LAKE EDEN
2025 AQUATIC VEGETATION SURVEY REPORT

PREPARED FOR THE LAKE EDEN ASSOCIATION

NOVEMBER 24, 2025

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1. Introduction

Arrowwood Environmental (AE) was retained by the Lake Eden Association to conduct an inventory of aquatic macrophytes in Lake Eden in Eden, Vermont. The inventory is part of an ongoing effort to control Eurasian watermilfoil (*Myriophyllum spicatum*, EWM) in the lake. The survey consisted of an inventory and mapping of EWM in the lake as well as a quantitative grid point survey of all aquatic vegetation in the lake. The methods and results of the survey are presented below.

2. Methods

The study area for the aquatic plant inventory consisted of the entirety of Lake Eden with the shoreline boundaries derived from the Vermont Hydrography Dataset (VHD). Only aquatic species and emergent species that typically occur within aquatic plant communities were included in this inventory. This includes aquatic vascular plants as well as macroalgae, together considered aquatic "macrophytes."

Field work on Lake Eden system was conducted by Arrowwood personnel on September 8 and 16, 2025. During the field work, the lake was circumnavigated with a motorboat. The motorboat was used for the majority of the inventory while a kayak was used to inventory shallow areas.

Two different methods were used to inventory aquatic macrophytes in Lake Eden: Grid Point Sampling, and Visual Littoral Surveys. The methodology used for each of these survey types is outlined below.

A. Grid Point Sampling

The Grid Point Sampling method provides a systematic and standardized procedure for sampling aquatic vegetation in lakes and lakes (Hauxwell et al. 2010). A total of 199 grid points were located throughout the littoral zone of Lake Eden as shown in the map in Appendix 2a.

Table 1. Aquatic sampling rake data collected at each grid point

METRIC	Description and categories	
RAKE FULLNESS	*Amount of aquatic vegetation on the sampling rake*	
	None	No plants present on rake
	Single	A single plant present on rake
	Low	Sparse vegetation present on rake
	Medium	Moderate amount of vegetation on rake, typically enough to cover center of the rake but not the tines
	High	Large amount of vegetation on rake, typically enough to cover the rake tines, difficult to bring into the boat
SPECIES ABUNDANCE	*Ranking of abundance of each species on sampling rake*	
	Single	A single plant present on rake
	Low	Species was sparse on rake
	Medium	Species was moderately abundant on rake
	High	Species was abundant on rake

The lake boundary and predetermined grid point locations were uploaded to an iPhone or iPad data collector, running ArcGIS Collector and Survey123 field data collection applications. An ortho-photo basemap project was created on the iPhone/iPad with the grid point locations for use during the fieldwork. This system was used to navigate to each grid point using a boat. All data was

recorded using a digital data form on the data collection unit. Tables 1 and 2 list the data and categories of data that were collected at each grid point.

Table 2. Vegetation abundance and site data collected at each grid point

METRIC	*Description and categories*	
BIOMASS	*Amount of plant growth vertically in the water column*	
	None	No aquatic plants present
	Low	Plants growing only as a low layer above the sediment
	Moderate	Plants growing well into the water column but generally not reaching the water surface
	High	Plants filling the water column and/or surfacing enough to be a possible recreational nuisance
	Very High	Plants filling the water column and completely covering the surface; obvious nuisance conditions
PERCENT COVER SUBMERGED	A record of the percentage of the lake bottom covered by submerged aquatic plants using the following cover categories: <1%; 1-5%; 5-25%; 25-50%; 50-75%; 75-100%	
PERCENT COVER FLOATING	A record of the percentage of the lake surface covered by floating aquatic plants using the following cover categories: 1-5%; 5-25%; 25-50%; 50-75%; 75-100%	
NONNATIVE INVASIVE SPECIES (NNIS)	Presence of invasive species with species name and number of plants or percent cover of NNIS plants using the following cover categories: <1%; 1-5%; 5-25%; 25-50%; 50-75%; 75-100%	
SEDIMENT TYPE	Type of sediment present using the following categories: Bedrock; Boulder; Cobble; Gravel; Sand; Silt; Clay; Muck	
WATER DEPTH	Depth of water taken using sonar (from motorboat) or kayak paddle (from kayak).	
AQUATIC NATURAL COMMUNITY	Type of aquatic natural community present at grid point	

An aquatic survey rake was used to gather the vegetation data at each point location. In waters shallower than 8', a rake on a pole was used to sample

vegetation. In waters deeper than 8', a survey rake attached to a rope was used to sample vegetation. Rake fullness, as outlined in Table 1, was recorded for each sample to obtain information about vegetation density (Hauxwell et al. 2010; Madsen et al. 1996). Each aquatic plant on the rake was identified to species, if possible. Specimens that were difficult to identify in the field were collected and examined under a dissecting scope. Voucher specimens of many species recorded in the lake were collected and stored at either the Arrowwood Herbarium or at the Pringle Herbarium at the University of Vermont. The abundance of each species on the rake was recorded using the categories outlined in Table 1.

In addition to rake data, vegetation abundance and general site data (described in Table 2) was collected at each grid point.

Overall plant biomass data is used to understand the potential for aquatic plants growing at levels high enough to reach nuisance conditions. The categories for this metric are shown in Table 2. Since this metric measures potential nuisance conditions, it is largely dependent upon water depth in addition to plant growth. Dense plant growth in the water column, for example, does not generally present nuisance conditions if it is well below the surface of the lake. The same amount of growth, however, in very shallow water would potentially create nuisance conditions.

Percent cover of both submerged and floating aquatic plants was recorded at each grid point using the categories shown in Table 2. Recording percent cover of aquatic plants is a similar metric as the biomass but not dependent on water depth. If submerged vegetation was growing dense enough that it was laying on the surface of the water, it was considered a floating aquatic plant for this metric.

Figure 1. Aquatic Sampling Rake

Presence or absence of non-native invasive species was evaluated in an approximately 500 square foot area at each grid sampling point. Data on either the number of plants or the percent cover that the plants occupy was recorded as outlined in Table 2. If an NNIS infestation was widespread, "off-grid" sampling points were used to determine the boundaries of the infestation (see Visual Littoral Survey methods below).

Water depth and sediment type data were collected at each grid point as outlined in Table 2. For each grid point where the aquatic natural community was known, data was collected on the presence of this type.

B. Visual Littoral Survey

The grid point sampling provides a systematic and repeatable method for sampling aquatic vegetation; however, it does not provide information about the nature of aquatic vegetation in between the grid points. Relying solely on this method, therefore, has the potential to leave significant gaps in the knowledge of aquatic vegetation in the overall lake. The visual littoral survey method was employed to fill in these gaps and provide a more complete picture of aquatic vegetation presence and distribution. This survey methodology is based on methods from the Vermont Agency of Natural Resources Department of Environmental Conservation (2006) field manual.

When navigating in between grid point locations, aquatic vegetation was viewed from the boat. An "off-grid" data point was taken to document invasive species,

record information about aquatic natural communities, record areas of high biomass, document rare species or record other features of interest. Data was recorded on the digital data collection form at these "off-grid" points. Only a subset of the data presented in Tables 1 and 2 was collected at these points related to the specific feature being documented. In some cases, a field sketch map of a particular feature (typically an EWM infestation or natural community) was used to document the extent of the feature. This was conducted on the iPhone/iPad using a basic line feature class.

Mapping the distribution and abundance of EWM was a major focus of the visual littoral survey. Dedicated visual littoral surveys were conducted to map EWM throughout the entire littoral zone. Sub-meter capable GPS systems and specific EWM data mapping protocol using ArcGIS Quick Capture were used for efficient data collection of EWM infestations. This methodology allows for the rapid collection of percent cover data, plant count data and infestation boundary data.

C. Creating maps of EWM

Once field work was complete, the spatial data was analyzed in ArcGIS. In order to create a complete map of extent of aquatic vegetation in the lake, the grid points and off-grid points were used to create a polygon layer of vegetation. Using ortho-photo interpretation, bathymetric maps of the lake and the field data, a polygon feature class was created of the extent of the aquatic vegetation in the lake at the time of the survey (the littoral zone).

D. Non-Target Impacts from Control Activities

In addition to EWM, ProcellaCOR™ EC is an herbicide known to impact many aquatic plant species including other milfoils (*Myriophyllum spp.*), bladderworts (*Utricularia spp.*), water lilies (*Nymphaea spp.*) and pond lilies (*Nuphar spp.*). In order to determine if the herbicide application in Lake Eden has affected non-target plant species, a methodology to assess potential impacts was developed.

This assessment involves a visual littoral survey of plant impacts throughout the pond with particular focus on areas in the vicinity of the herbicide application. For each impacted species, data is collected on the percentage of the population impacted and the degree of impact on the plants. The degree of impact has been categorized as shown in Figure 2.

Figure 2. Non-Target Impact Assessment

The degree of impact on non-target plants can range from non-fatal curling of leaves to complete leaf necrosis and will vary depending on the plant species and degree of exposure to the herbicide. The lesser impact categories (curling of leaves) typically have a minor effect on overall plant surivorship. Complete necrosis of the leaf tissue may or may not lead to plant mortality depending on the species.

Table 3. Cover categories for EWM

Percent Cover	Density Description
0	None
1-5%	Trace
5-25%	Sparse
25-50%	Moderate
50-75%	Moderate-Dense
75-100%	Dense

Using the littoral zone as a basemap, the EWM point data was used to create a map of EWM infestations. In the fall of 2025, all the EWM infestations were recorded as point data for the cover categories in Table 3. There were no large infestations recorded. EWM plant numbers in the point data were converted to density categories for the purpose of creating a map of EWM infestations (Appendix 2c).

The map of EWM presence in the Lake should be viewed in conjunction with ongoing EWM control activities. The presence and density of EWM surveyed are, in many cases, dependent on and determined by EWM control efforts. If, for example, Diver-Assisted Suction Harvesting (DASH) occurred on a dense infestation of EWM before the inventory was undertaken, no EWM would be recorded at that location. Conversely, an infestation of EWM may be included on the maps that has since been removed by DASH or other control methods.

3. Results

The results of the aquatic plant inventory for Lake Eden are presented in three sections below: A) Native Aquatic Vegetation; B) Non-native Invasive Species; C) Non-Target Impacts from Control Activities.

A. Native Aquatic Vegetation

Analysis of the grid sampling survey data is presented in summary form in Table 4. The dataset allows for analysis of the most abundant species that occur on the rake samples shown as the Frequency of Occurrence (FOO). Full results of the rake samples are included in the tables in Appendix 1.

The list of species in these tables is arranged from most abundant to least abundant species encountered during the 2025 rake sampling.

Table 4. Frequency of occurrence (FOO) data for Lake Eden

Latin Name	Common Name	FOO 2024	FOO 2025
<Null>	NA	73%	39%
Elodea canadensis	water-weed	10%	13%
Potamogeton robbinsii	Robbins' pondweed	10%	13%
Nitella spp.	stonewort	11%	8%
Potamogeton epihydrus	ribbon-leaved pondweed	2%	5%
Potamogeton berchtoldii	Berchtold's pondweed	2%	4%
Myriophyllum spicatum	Eurasian water-milfoil	NA	3%
Nymphaea odorata	waterlily	1%	3%
Potamogeton amplifolius	broad-leaved pondweed	4%	3%
Eleocharis acicularis	needle spike-rush	4%	2%
Najas flexilis	common naiad	1%	2%
Vallisneria americana	eel-grass	1%	2%
Equisetum fluviatile	water horsetail	1%	1%
Eriocaulon aquaticum	pipewort	4%	1%
Potamogeton illinoensis	Illinois pondweed	3%	1%
Potamogeton natans	floating pondweed	NA	1%

The most common species documented on the rake samples in Lake Eden remained relatively consistent from 2024-2025. The most common species in both years include water-weed, Robbins' pondweed, and stonewort. The <Null> values represent points that lacked vegetation on the sampling rake.

B. Non-Native Aquatic Species

EWM was the only aquatic invasive species documented in Lake Eden during the current inventory. Herbicide treatment was performed in the Lake on August 26, 2025, in the Public Beach, Boat Launch, and northern half of the Northwest Quadrant. Diver-Assisted Suction Harvesting (DASH) and multiple hand-pulling control measures were also implemented throughout the lake in the summer and fall of 2025

Summary data on EWM abundance in Lake Eden from June (pre-management) and September is shown in Table 7. Maps of EWM distribution in the Lake are included in Appendix 2.

Table 5. Summary data on EWM abundance in Lake Eden

Site Name	June 2025	September 2025
Boat Launch	100s*	
Fishhook	2	
Northeast Quadrant	7	
Northwest Quadrant	118	7
Public Beach	420	
Scout Camp	20	1
Southeast Quadrant	8	2
Southwest Quadrant	14	
SW Quad: South Bay	45	58
SW Quad: West Bay	50	4

** EWM in the Boat Launch area was too abundant to count and contained hundreds of plants.*

Figure 3. EWM showing complete necrosis from herbicide treatment

The data in Table 5 shows that the EWM abundance in Lake Eden decreased substantially after herbicide treatment. No EWM plants were found post-herbicide in the Boat Launch area and only a single EWM plant was found in the Scout Camp area post-treatment. The EWM plants that were documented in the Northwest Quadrant were mostly located southwest of the herbicide treatment area. The herbicide application in the Public Beach area appears to have been successful; no EWM plants were documented post-herbicide.

EWM continues to be present in other parts of the lake outside of the herbicide treatment zones; most notably in the South Bay and West Bay of the SW Quadrant. While 58 EWM plants were documented in the South Bay, there were likely more plants that were present in deeper areas that could not be seen from the visual surveys. In addition, active DASH work was occurring in this area during the time of the September survey. The 58 plants shown in Table 5 may therefore not reflect the number of plants present after that work.

C. Non-target Impacts from Control Activities

The Lake Eden Association obtained a permit from Vermont Agency of Natural Resources to apply the herbicide ProcellaCOR™ EC to control EWM. The

herbicide was applied on August 26, 2025, in the Boat Launch, Scout Camp and part of the Northwest Quadrant.

The impacts documented to different plant species in each area are summarized in Table 8. A brief description of impacts for area is also presented below.

Table 6. Non-Target Impacts to Plants in Lake Eden

Area	*Species (rarity rank)*	% Impacted	Degree of Impact
Boat Launch	*Nymphaea odorata (S4)*	5%	1. Slight Curling
		90%	4. Complete Necrosis
	Sparganium angustifolium (S4)	10%	1. Slight Curling
		5%	3. Partial Necrosis
Public Beach	*Nymphaea odorata (S4)*	80%	3. Partial Necrosis
		15%	4. Complete Necrosis
Scout Camp	*Nymphaea odorata (S4)*	15%	1. Slight Curling
NW Quadrant	*Nymphaea odorata (S4)*	10%	1. Slight Curling
SW Quadrant	*Nymphaea odorata (S4)*	10%	1. Slight Curling

Boat Launch. The non-target impacts on water lily (*Nymphaea odorata*) were quite pronounced in the Boat Launch area, where 90% of these plants exhibited complete leaf necrosis. This species has a large storage organ

beneath the sediment and typically produces many leaves; necrosis of some leaves therefore does not typically result in overall plant mortality. However, the level of impact exhibited in the Boat Launch area may have resulted in plant mortality. It is unknown what impact this will have on the population of water lilies in this area.

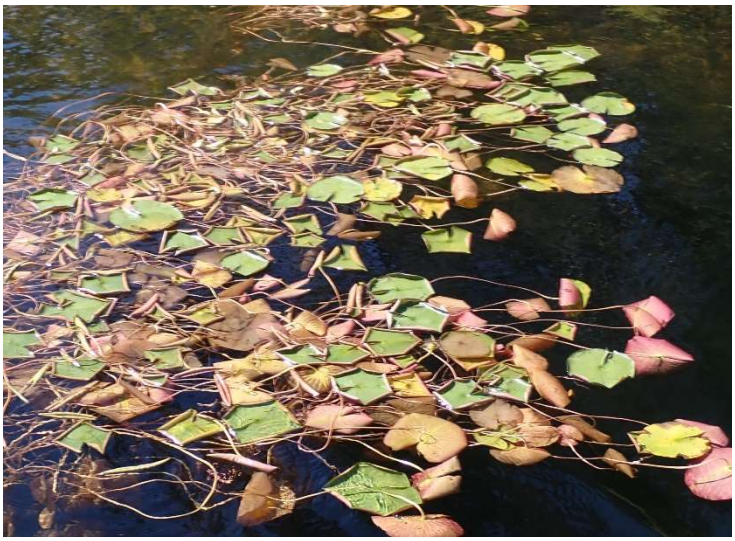

Figure 4. Water lily leaves showing impacts from herbicide

Potential impacts on *Sparganium angustifolium* were also seen in this area in the form of slight leaf curling and partial necrosis. There has been no previously documented evidence of ProcellaCOR herbicide impacting this genus of plants, so these impacts are considered "potential". These impacts are minor and not likely to result in plant mortality.

Public Beach. Most water lily leaves in the Public Beach area exhibited partial necrosis and some showed complete necrosis. It is likely that most of these plants will survive these impacts.

Scout Camp. Impacts on water lilies in the Scout Camp area were minor, with only 15% showing partial curling of leaves.

NW Quadrant and SW Quadrant. Along these shores, only occasional patches of water lily plants occur, and some curling of leaves was documented. Most of these impacts occurred in areas outside of the herbicide treatment areas.

4. Conclusion

An inventory was conducted of native and non-native aquatic vegetation in Lake Eden using grid-point sampling and visual littoral surveys. The dominant species of native vegetation remained relatively constant as measured by frequency of occurrence data from the grid-point sampling. Numerous EWM control methods were implemented in 2025 including DASH, hand-pulling and herbicide treatment. Due to these control efforts, EWM abundance in the lake decreased substantially from 2024 to 2025. At the time of the September survey, EWM was still present in scattered locations throughout the lake and in more established infestations in the SW Quadrant. Impacts on native vegetation from herbicide application were noted in various locations in the lake but were most pronounced in the Boat Launch area. Data on the distribution and abundance of EWM throughout Lake Eden will help to guide management in 2026.

5. Literature Cited

Hauxwell, Jennifer, Susan Knight, Kelly Wagner, Alison Mikulyuk, Michelle Nault, Meghan Porzky, Shaunna Chase, and J Hauxwell. 2010. "Recommended Baseline Monitoring of Aquatic Plants in Wisconsin: Sampling Design, Field and Laboratory Procedures, Data Entry and Analysis, and Applications." https://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/ecology/Aquatic Plants/PI-Protocol-2010.pdf.

Madsen, John D, Jay A Bloomfield, James W Sutherland, Lawrence W Eichler, and Charles W Boylen. 1996. "The Aquatic Macrophyte Community of Onondaga Lake: Field Survey and Plant Growth Bioassays of Lake Sediments." *Lake and Reservoir Management* 12 (1): 73–79. https://doi.org/10.1080/07438149609353998.

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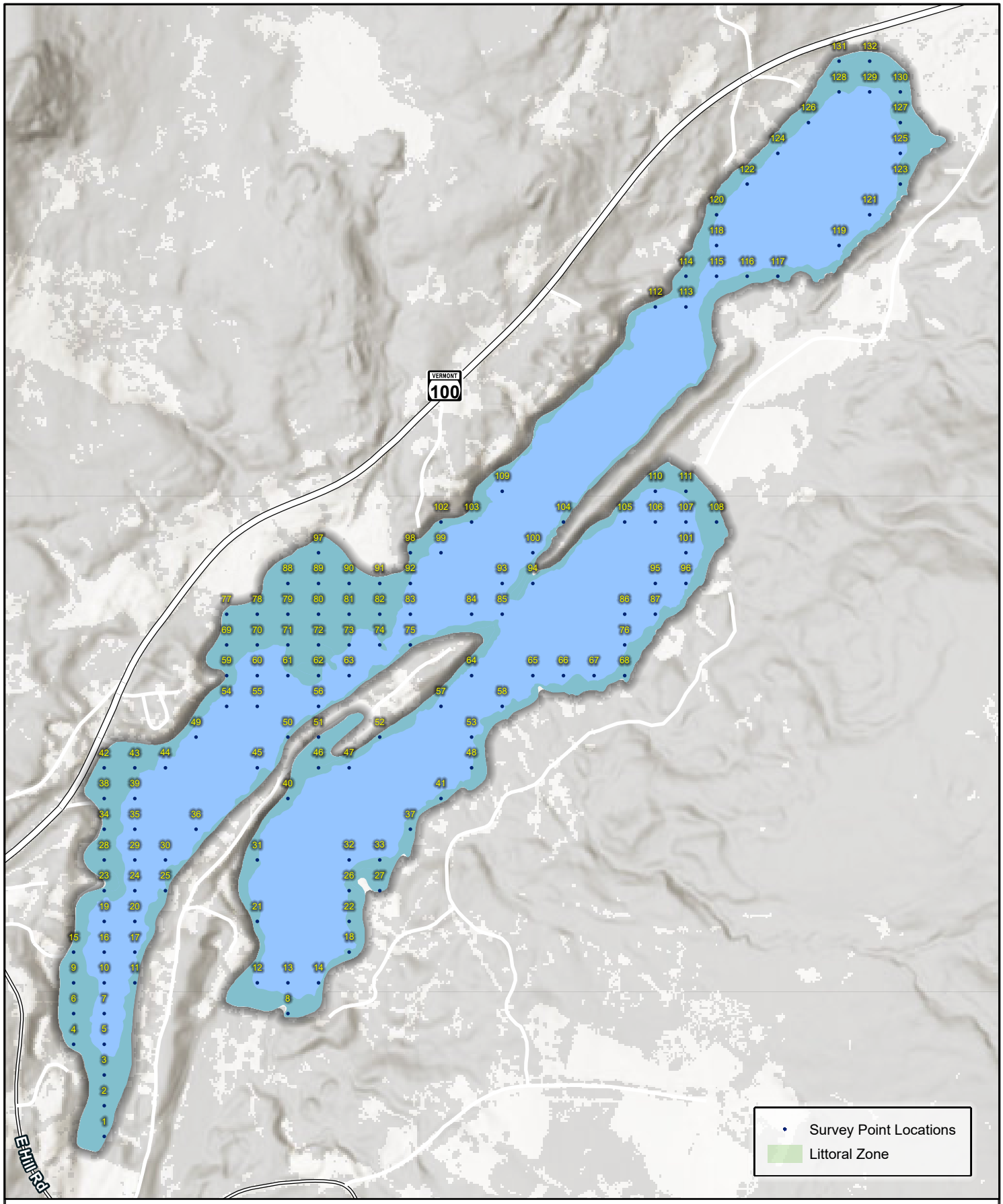
Appendix 1: Lake Eden Aquatic Sampling Rake Data

1=Single 2=Low 4=Moderate 4=High
** Points with no plants on rake are not shown*

Grid Point	Eleocharis acicularis	Elodea canadensis	Equisetum fluviatile	Eriocaulon aquaticum	Myriophyllum spicatum	Najas flexilis	Nitella spp.	Nymphaea odorata	Potamogeton amplifolius	Potamogeton berchtoldii	Potamogeton epihydrus	Potamogeton illinoensis	Potamogeton natans	Potamogeton robbinsii	Vallisneria americana
1	1														
6						2	2								
8		2						2				2		2	
23						1									
28														3	
34														2	
38														1	
41										1					
42														2	
51		2						2							
68		2												2	
69		2					2								
70					2										
77	2	2					0		2		2				
78							2							2	
79		2			2					2					
80							2			2					
88		2							2					2	
89														2	
90		2												2	
91							2								
97														3	
98		2						2			2				
108									2					3	
114		2									2				
116		2			2										
117											2				
123							2			2					
127		2					2						2	2	
131			0	2											
132		2									2			2	2

Appendix 2a: Lake Eden Grid Point Location Map

Appendix 2b: Lake Eden 2025 Post-Treatment Eurasian Watermilfoil Map



Lake Eden, Eden, Vt.

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Prepared By: A Worthley *WGS 1984 Web Mercator Auxiliary Sphere*

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0 300 600 900 1,200

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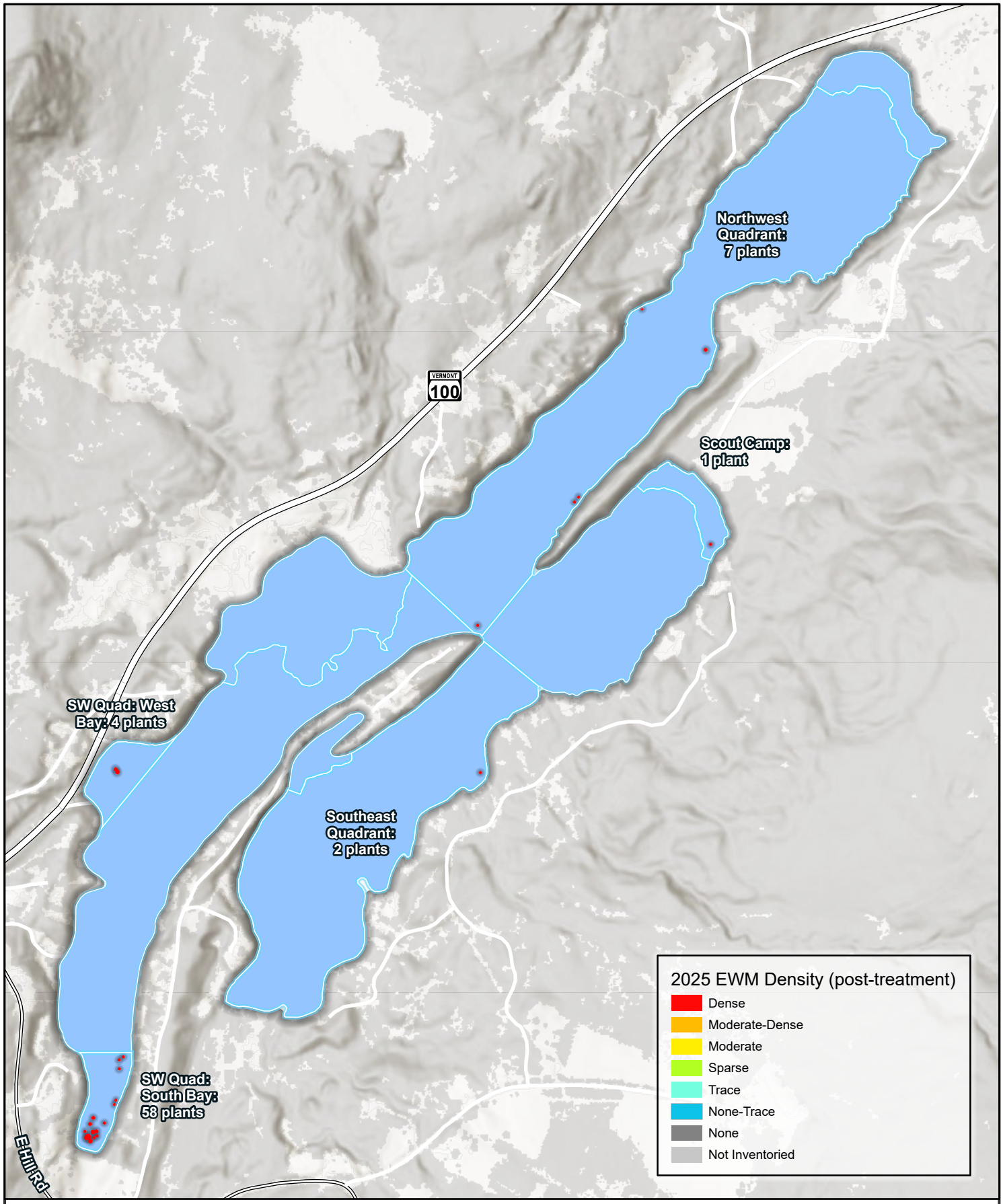

Lake Eden, Eden, Vt.

Friday, November 21, 2025 File: LakeEden:8.5x11 Report Appendix 2025

Prepared By: A Worthley *WGS 1984 Web Mercator Auxiliary Sphere*

0 300 600 900 1,200 Feet

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