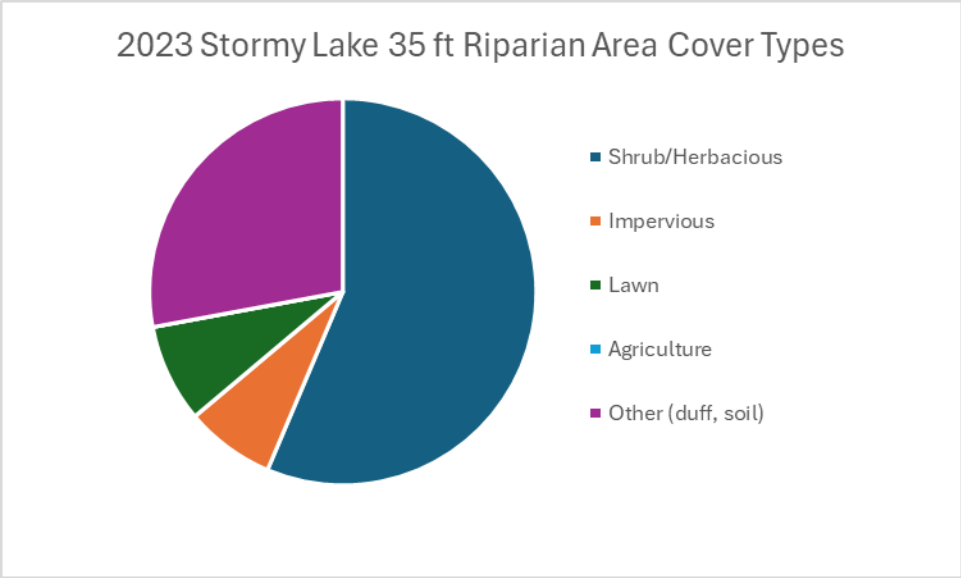
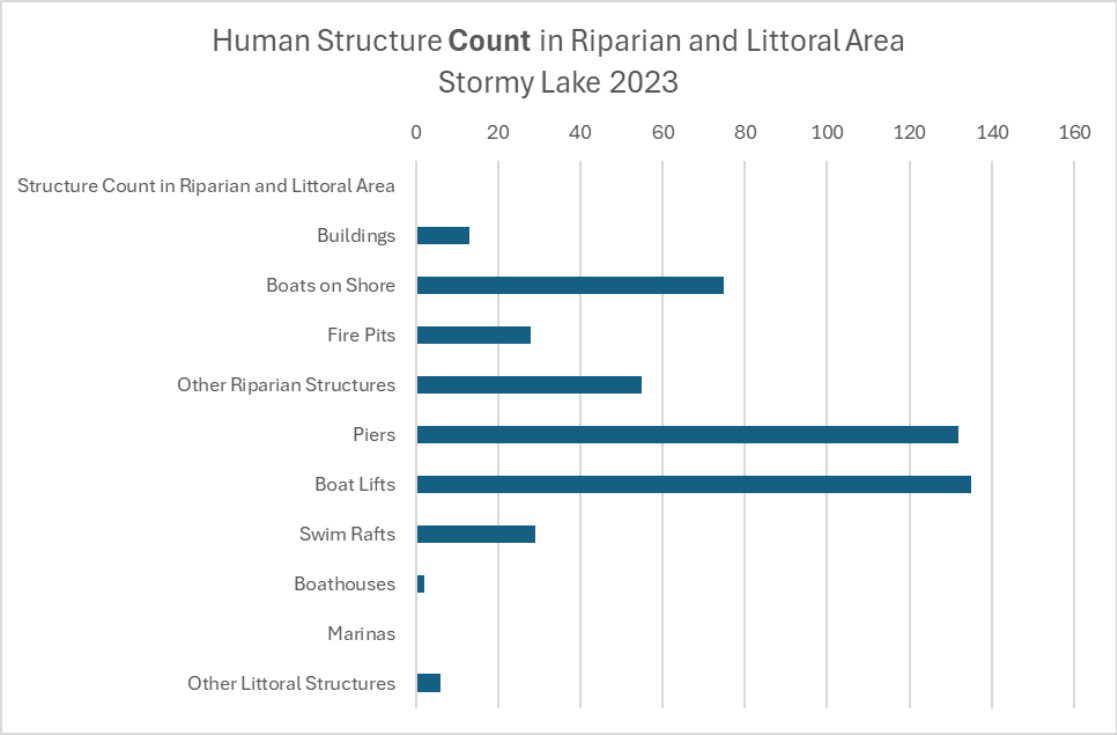


Figure 14. Ground cover type in Riparian Buffer Area (35 ft. inland from shore) on Stormy Lake, 2025.

The Stormy Lake Association may want to consider encouraging the restoration of shorelines where landowners are willing on parcels that have areas converted to lawn, beach, or have been cleared for lake views; where there is exposed soil at risk of eroding into the lake; or parcels where there is a high percentage of impervious surfaces. See Appendix 5 for several maps of Riparian Buffer Zone Cover Type maps by parcel, including a map of where lawn or soil is sloping to the lake – this may be a good starting point for selecting strategic shoreline buffer restoration areas.

Several human structures or modifications were noted in the Riparian and Littoral Zones. See figure 16 for Human Structures in Riparian Buffer and Littoral Zones Charts. Because of their ecological importance, these areas are typically protected by County Zoning and DNR regulations, and permits are often required to modify or place new structures in these areas. In Stormy Lake boats lifts were the most common structure followed by piers. Ten docks or less per kilometer (16 docks/mile) of shoreline, as a reflection of shoreline development, has been shown to be a threshold of maintaining high fish diversity in Minnesota (Jacobsen et. al). Stormy Lake's pier density was 27.41 docks/mile of shoreline, exceeding this figure.

Figure 15. Dock density on Stormy Lake was 27.41 docks/mile. Development, as reflected by counting docks, has been shown to have negative effects on fish diversity if greater than 16 docks/mile (Jacobsen et.al).



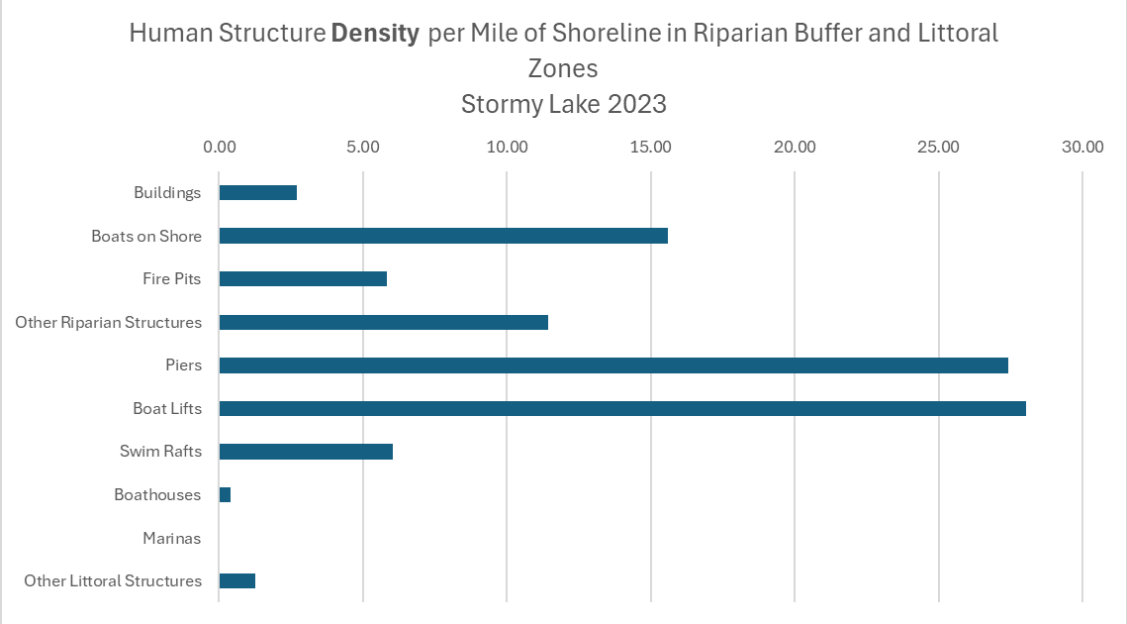


Figure 16. Number (top) and density per mile of shoreline (bottom) of human structures documented in the Riparian Buffer and Littoral Zones on Stormy Lake 2023.

Of the 140 parcel surveyed, 128 had runoff and/or erosion concerns. Two parcels had point sources (likely rain water discharges); 98 parcels had straight stairs or trail to the lake; 75 parcels had either lawn or bare soil sloping to the lake; and 103 had areas of bare soil. Often bare soils was due to beach areas or eroding slopes. See figure 17.

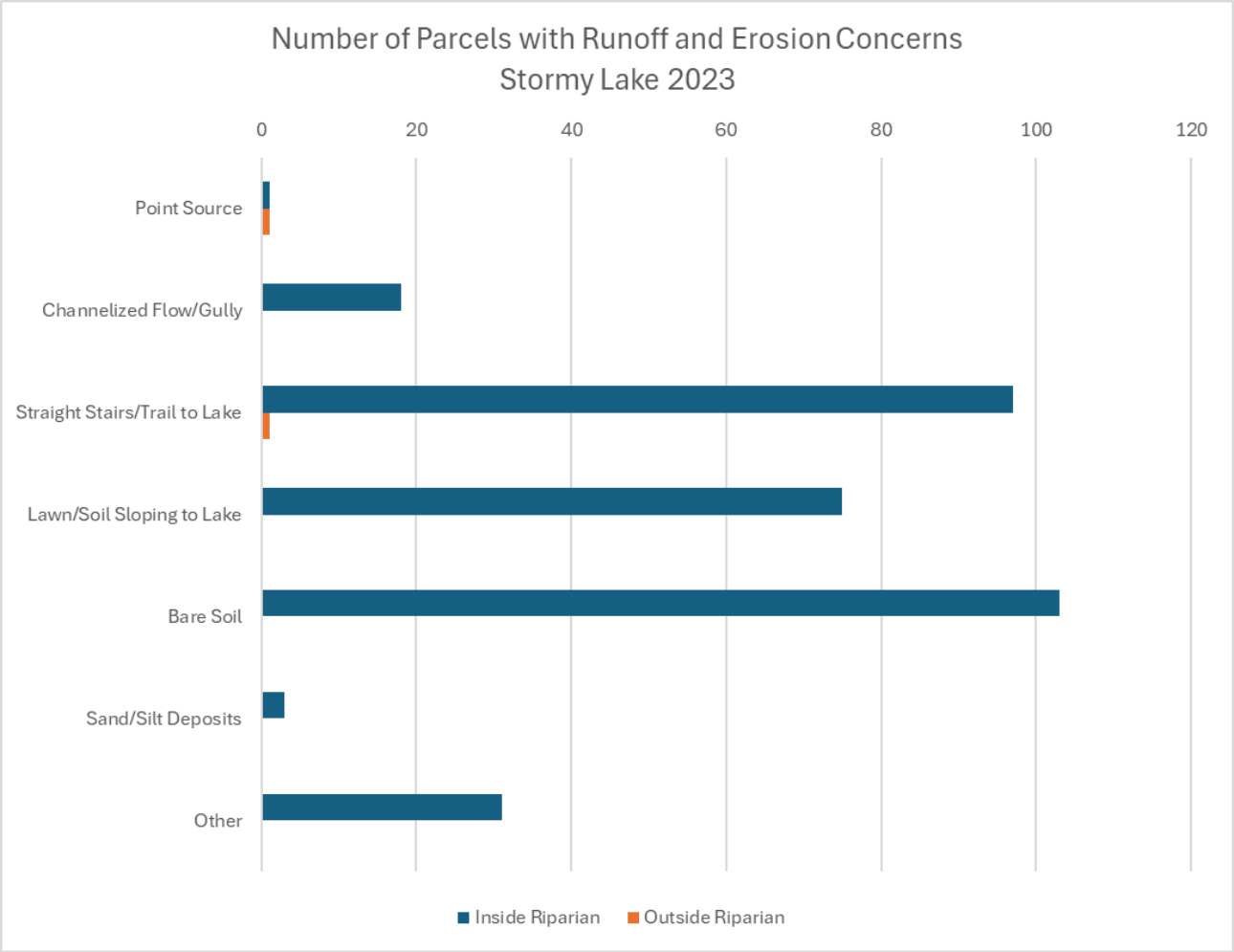


Figure 17. Number of parcels with runoff and erosion concerns in Riparian Zone and Outside Riparian Zone on Stormy Lake 2023. Of the 140 parcels, 128 had erosion or runoff concerns (91%).

While these riprap or seawalls might have landscaping appeal, they do detract from providing natural wildlife habitat. Riprap and seawalls create difficult transitions for certain wildlife – imagine being a turtle trying to access land from the water. They can also deflect wave energy and scour the nearby lake bottom or adjacent shorelines. Note that installing, repairing, or replacing these structures often requires DNR permits. There is a riprap permit exemption if particular specifications are met with the riprap design. However, many parcels appeared to use rocks in their riprap that would be larger than the current standard (6-48 inch diameter rock); and were placed at slopes much steeper than the current standard (1 ft horizontal to 1.25 vertical). When repairing or replacing riprap, make sure to review allowable standards for sizing and slope of riprap. These standards are in place allow for the best wildlife habitat while minimizing ice shove problems. Overall, the bank zone of Stormy Lake is modified and/or eroding more than many other lakes surveyed by Vilas County Land & Water. Shoreland lengths of these human modifications to the bank zone appear in figure 18.

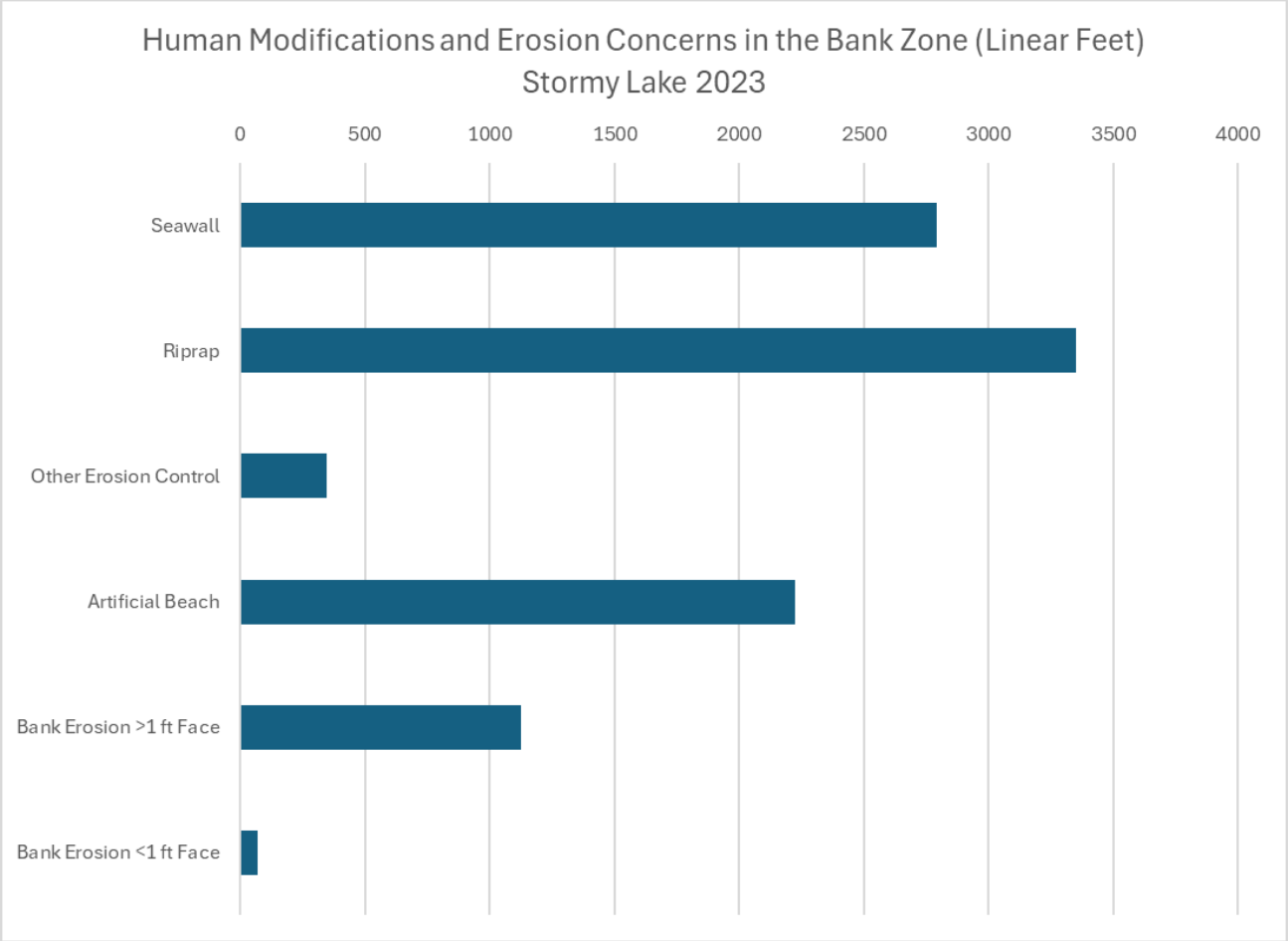


Figure 18. Linear feet of human modifications to the bank zone on Stormy Lake 2023.

Besides typical bank erosion control methods like rock riprap or seawalls, Stormy Lake had 345 ft of "other erosion control structures". Most common was timbers to hold beach or lawn in place at the bank. See figure 19. Most often, addressing shoreline erosion issues on the bank requires DNR permits, and may necessitate engineering. Before attempting bank stabilization do-it-yourself fixes, check with Vilas County Land & Water Conservation on what is likely to work for your site, access low-cost or free engineering input if needed, and learn what permits would be required. On low wave energy sites, simply re-vegetating the bank area is enough to stabilize the bank and slow erosion.

Figure 19. Other erosion control structures encountered in the bank zone on Stormy Lake included timbers or logs to hold back beaches or lawn.

Emergent and/or floating plants were observed in the littoral zone adjacent to 49 of the 140 parcels. Evidence of aquatic plant removal was seen adjacent to 7 parcels on Stormy Lake.

Photos of the riparian area and data from the shoreline assessment are housed with the Vilas County Land & Water Conservation Department and will be shared with the Department of Natural Resources.

Observations

The soil around Stormy Lake is quite sandy, and staff found at least 23 parcels with significant hillside erosion above the bank. See figure 20 for some example photos.

Figure 20. At least 23 properties with slopes down to the lake showed significant erosion above the bank.

At least 48 parcels had artificial beaches (either by adding sand or removing riparian vegetation). Stormy Lake is surrounded by sandy soil with little structure to it – sometimes referred to as the Conover sugar-sand. This soil is relatively easy to remove vegetation above the ordinary high water mark to create a beach area. Beach creation and maintenance is not a best practice because beaches are erodible areas (and therefore add nutrients into the lake) and do not provide much wildlife habitat. Removing plants in the 35 ft shoreline buffer zone outside of the viewing and access corridor is also not a best practice because shoreline buffers control nutrient inputs into the lake; prevent sediment deposits; and provide habitat. In addition, both these activities are regulated by Vilas County Zoning.

Figure 21. At least 48 properties had artificial beaches. Some beaches were due to adding sand, but more were due to removing riparian vegetation to expose the sandy soil.

While surveying on August 23, 2023, staff found an area of "milky white water". After consulting with a few lake biologists, it is still uncertain why the water is this color. Most likely options could be decaying blue-green algae; or wastewater discharge; or bacterial activity. See figure 22.

Figure 22. Milky white water adjacent to shore. It is unclear what caused the water to be this color.

Acknowledgements

Surveying and analyzing the data on Stormy Lake was possible because of:

- WI DNR Surface Water Grant Program
- The Vilas County Land & Water Conservation Committee's support of lake research and stewardship in Vilas County
- The Stormy Lake Association and riparian owners' willingness to participate in the study
- Tom Navratil and Don Olson, who generously volunteered their time to help with surveying and to give staff some lessons on lake history.

Thank you to all who helped to support this project!

Recommendations

Generally Stormy Lake is in a condition where protection (vs. restoration) makes most sense – its water quality is in good shape, but the shoreline habitat should be improved and protected to offer better wildlife habitat and to maintain water quality. Due to its location and hydrology in the watershed, best practices from riparian landowners can more directly impact Stormy Lake. The Stormy Lake Association should focus on capacity, education, monitoring, and protection actions:

- **Implement the following action items in small pieces:**
  - The Stormy Association has a limited number of members, and fewer who live on the lake full-time. Any efforts to implement the activities outlined below should be planned carefully to avoid burning out. Some consideration would be:
    - ☐ Create a prioritization list of these actions and tackle only a few larger activities listed below at a time.
    - ☐ Plan to rotate initiatives to implement for specific time periods to avoid burning out. (i.e. water quality monitoring during 2026-2030, then take a break for a few years.)
    - ☐ Ask volunteers to accept "term limits" so they have an end point in mind (i.e. 5 summers & winters of water quality monitoring; or 1 calendar year of shoreline education to property owners).
    - ☐ Make sure to have a contingency plan in place so data is not lost with volunteer transitions (i.e. shared Google drive; central location of paper files; etc.).
    - ☐ If volunteerism is lacking, consider for-hire options with lake professionals where feasible.

- **Monitor Stormy Lake:**
  - ☐ Continue to monitor water quality at the deep hole through the Citizen Lake Monitoring Network. Suggested parameters are water clarity (Secchi), dissolved oxygen, total phosphorus, and chlorophyll *a*. Recommend collecting data from May-Oct 5 years at a time or more. Watch the Wisconsin Water Explorer (Wex) for trends in water quality data.
  - ☐ Start an aquatic invasive species monitoring program through the Citizen Lake Monitoring Network. No new AIS were found on Stormy Lake, but an annual effort to check for AIS may be important to catch invasive species early. Contact either Chastin Harlow of WI DNR at 715-499-5535 or castin.harlow@wisconsin.gov or Cathy Higley of Vilas County Land & Water at 715-479-3738 or cahigl@vilascountywi.gov for materials, equipment, and training.

- **Create a lake stewardship education campaign:**
  - ☐ Promote education of Stormy Lake Association board members by joining regional and state lake associations - Vilas County Lakes & Rivers Association (vclra.org) and/or Wisconsin Lakes (wisconsinlakes.org). This will give more open communication on regional and state initiatives as well as training opportunities (i.e. WI Lakes Convention).

- ☐ Provide educational materials to riparian owners on the crucial role shoreline buffers (natural vegetation) play in maintaining Stormy Lake's water quality and fish & wildlife habitat. Encourage landowners to keep or restore shoreline buffers of 35 ft or greater from shore. Try mailings, Facebook posts, or other means to connect with riparian owners. Landowners doing a great job on their shoreline can be nominated for Vilas County Lakes & Rivers Association's Blue Heron Award or the Vilas County Land & Water Conservation Stewardship Award. Contact Tom Ewing of VCLRA for further information 630-251-0247 or president@vclra.org; or Quita Sheehan from Vilas County Land & Water Conservation 715-479-3747 or mashee@vilascountywi.gov for award info, assistance, available free materials, or questions.
- ☐ Offer information on the aquatic plants of Stormy Lake to riparian owners and how they create habitat for fish and other aquatic life.
- ☐ Offer information on where the coarse woody habitat is in the lake. Encourage riparian owners to leave wood where it falls in the lake if possible to promote fish habitat and wave buffering (therefore aiding shoreline stabilization).
- ☐ Communicate lake stewardship expectations with guests at owners' homes and to short-term renters. Activities like how to protect the loon nest, where and when to enjoy wake sports, Conover's ordinance on boating, and best practices for preventing the spread of spiny waterflea are topics that might covered. If needed, consider creating a welcome handout/magnet or other "freebee" with this message for visitors. Contact Cathy Higley with Land & Water Conservation at 715-479-3738 or cahigl@vilascountywi.gov for assistance or funding guidance.
- ☐ Offer more information on shoreline restoration for landowners. Many landowners would benefit from knowing strategies (including DIY options) to stabilize banks or hillsides that are eroding into the lake; what to consider if owners have beaches; when permits are needed; and where to go for technical and/or financial help. Contact Cathy Higley with Land & Water Conservation at 715-479-3738 or cahigl@vilascountywi.gov for assistance.
- ☐ Continue a Clean Boats Clean Waters campaign at the Stormy Lake boat landing, especially during busy weekends and holidays like Memorial Day, the Fourth of July, and Labor Day. Recruit volunteers and/or hire inspectors as needed. This will help reduce the spread of spiny waterflea, and lessen the risk of exposing the lake to yet more invasive species.

- **Protect the condition of Stormy Lake's water quality and shoreline habitat:**
  - ☐ There are four parcels on Stormy Lake with over 500 ft of shoreline that may be considered for permanent protection through conservation easements from the Northwoods Land Trust. These easements are intended to keep shorelines in the same condition they are in now even if the land is sold to a new owner. Contact Ted Anchor, Executive Director of the Northwoods Land Trust (northwoodslandtrust.org) at 715-479-2490 or ted@northwoodslandtrust.org for more information.
  - ☐ Help guide landowners in addressing runoff and erosion concerns from areas of bare soil (including hill erosion) in the riparian zone and bank erosion with rain gardens, water diversions, French drains, soil lifts, or other approved best practices as appropriate. See

Bare Soil map. Eroding soil adds extra phosphorus and sediments into the water and degrades water quality. Staff from Vilas County Land & Water Conservation are able to do site visits, recommend solutions, and in certain instances offer grant fund reimbursement for installing best practices. Contact Cathy Higley from Vilas County Land & Water Conservation 715-479-3738 or cahigl@vilascountywi.gov or Quita Sheehan at 715-479-3747 or mashee@vilascountywi.gov for assistance, questions, or possible funding.

- ☐ Consider adding more coarse woody habitat in the lake where landowners are interested. This can be done by tree drops or with Fish Sticks. Either activity may need Zoning and/or DNR permits. Contact Cathy Higley from Vilas County Land & Water Conservation 715-479-3738 or cahigl@vilascountywi.gov for assistance.
- ☐ Work with landowners interested in restoring some their shoreline that is currently lawn or beach by letting the natural vegetation grow or by adding native plantings. Adding natural vegetation helps conserve water quality and wildlife habitat. Contact Cathy Higley from Vilas County Land & Water Conservation 715-479-3738 or cahigl@vilascountywi.gov or Quita Sheehan at 715-479-3747 or mashee@vilascountywi.gov for assistance, questions, or possible funding.

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Appendices

Appendix 1: Methods
Appendix 2: Water Quality Raw Data and Temperature & Dissolved Oxygen Profiles
Appendix 3: Aquatic Plant Point-Intercept Sampling Point Map, Plant Photos, and Species Richness Map, and Total Rake Fullness Map
Appendix 4: Coarse Woody Habitat Map
Appendix 5: Shoreland Data Maps

Appendix 1: Methods

All surveys mentioned below were completed following the WI DNR's Directed Lakes protocols April 2022 revision ("Directed Lakes Protocol" 2022). Any deviations from the protocols are mentioned within each section here. Decontamination of the boat and equipment via the DNR's bleach method or hot pressure washing method occurred before a new body of water was entered (*Boat, Gear, and Equipment Decontamination and Disinfection Manual Code 9183.1*).

Water Quality Sampling

Water quality sampling was done on three occasions. Temperature and dissolved oxygen profiles were measured at the deep hole using a calibrated YSI ProODO meter.

Lake water for chemistry analysis was collected with a 2 meter Integrating Sampler from the deep hole of Stormy Lake. Samples were analyzed by the WI State Lab of Hygiene in Madison, WI. "Blank" and "duplicate" samples were also included for quality assurance. Sampling parameters varied by date:

2023

- July: Temperature and dissolved oxygen profile; Secchi; total phosphorus; chlorophyll a; alkalinity, pH, conductivity; nitrate + nitrite; & total Kjeldahl nitrogen
- August: Temperature and dissolved oxygen profile; Secchi; total phosphorus; chlorophyll *a*
- September: Temperature and dissolved oxygen profile; Secchi; total phosphorus; and chlorophyll *a*

Total phosphorus and chlorophyll *a* results were compared to the 2024 WisCALM criteria for two-story fishery lakes.

Aquatic Plant Point Intercept Survey

WI DNR staff created a grid-based map consisting of 463 point-intercept (PI) sampling points on Stormy Lake and shared the resulting shapefile. Using the Minnesota DNR GPS Application software and a Garmin 76CX unit, the PI points were downloaded. As indicated in the Directed Lakes protocols, the standard WI Point-Intercept methods were used (Hauxwell et. al. 2010). Land & Water staff navigated to each point that was shallower than the maximum depth for aquatic plants (determined during sampling) and identified each macrophyte collected on a double headed rake. Generally a rake on a pole was used to sample sites shallower than 15 ft, and a rake on a rope was used to sample sites that were deeper than 15 ft. Species that were seen within 6 ft. from the boat that were not collected on the double headed rake were recorded as "visuals". Additional plants found more than 6 feet away from a PI point were recorded as a "boat survey".

Two sites were not able to be sampled – one site was terrestrial; and the other was located under a dock.

Plants were identified using several resources: Aquatic *Plants of the Upper Midwest 3rd Edition* (Skawinski 2018), *Through the Looking Glass 2nd Edition* (Borman et. al. 2014), *Manual of Vascular Plants of the Northeastern United States and Canada 2nd Edition* (Gleason and Cronquist 1991), and "Identifying Pondweeds – A Brief Summary" (Knight 2017).

Results were entered on the Aquatic Plant Survey Data Workbook (*Aquatic Plant Management in WI* 2010). Statistics including Simpson's Diversity Index, Species Richness, Floristic Quality, and Average Value of Conservatism are sourced from this workbook's imbedded formulas.

A representative aquatic plant for each species located would be collected, photographed, and pressed. All pressed plants were verified with the UW-Stevens Point Freckmann Herbarium staff Paul Skawinski and Bob Freckmann. The Herbarium staff kept some plants and returned some plants to Vilas County Land & Water.

AIS Early Detection Surveys

Staff snorkeled around the lake in search of aquatic invasive species. Boat launches, inlets, outlets, high use areas, and changes in habitat are typically targeted areas. Stormy Lake's target sites included 5 areas: the boat launch; the peninsula area that separates the north bay from the rest of the lake; the north bay; the bay near the channel to Pearl Lake; near the wetland on the south shore close to Stormy Shores Ln; and the peninsula near the end of Stormy Point Rd. A boat meander survey around the lake edge that included riparian visual surveys was also done to increase aquatic and riparian invasive species detection.

AIS visually searched for included: hydrilla, water hyacinth, European frogbit, curly leaf pondweed, water lettuce, yellow floating heart, fanwort, Eurasian water-milfoil, Brazilian waterweed, parrot feather, didymo, water chestnut, purple loosestrife, yellow iris, knotweeds, Phragmites, narrow-leaf cattail, giant hogweed, hairy willow herb, Manchu tuber, faucet snails, zebra/quagga mussels, Chinese & banded mystery snails, Asian clams, rusty crayfish, red swamp crayfish, and starry stonewort.

Veliger tows were not done because historic calcium concentrations were not considered sufficient to sustain a population of zebra mussels.

Typically a sediment sample from the deep hole would be used to detect spiny waterfleas. This was not done on Stormy Lake because the lake already has spiny waterfleas.

Coarse Woody Habitat

Coarse woody habitat was surveyed according to the 2020 Lake Shoreland & Shallows Habitat Monitoring Field Protocol (Hein et. al. 2020). Coarse woody habitat situated between the ordinary high-water mark and the 2 ft. depth contour at least 4 inches in diameter and 5 ft. long was documented and mapped. A Garmin 76CX was used to mark each piece of wood. Certain features about the wood were manually noted: "Branchiness" (no branches; a few branches; full crown); does the wood cross the ordinary high-water mark (touch shore; not touch shore); and is 5 ft. of the wood currently submerged (in water; not in water).

Data was downloaded using Minnesota Garmin tool software, and the Vilas County Land Information Dept. created a map using ArcPro.

Shoreland Assessment

This survey collected information per land parcel and followed the protocols in the 2020 Lake Shoreland & Shallows Habitat Monitoring Field Protocol (Hein et. al. 2020). The Vilas County Land Information Department had created an ArcGIS Online tool that can be accessed offline and used on a tablet to locate parcel boundaries during the survey.

The protocols call for documenting the condition of the Riparian Buffer Zone 35 ft. inland from shore, the bank zone, and the littoral zone – see figure 23. If it was uncertain that structures were located within the 35 ft. riparian buffer zone, a rangefinder was used to measure distances from the boat.

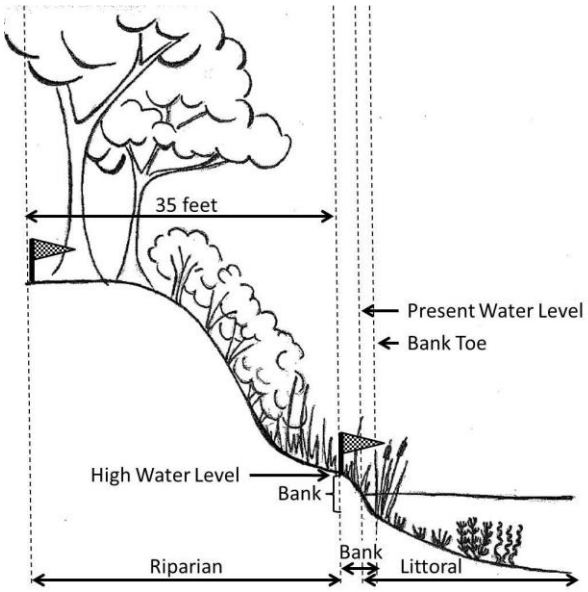


Figure 23. Shoreland areas assessed included the Riparian Buffer Zone, Bank Zone, and Littoral Zone. Graphic courtesy of WI DNR.

Data collected on the Riparian Buffer Zone were percent cover (canopy, shrubs, herbaceous, impervious surfaces, manicured lawn, agriculture, and other); human structures (buildings, boats on shore, fire pits, and other); runoff concerns (point source, channelized flow/gully, straight stair/trail/road to lake, lawn/soil sloping to lake, bare soil, sand/silt deposits, and other).

Data collected on the Bank Zone were horizontal lengths of the following: vertical sea wall; rip rap; other erosion control structures; artificial beach; bank erosion >1 ft. face; and bank erosion < 1ft. face.

Data collected on the Littoral Zone were the number human structures: piers, boat lifts, swim rafts/water trampolines, boathouses, and marinas. Presence/absence of aquatic emergent and floating plants were noted. Signs of aquatic plant removal were also noted.

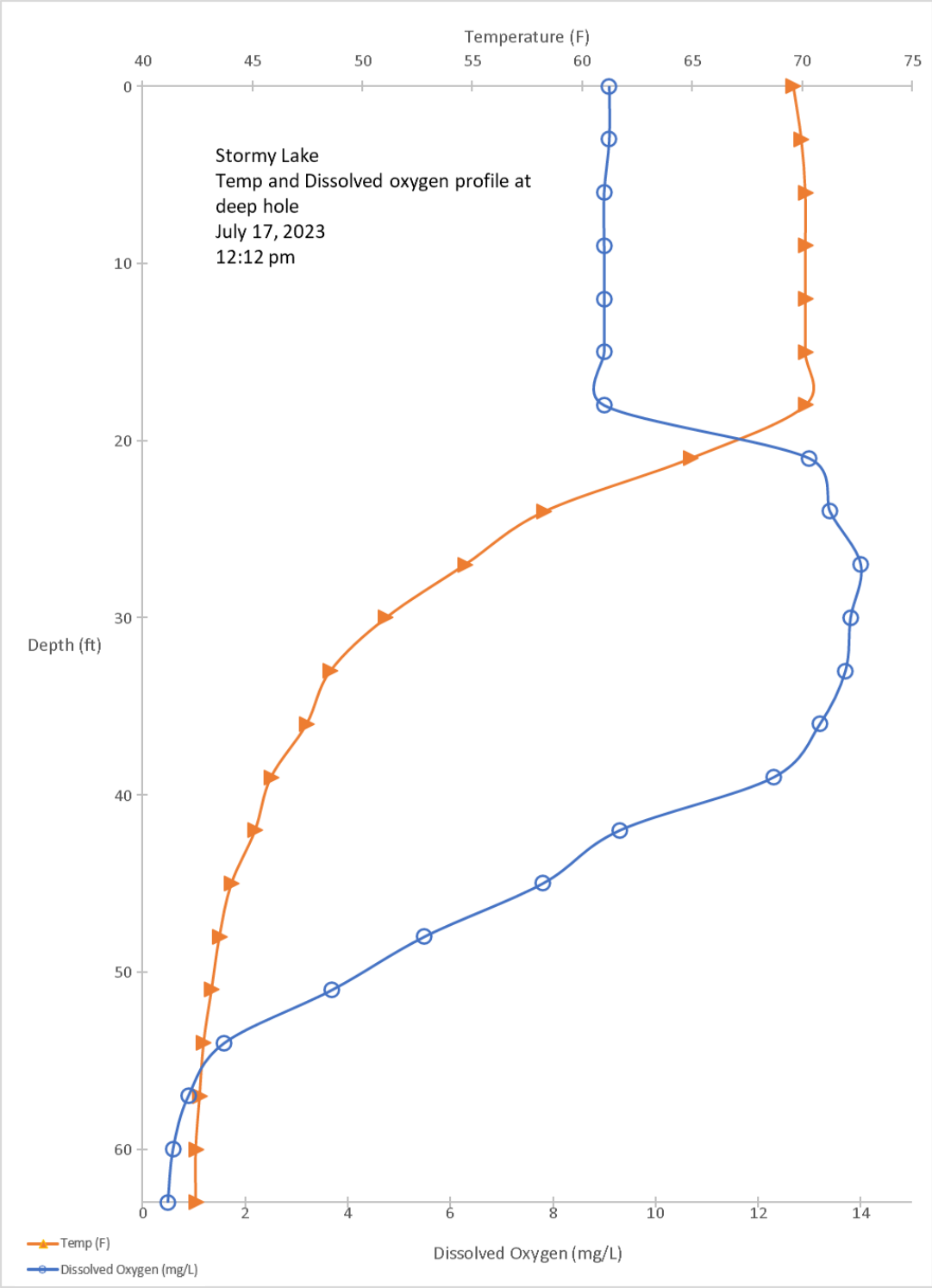
Data was collected on a paper datasheets, and the Vilas County Land Information Dept. created maps using ArcPro. Photos of the 35 ft. Riparian Buffer Zone were taken at approximately 50 ft. from shore and separated by parcel. However, nine property owners did not want photos taken of their shorelines, and these properties were omitted from the photo loop.

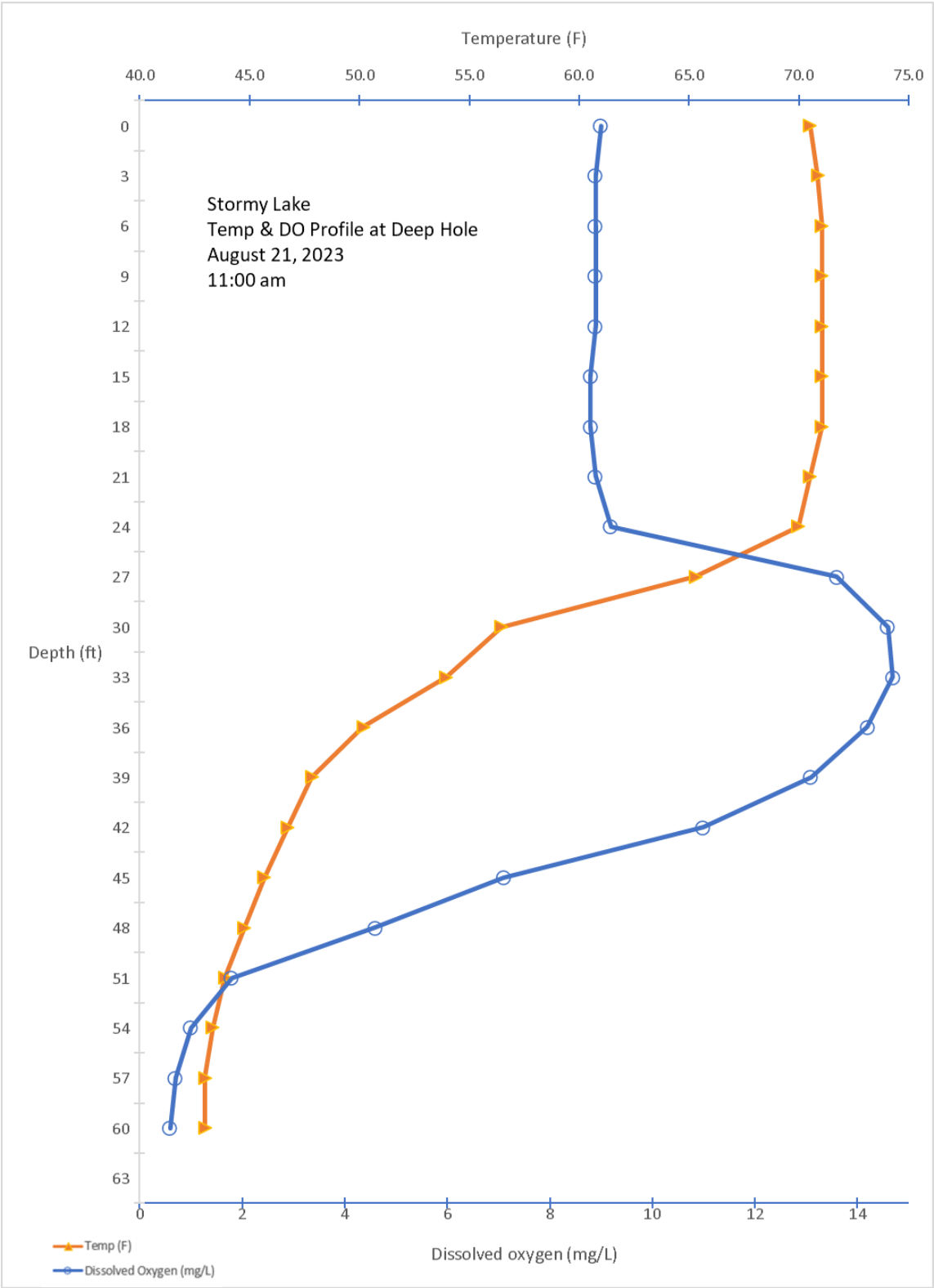
Appendix 2: Water Quality Raw Data and Temperature and Dissolved Oxygen Profiles

Table 3. Results of 2023 Stormy Lake water quality testing. Testing occurred on 7/17/23; 8/21/23; and 9/18/23.

	July 2023	Aug 2023	Sep 2023	Average
Secchi average (ft.)	16.50	18.00	26.00	20.17
Total Phosphorus (ug/L)	Not detected	10.3	Not detected	<10.3
Chlorophyll a (ug/L)	1.68	1.28	1.32	1.43
pH	7.7	n/a	n/a	7.7
Conductivity (uS/cm)	39.7	n/a	n/a	39.7
Nitrate + Nitrite (mg/L)	Not detected	n/a	n/a	Not detected
Total Kjeldahl Nitrogen (mg/L)	0.323	n/a	n/a	0.323

The July, August, and September temperature and dissolved oxygen profiles show the lake was strongly stratified, with higher oxygen concentrations at the thermocline.




Temperature (F)
40.0
45.0
50.0
55.0
60.0
65.0
70.0
75.0
Stormy Lake
Temp & DO Profile at Deep Hole
August 21, 2023
11:00 am
Depth (ft)
0
3
6
9
12
15
18
21
24
27
30
33
36
39
42
45
48
51
54
57
60
63
0
2
4
6
8
10
12
14
Dissolved oxygen (mg/L)
Temp (F)
Dissolved Oxygen (mg/L)

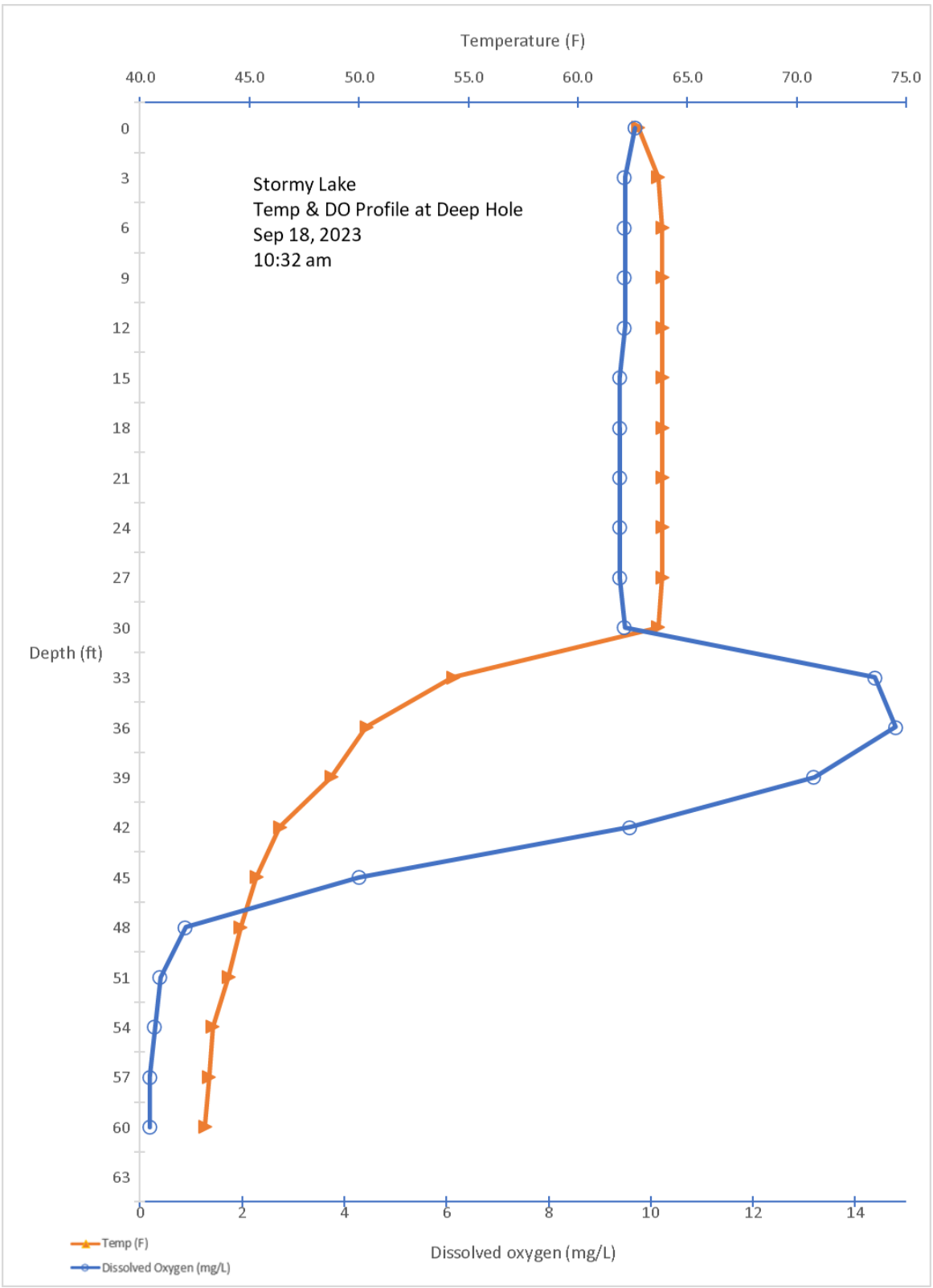


Figure 24. July, Aug, and Sep 2023 dissolved and temperature profiles for Stormy Lake.

Appendix 3: Aquatic Plant Point-Intercept Sampling Point Map, Plant Photos, Species Richness & Total Rake Fulness Maps

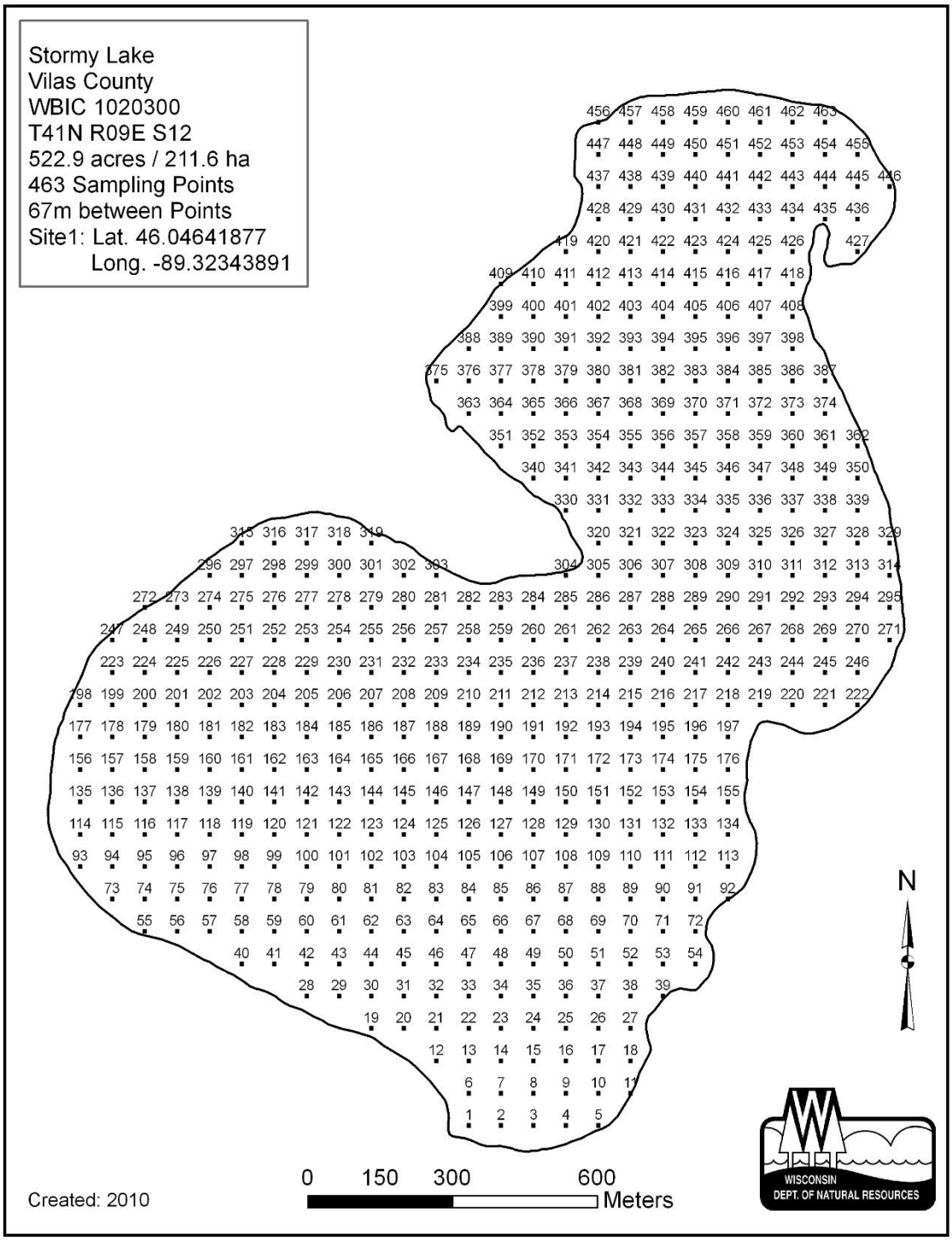


Figure 25. Aquatic plant point-intercept map for Stormy Lake. Courtesy of WI DNR.

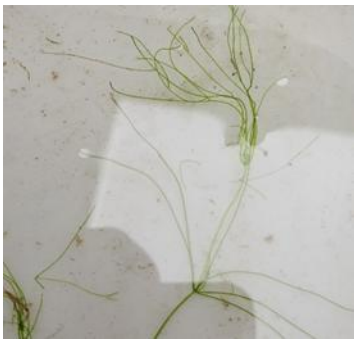


Figure 26. Slender nitella (*Nitella flexilis).* This plant occurred in over 24% of littoral sites surveyed and grew quite deep – up to 37 ft.

Figure 27. Fern pondweed (*Potamogeton robbinsii*). This plant occurred in only 2% of littoral sites surveyed, and was found in the north bay.

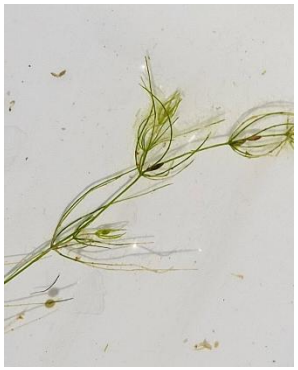


Figure 28. Gobular stonewort (*Chara globularis)*. This plant occurred in over 36% of littoral sites surveyed.

Figure 29. Variable pondweed (*Potamogeton gramineus*). This plant occurred in over 5% of littoral sites surveyed. Image edited from photo found at Flora of Wisconsin Consortium of Wisconsin Herbaria, photo by Brenton Butterfield.

Figure 30. Dwarf watermilfoil (*Myriophyllum tenellum*). This plant occurred in over 2% of littoral sites surveyed. Image edited from photo found at Flora of Wisconsin Consortium of Wisconsin Herbaria, photo by Brenton Butterfield.

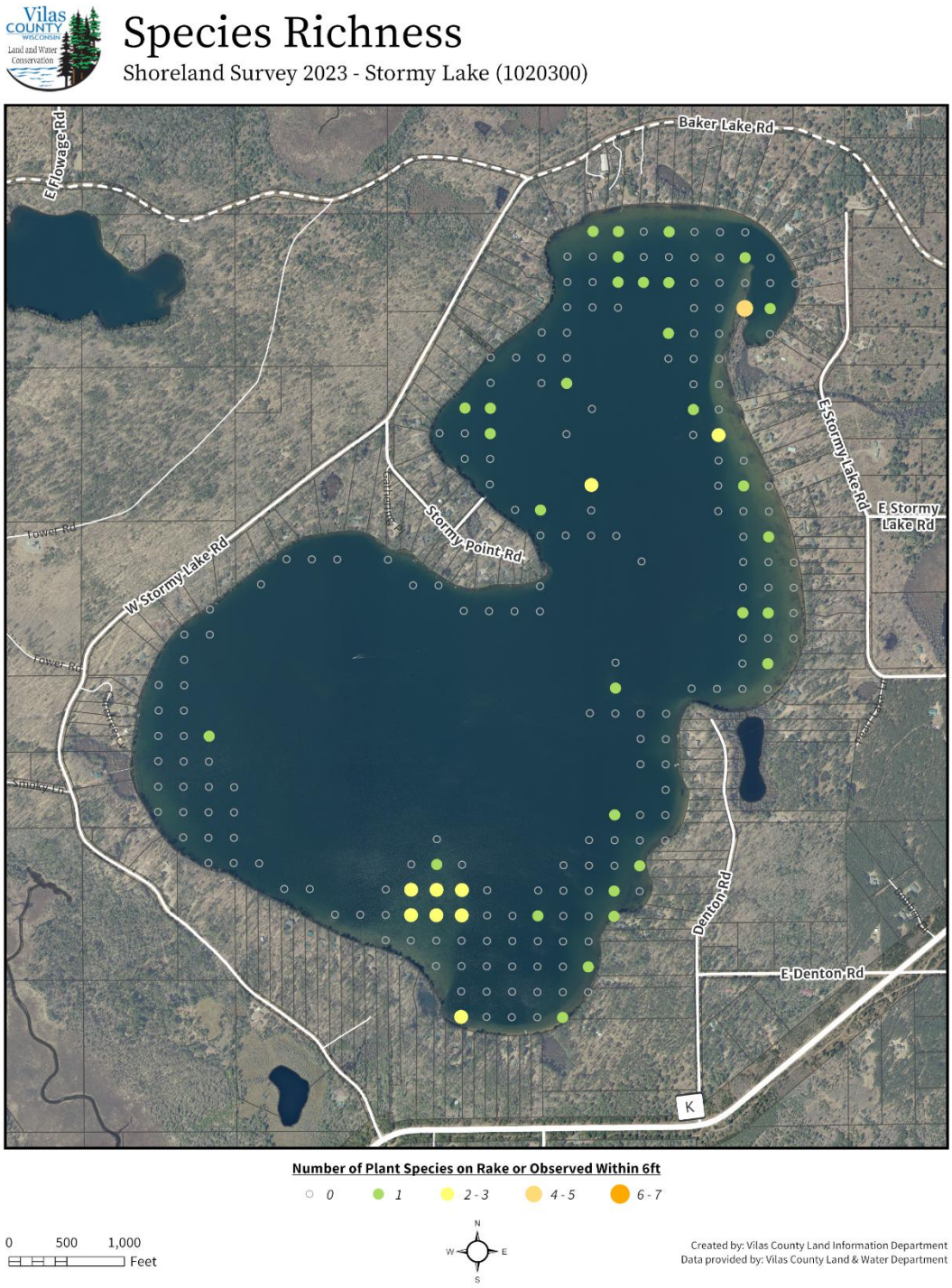


Figure 31. Stormy Lake species richness by sampling point.

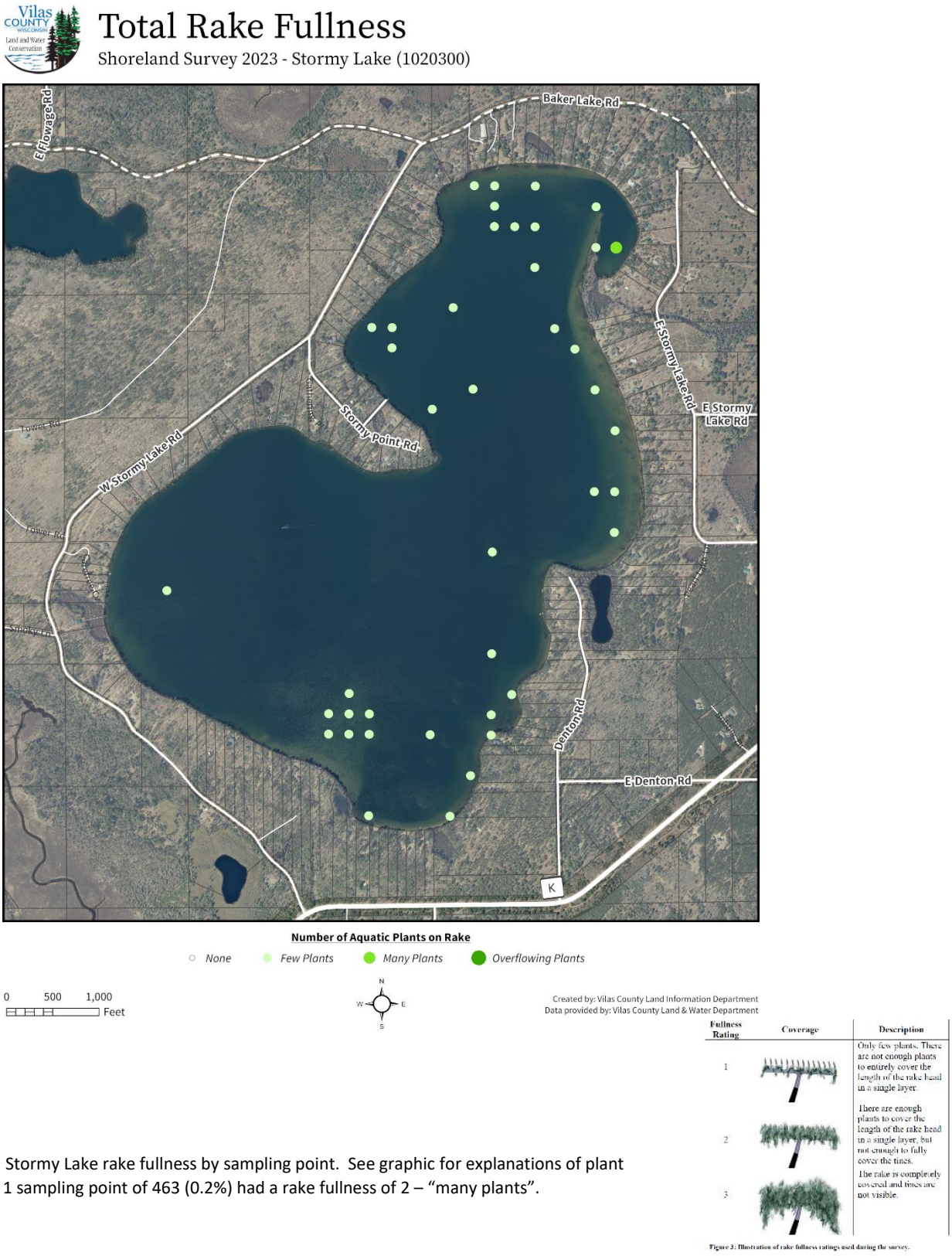


Figure 32. Stormy Lake rake fullness by sampling point. See graphic for explanations of plant densities. 1 sampling point of 463 (0.2%) had a rake fullness of 2 – “many plants”.

Appendix 4: Coarse Woody Habitat Map

Figure 33. Coarse Woody Habitat Characterization for Stormy Lake, 2023. 6.43 logs/mile were documented.

Appendix 5: Shoreland Survey Maps

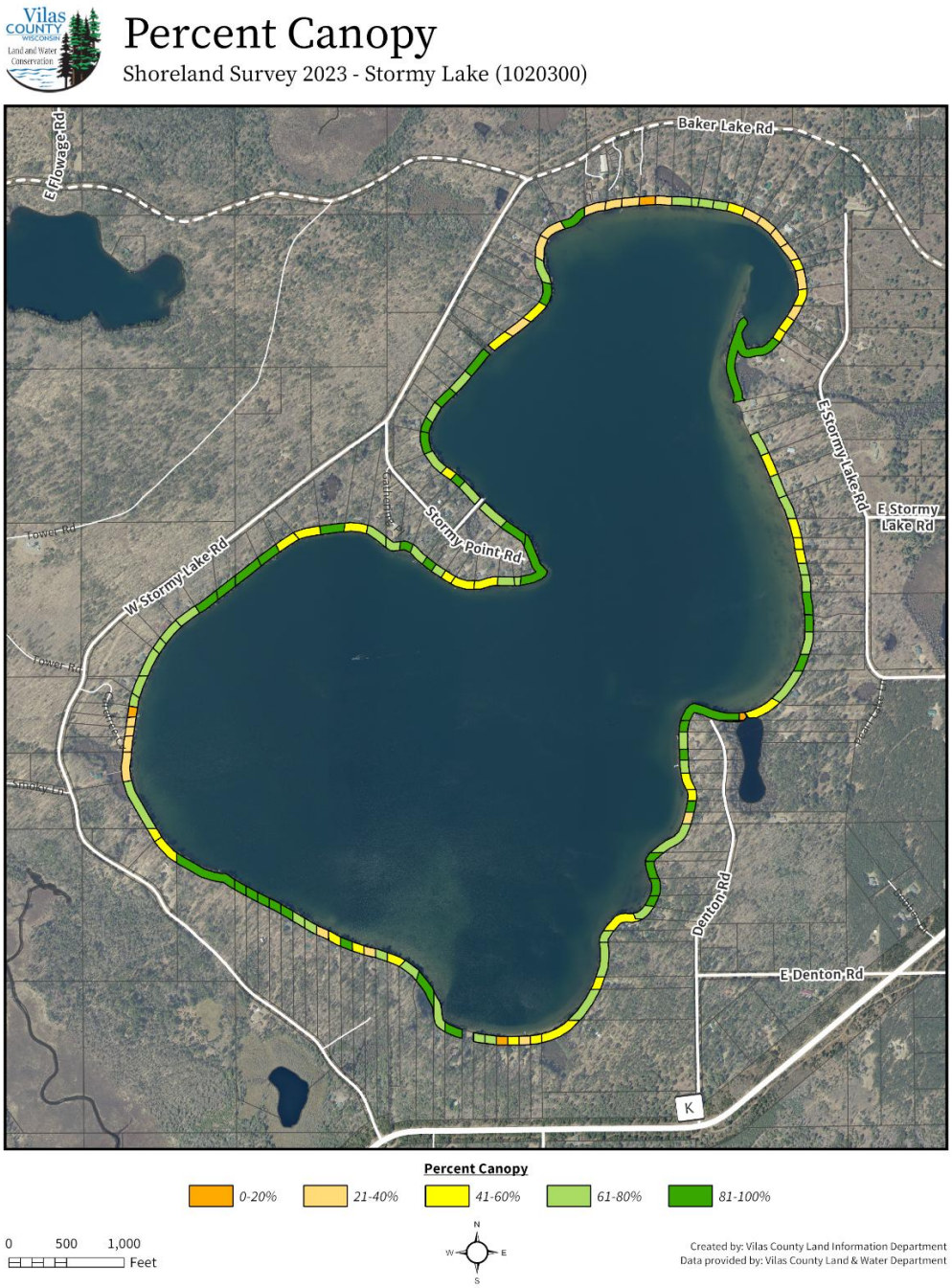


Figure 34. Canopy cover percent per parcel within 35 ft buffer area on Stormy Lake 2023.

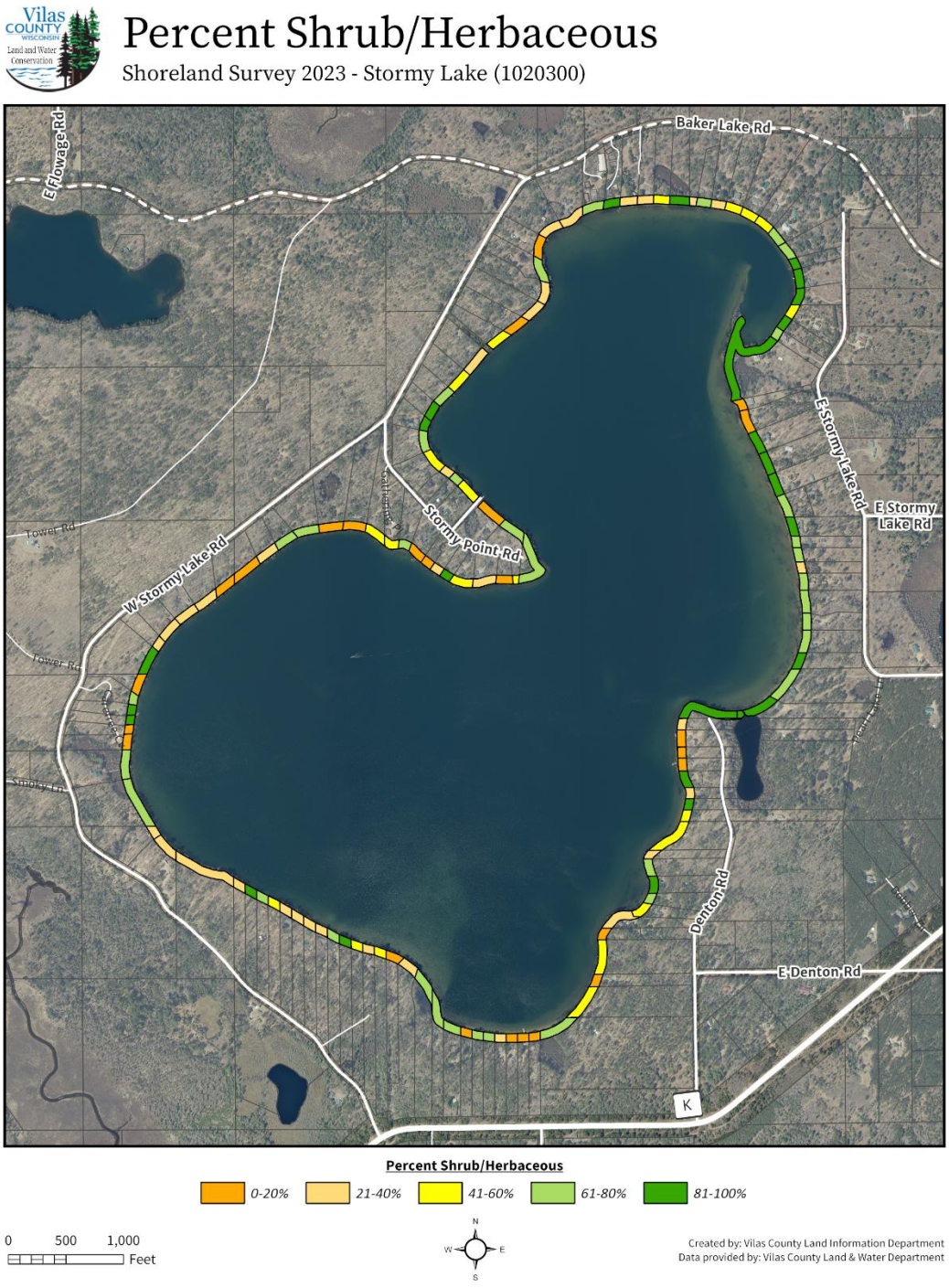


Figure 35. Percent shrub/herbaceous cover per parcel within 35 ft buffer area on Stormy Lake 2023.

Figure 36. Percent lawn cover per parcel within 35 ft buffer area on Stormy Lake 2023.

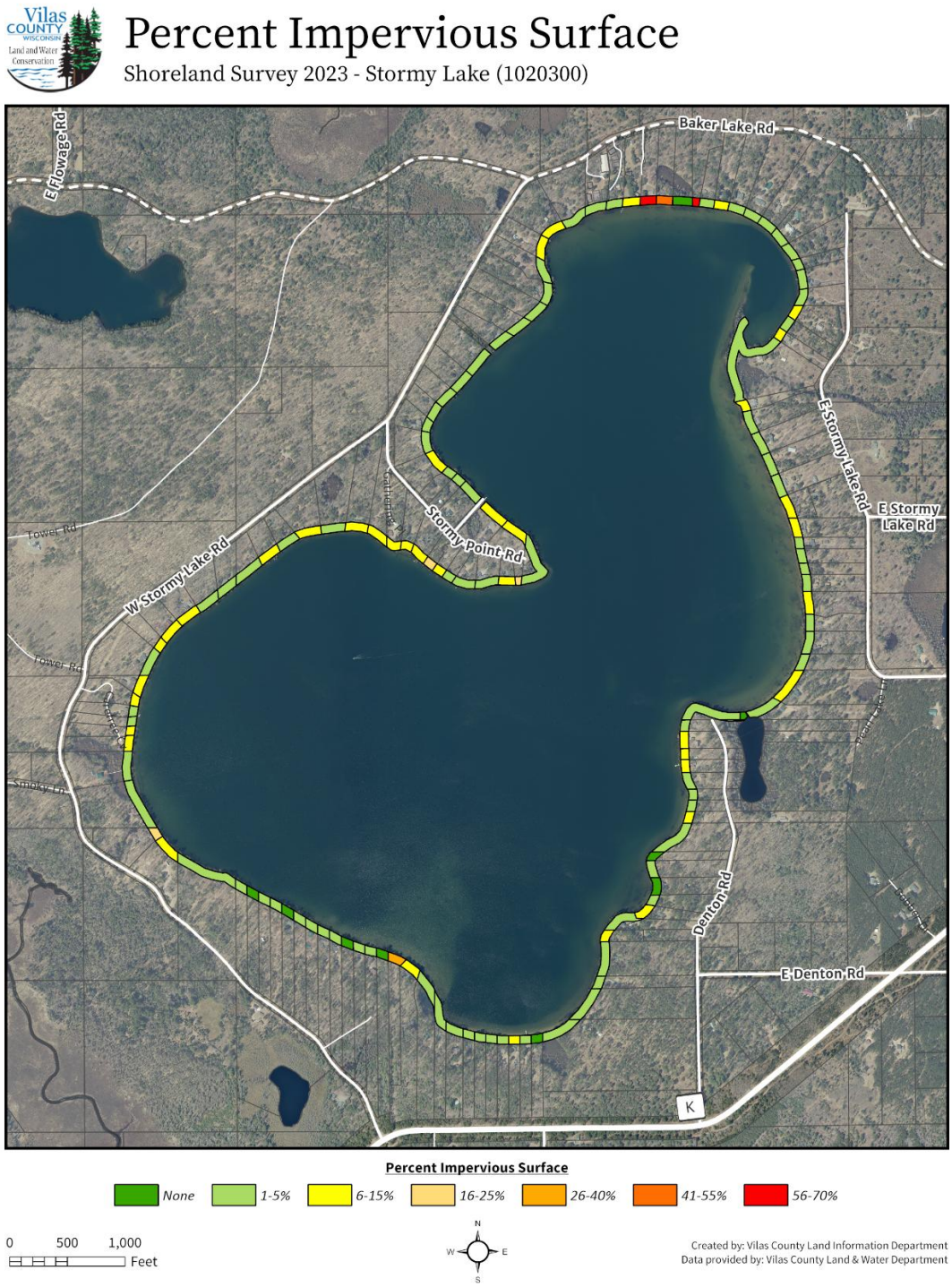


Figure 37. Percent impervious surfaces within 35 ft. riparian buffer zone per parcel on Stormy Lake 2023.

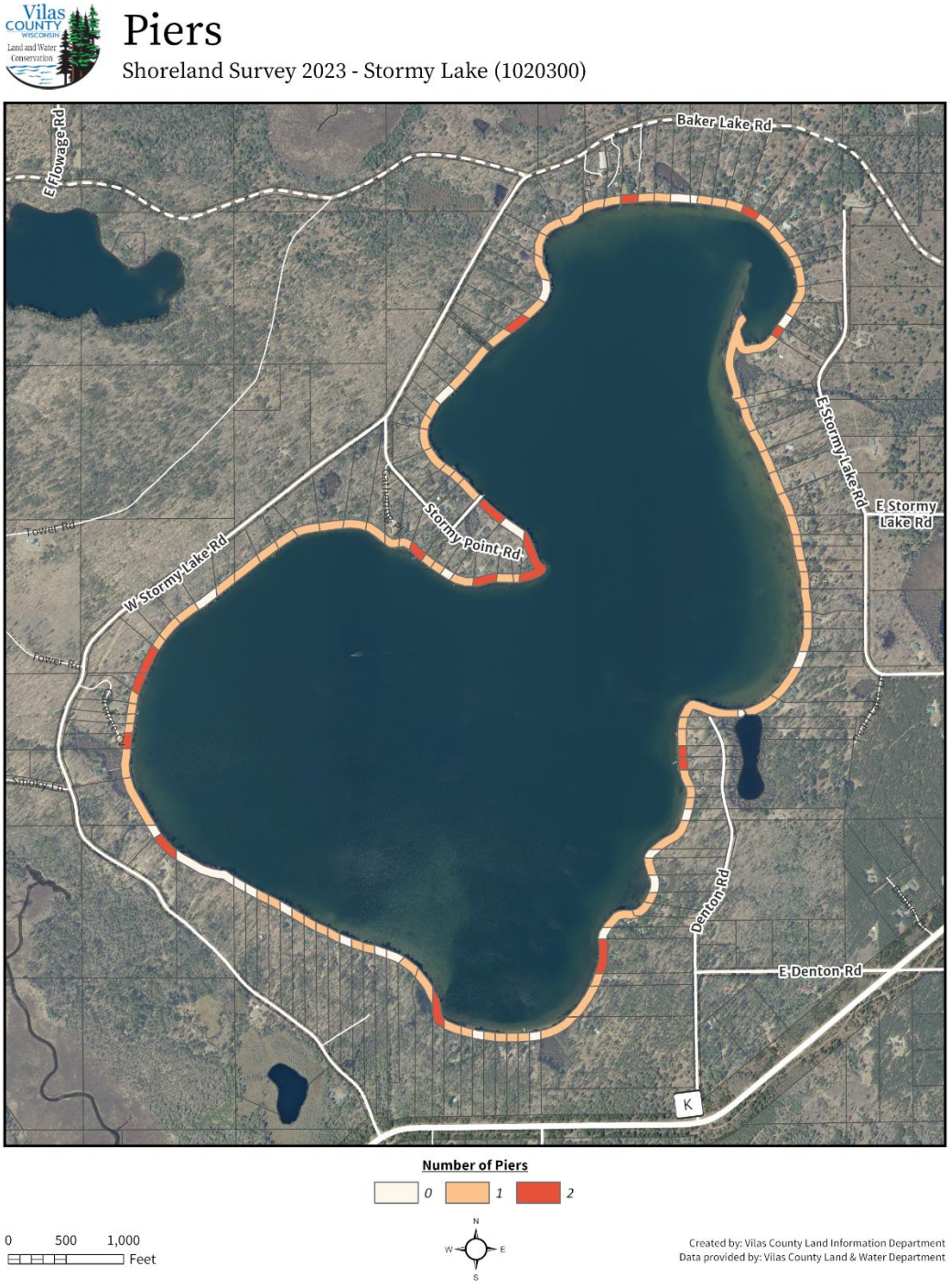


Figure 38. Number of piers per parcel on Stormy Lake 2023.

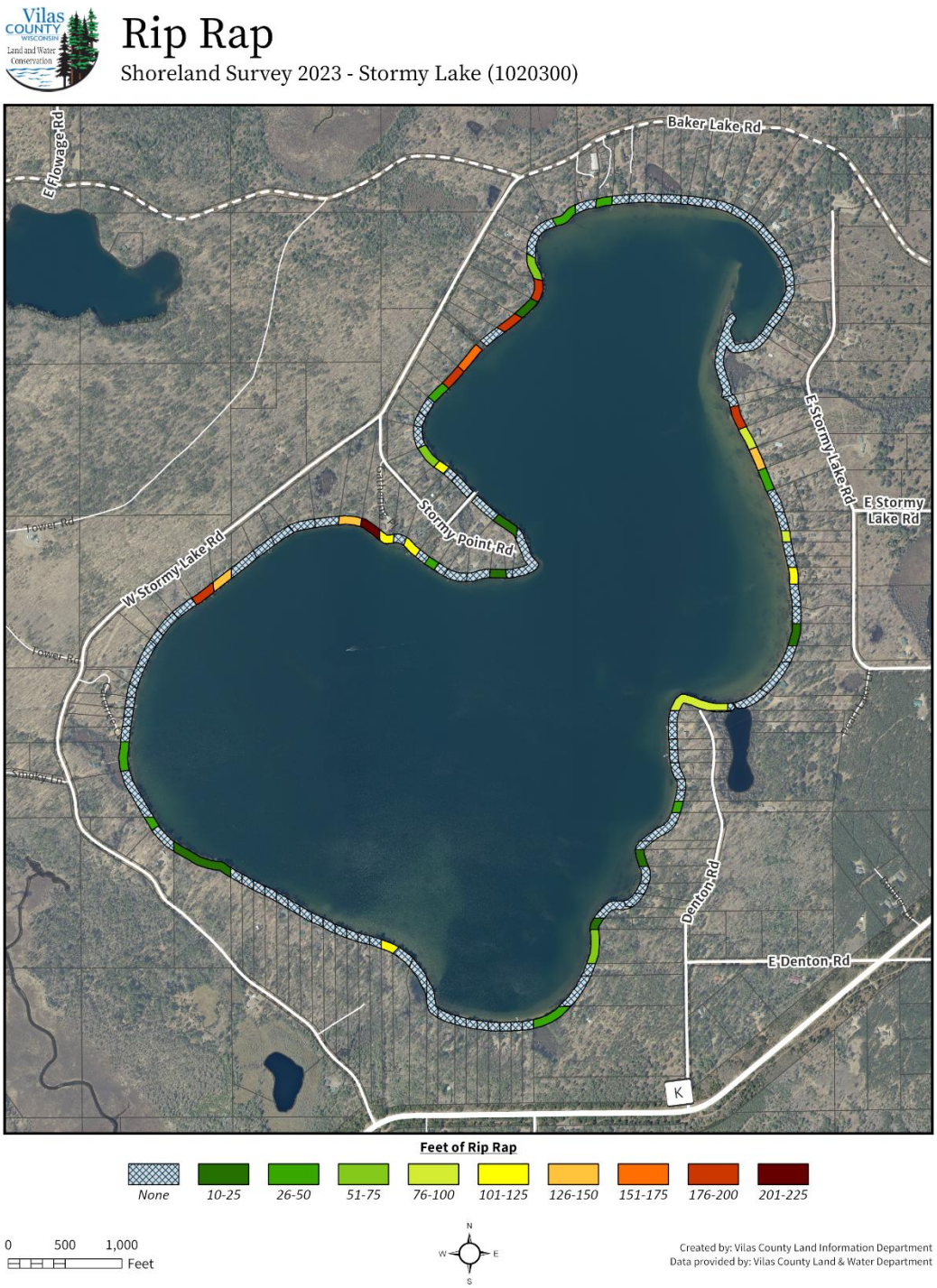


Figure 39. Feet of riprap per parcel on Stormy Lake 2023.

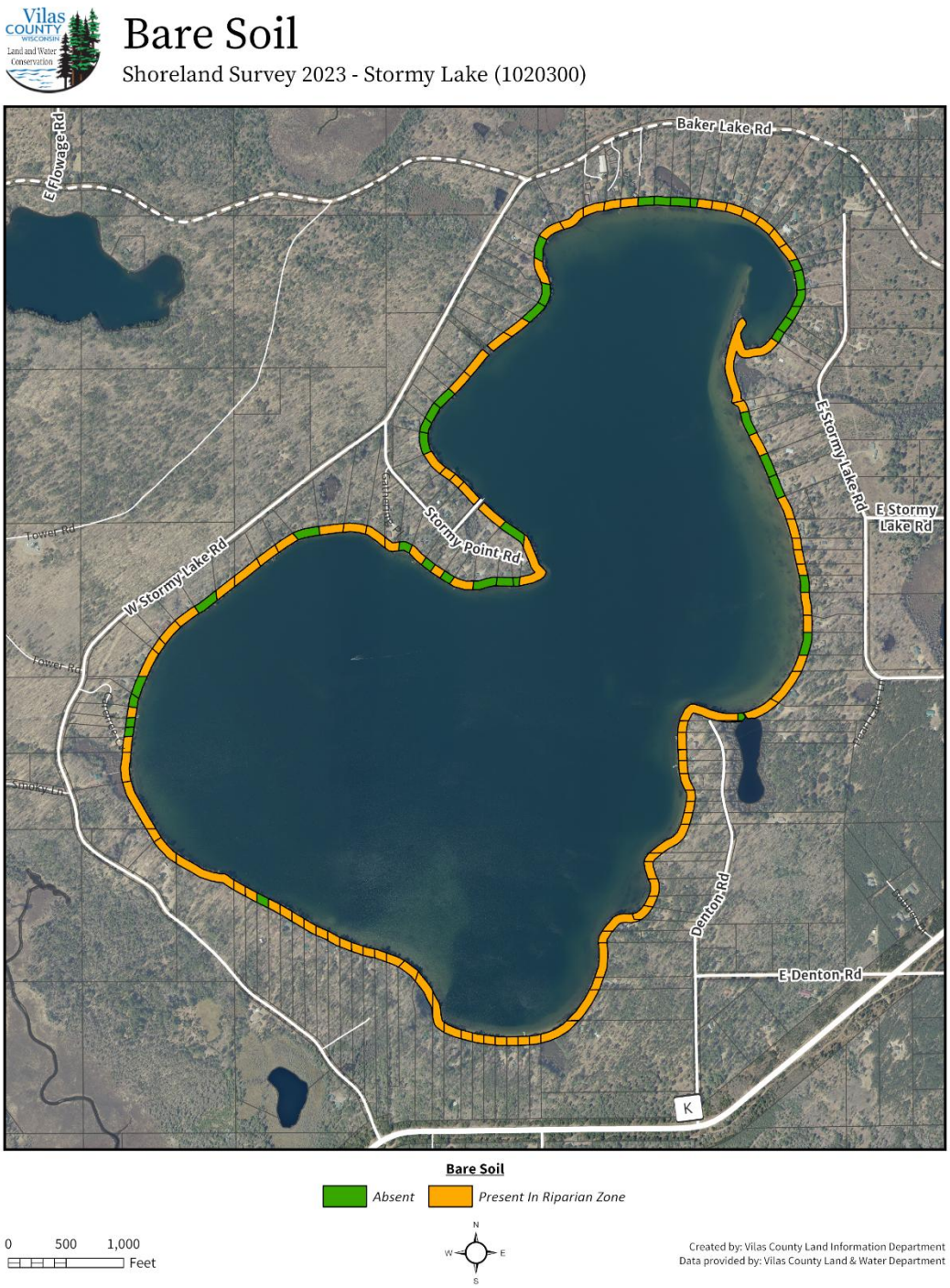


Figure 40. Parcels where bare soil was present inside or outside of the 35 ft. riparian buffer zone on Stormy Lake 2023.

Figure 41. Parcels where lawn or soil slopes to lake on Stormy Lake 2023.

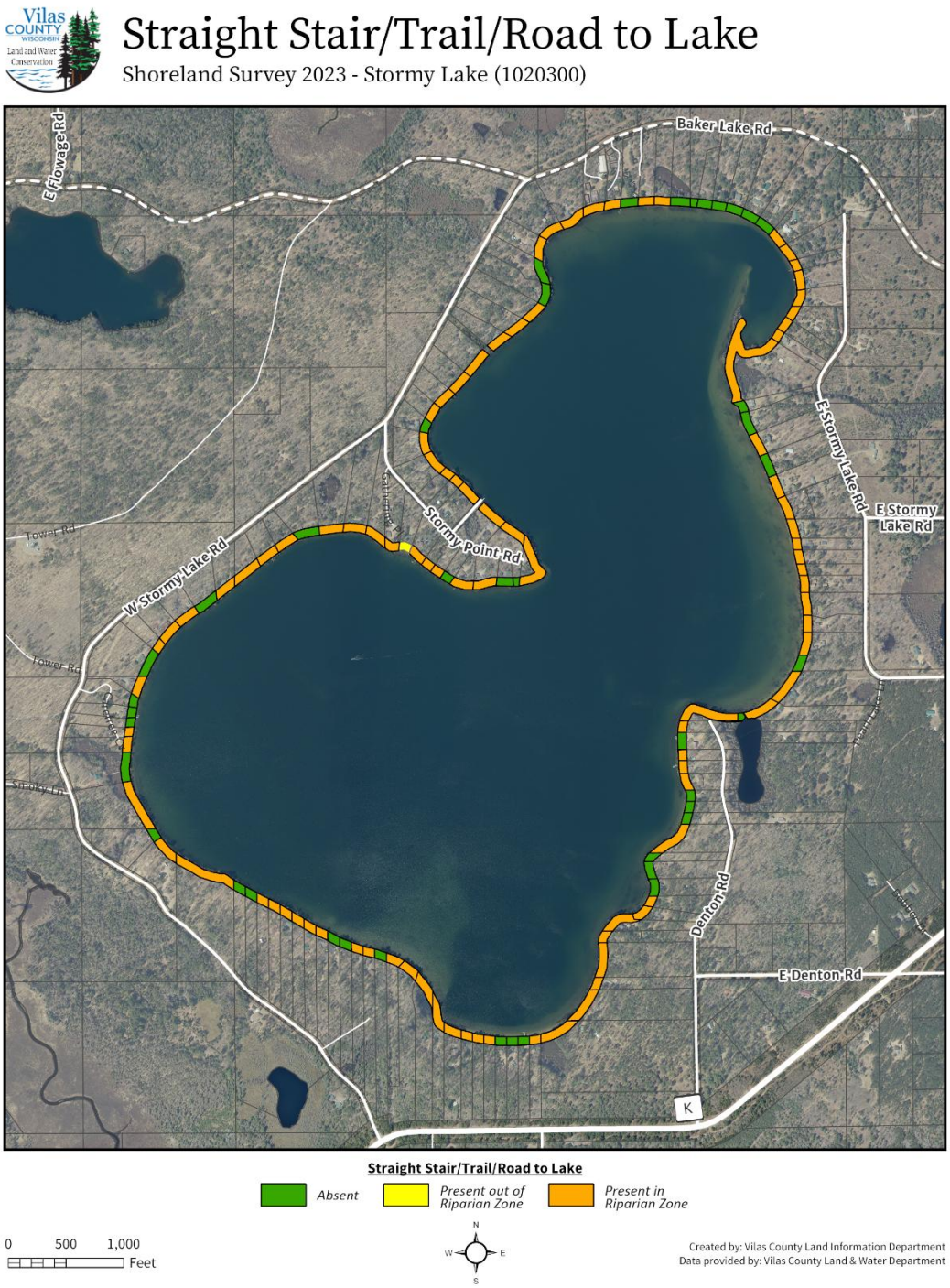


Figure 42. Parcels where straight stairs, trail, or road lead to the lake on Stormy Lake 2023.

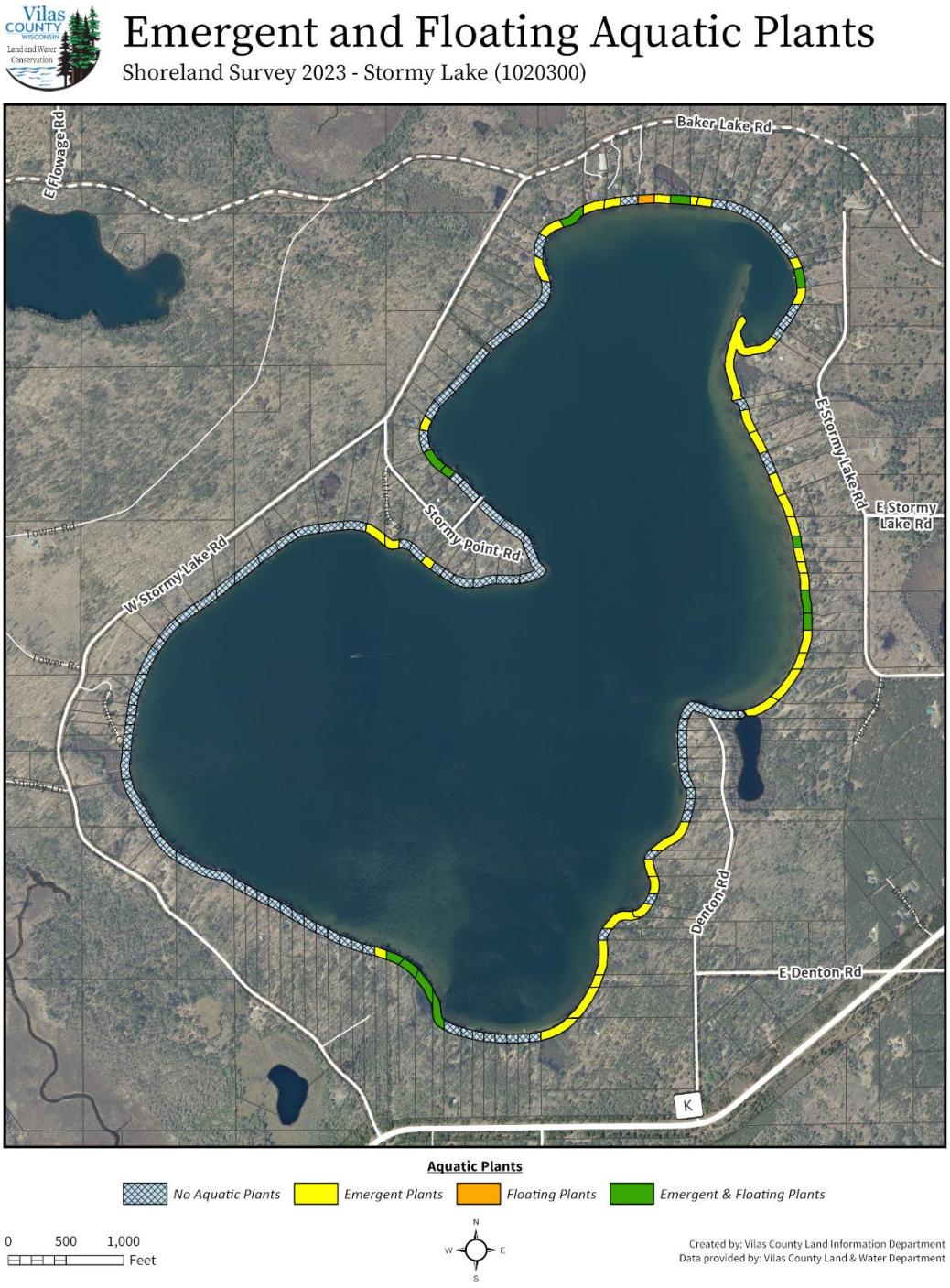


Figure 43. Parcels where emergent or emergent and floating plants were observed on Stormy Lake 2023.