

Lake Water Quality Program

Environmental Planning Initiatives



Aquatic Vegetation Mapping Report

Overview

The City of Greater Sudbury is home to over 330 freshwater lakes, more than any other municipality in Canada. These lakes provide citizens and tourists with a vast array of recreational opportunities as well as providing a source of clean drinking water to a large portion of the municipality. Over the last few decades our local lakes have come under threat of aquatic invasive species, such as Eurasian Watermilfoil. There are currently 18 lakes within City of Sudbury boundaries that are impacted with the growth of Eurasian Watermilfoil, a fast growing and dense aquatic vegetation species that has many negative effects on aquatic wildlife and recreational activities.

The City's Lake Water Quality Program has been involved in various education and awareness campaigns for aquatic invasive species for several years and continues to expand these efforts to ensure that residents are well-informed on this topic. In 2017, the Lake Water Quality Program revisited the original aquatic vegetation mapping program that was done on multiple lakes in the city in 2014 to enhance our understanding of the spread and impact of Eurasian Watermilfoil on local waterways. A new, more rigorous and robust sampling protocol was developed that results in mapping all aquatic plant species within the affected lakes. The protocol consists of systematic, quantitative and replicable sampling that allows the mapping and tracking of growth or declines of all aquatic plant species within the sampled lakes over time. The results of the sampling in 2017 on St. Charles Lake revealed a total of 18 aquatic plant species within the lake. Eurasian Watermilfoil (*Myriophyllum spicatum*) was the most frequent species recorded followed by the following native species: Muskgrass (*Chara spp.*), Slender Pondweed (*Potamogeton pusillus*) and Northern Watermilfoil (*Myriophyllum sibiricum*). In 2018, Richard Lake was surveyed and 15 species were recorded within the lake. The most frequent species recorded was native Muskgrass (*Chara spp.*) followed by Flat-Stem Pondweed (*Potamogeton zosterifolius*), Eurasian Watermilfoil (*Myriophyllum spicatum*) and Northern Watermilfoil (*Myriophyllum sibiricum*). This report provides details on the aquatic vegetation sampling efforts undertaken on these two lakes.

Methodology

The Lake Water Quality Program has based its aquatic vegetation sampling efforts on the baseline monitoring protocol developed by the Wisconsin Department of Natural Resources (Hauxwell et al, 2010). This protocol employs a point-intercept sampling design that overlays a number of geo-referenced points in a grid pattern over the lake to ensure that year over year results are comparable. The sampling protocol permits the assessment of all aquatic plant species as well as an estimation of species richness, frequency, abundance and maximum depth of colonization within the lake.

Aquatic Plant Distribution Maps

The protocol outlines the basic information needed to create an evenly distributed grid that is overlaid onto the lakes' littoral areas to ensure consistent mapping throughout the water body. The littoral areas of a lake are those where sunlight is able to penetrate down the sediment and, as a result, where the most abundant plant growth is found. The sampling protocol defines the littoral area as occurring in 6 meters of water depth at most.

Aquatic Vegetation Mapping Report

The sampling grid resolution was calculated from the following factors: 1) the lake's area in hectares, 2) the percentage of the lake's littoral area, and 3) the shoreline development factor or 'SDF'. The SDF is the ratio of the length of the shoreline to the circumference of a circle equal in area to that of the lake; it is not a measure of housing development on a given lake (Mikulyuketal et al, 2010). A higher SDF signals greater complexity of a given shoreline, which allows for increased development of the aquatic plant communities in the littoral area.

Following the protocol, the number of sampling locations on St. Charles Lake and Richard Lake were determined to be 304 points and 260 points, respectively (see Figures 1 and 2). The number of sampling points was then used to create an evenly disturbed grid onto the littoral areas of each lake. Each point is geo-referenced using NAD83 UTM coordinates (see Appendix A – Coordinates).

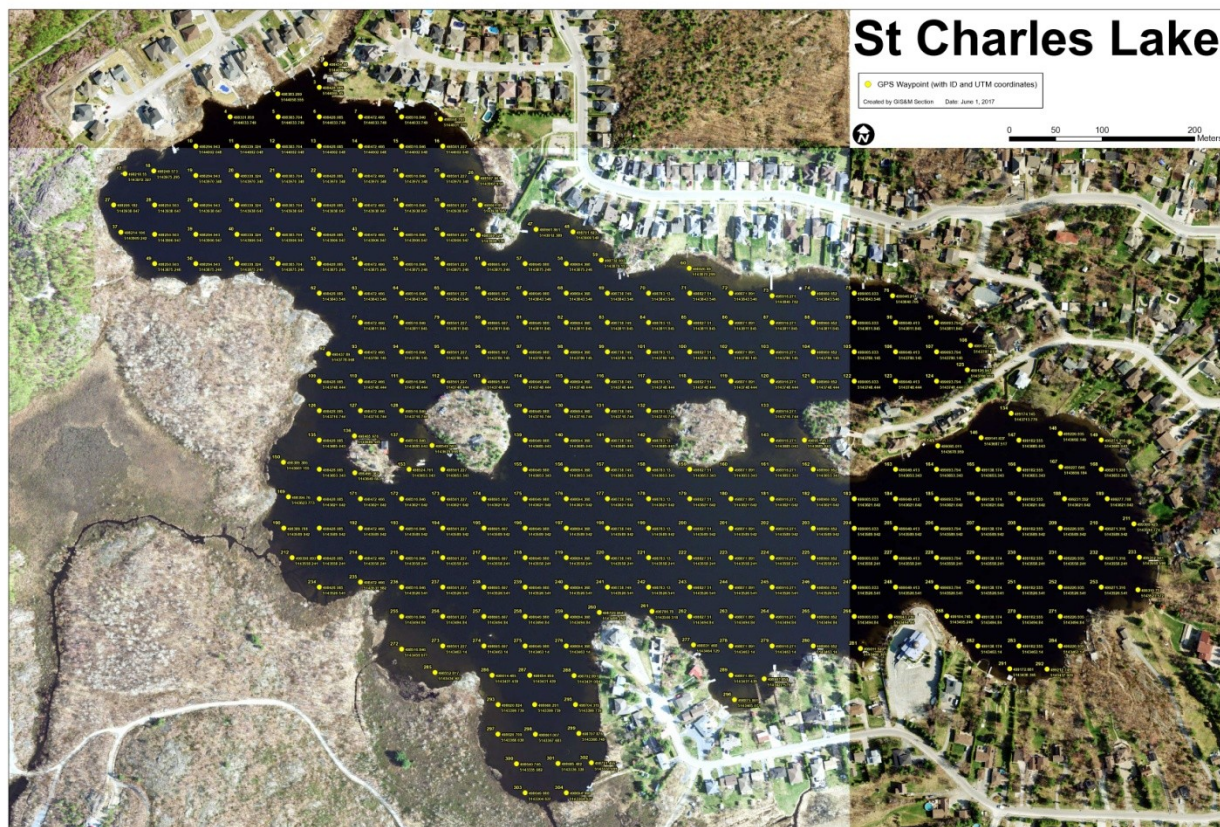


Figure 1. Map of the geo-referenced sampling points for St. Charles Lake.

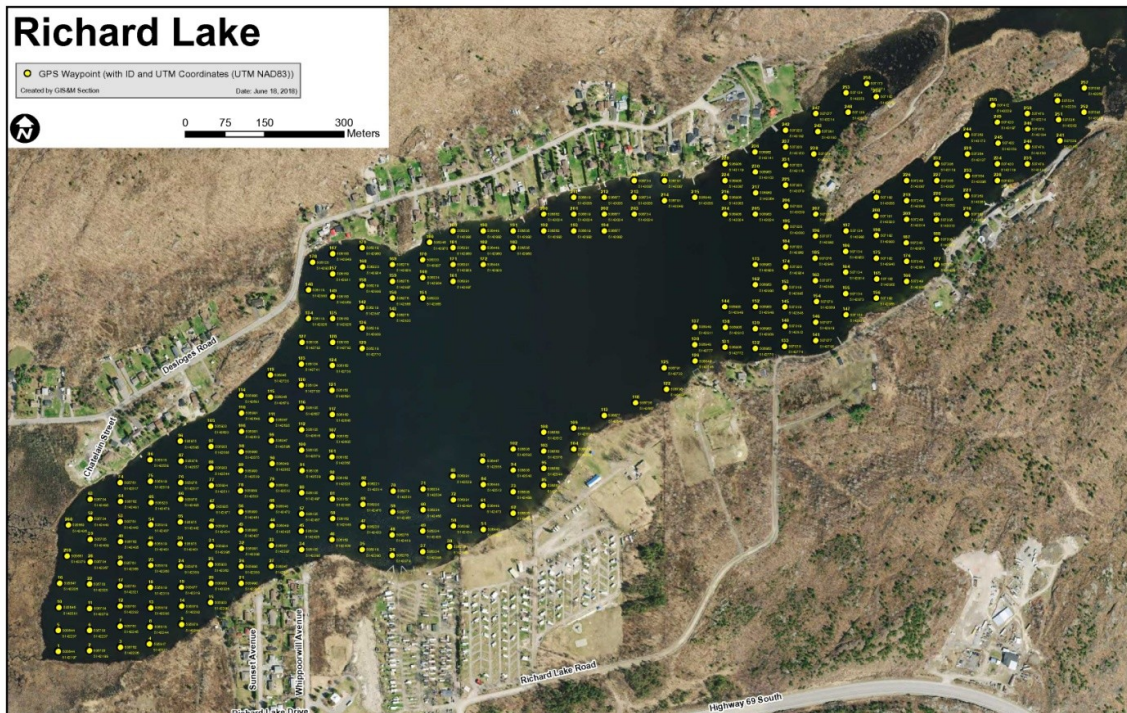


Figure 2. Map of the geo-referenced sampling points for Richard Lake. Following the protocol, areas greater than 6m in depth are not sampled.

Field Survey Techniques & Equipment

Field surveys for the aquatic vegetation mapping require relatively little equipment. Foremost is the rake sampler, which comes in many forms. The City uses the same rake sampler for each lake to ensure consistency. The rake sampler used is a 19-tine thatching rake with the head removed and secured to a 50' section of rope, see Figure 3. The thatching rake was selected for its double sided design, low cost and its ability to effectively remove and hold aquatic vegetation while sampling. A Garmin GPSMAP 64S handheld global positioning system, GPS, was used to navigate to each sampling location. The location reported by the GPS is accurate to within 15 meters and will generally have accuracy within 5 to 10 meters under normal conditions (Garmin Ltd. 2019).



Figure 3. City of Greater Sudbury modified thatching rake used for aquatic vegetation sampling.

Aquatic vegetation sampling on St. Charles Lake took place between July 31, 2017 and August 8, 2017 and Richard Lake sampling took place between August 1, 2018 and August 20, 2018. The sampling period ensured that the aquatic vegetation within the lake was near peak growth. At each sampling point, the rake was tossed into the water within 1-3 meters of the watercraft and dragged across the substrate before being pulled into the watercraft. Rake fullness was recorded starting in 2018 on Richard Lake to help determine density of plant growth at each site with species being recorded and identified. After each rake toss the watercraft was relocated to

compensate for any movement that may have occurred. A total of three (3) rake tosses were completed at each sampling point to ensure an accurate representation of plant species at each site.

The results from each lake were inputted into GIS software and overlaid on satellite imagery to create a visualization of the extent of each species within the water body. Maps of the aquatic plant species found in St. Charles Lake and Richard Lake can be found in Appendix B and C respectively.

Results

St. Charles Lake

A total of 304 points were sampled on St. Charles Lake from which a total of 18 aquatic plant species were recorded. The four most frequent species recorded were Eurasian Watermilfoil (*Myriophyllum spicatum*), and the following native species: Muskgrass (*Chara* spp.), Slender Pondweed (*Potamogeton pusillus*) and Northern Watermilfoil (*Myriophyllum sibiricum*). Table 1 lists the aquatic plant species recorded and their frequency of occurrence.

Table 1. Aquatic plant species recorded in St. Charles Lake in 2017.

Common Name	Scientific Name	# of sampling points where present	% of sampling points
Eurasian Watermilfoil	<i>Myriophyllum spicatum</i>	197	64.8%
Muskgrass	<i>Chara</i> spp.	161	53.0%
Slender Pondweed	<i>Potamogeton pusillus</i>	154	50.7%
Northern Watermilfoil	<i>Myriophyllum sibiricum</i>	103	33.9%
Largeleaf Pondweed	<i>Potamogeton amplifolius</i>	24	7.9%
Slender Watermilfoil	<i>Myriophyllum tenellum</i>	23	7.6%
Common Pipewort	<i>Eriocaulon aquaticum</i>	20	6.6%
Spiny-spore Quillwort	<i>Isoetes echinospora</i>	10	3.3%
Yellow Waterlily	<i>Nuphar lutea</i>	8	2.6%
White Waterlily	<i>Nymphaea odorata</i>	7	2.3%
Richardsons Pondweed	<i>Potamogeton richardsonii</i>	6	2.0%
Nodding Waternymph	<i>Najas flexilis</i>	3	1.0%
Canadian Waterweed	<i>Elodea canadensis</i>	2	0.7%
Wild Celery	<i>Vallisneria americana</i>	2	0.7%
Watershield	<i>Brasenia schreberi</i>	1	0.3%
Water Smartweed	<i>Persicaria amphibia</i>	1	0.3%
Sweet Gale	<i>Myrica gale</i>	1	0.3%
Leafy Pondweed	<i>Potamogeton foliosus</i>	1	0.3%

The presence/absence for each species on St. Charles Lake was compiled and overlaid onto geo-referenced satellite imagery. These data were then projected onto a map to show the total extent of each aquatic species throughout the lake. These maps can be found in Appendix B – St. Charles Lake Vegetation Mapping Results.

The species information collected on St. Charles Lake helps shed light on the extent of the growth of Eurasian Watermilfoil in the lake and whether this invasive aquatic plant is having a negative impact on the native aquatic plants within the lake. The results indicate that at 57% of the sampling points there was a mixture of Eurasian Watermilfoil and native species growing together, at 8% of the sampling points Eurasian Watermilfoil was recorded exclusively, at 8% of sampling points no aquatic plants were recorded and at 27% of sampling points only native aquatic species were recorded. See Table 2 for full details below.

Table 2. Composition of native and invasive aquatic vegetation throughout St. Charles Lake.

	Eurasian Watermilfoil Only	Native Species Only	Mixture of Eurasian Watermilfoil & Native Species	No Vegetation Present
# of sampling points	24	81	173	26
% of Lake	7.9%	26.6%	56.9%	8.6%

Richard Lake

A total of 260 points were sampled in Richard Lake in 2018. At each sampling point, the 'rake fullness' was estimated and the dominant species was noted, as long as dominance was clearly observable. A total of 14 aquatic plant species were recorded of which the following four species were most common: Muskgrass (*Chara* spp.), Flat-stem Pondweed (*Potamogeton zosterifolius*), Eurasian Watermilfoil (*Myriophyllum spicatum*) and Northern Watermilfoil (*Myriophyllum sibiricum*) respectively. A list of the aquatic species recorded along with the total number of sampling points at which each was found is presented on Table 3.

Maps of the presence/absence for each species on Richard Lake can be found in Appendix C – Richard Lake Vegetation Mapping Results. Additionally, maps were created to show the dominant species at each sampling point (Figure 4), along with the density of the plant growth at each point (Figure 5), and a map detailing the sampling points where invasive Eurasian Watermilfoil and native Northern Watermilfoil are growing together or separately (Figure 6).

The species information collected on Richard Lake will serve as a baseline for comparisons with future aquatic plant surveys in the lake and will assist in determining if Eurasian Water-milfoil is having a negative impact on the native aquatic species within the lake. Data collected in 2018 show that at 22% of the sampling points there was a mixture of both native aquatic species and the invasive Eurasian Watermilfoil, at 44% of sampling points no aquatic plant growth was recorded, at 32% of the sampling points only native species occurred and at only 2% of the sampling points Eurasian Watermilfoil grew exclusively (Table 4).

Table 3. Frequency of aquatic plant species recorded in Richard Lake in 2018.

Common Name	Scientific Name	# of sampling points where present	% of sampling points
Muskgrass/Stonewort	Chara spp.	77	29.6%
Flat-Stem Pondweed	Potamogeton zosterifolius	73	28.1%
Eurasian watermilfoil	Myriophyllum spicatum	64	24.6%
Northern watermilfoil	Myriophyllum sibiricum	56	21.5%
Richardson's pondweed	Potamogeton richardsonii	39	15.0%
Nitella spp	Nitella spp.	19	7.3%
Largeleaf pondweed	Potamogeton amplifolius	18	6.9%
Spiny-spored quillwort	Isoetes echinospora	16	6.2%
Slender Naiad	Najas flexilis	12	4.6%
White water-lily	Nymphaea odorata	7	2.7%
Slender pondweed	Potamogeton pusillus	5	1.9%
Canada Waterweed	Elodea canadensis	3	1.2%
Tapegrass	Vallisneria americana	3	1.2%
Illinois pondweed	Potamogeton illinoensis	1	0.4%

Table 4. Composition of native and invasive aquatic vegetation in Richard Lake in 2018.

	Eurasian Watermilfoil Only	Native Species Only	Mixture of Eurasian Watermilfoil & Native Species	No Vegetation Present
# of sampling points	6	83	58	113
% of Sites on Lake	2.3%	31.9%	22.3%	43.5%

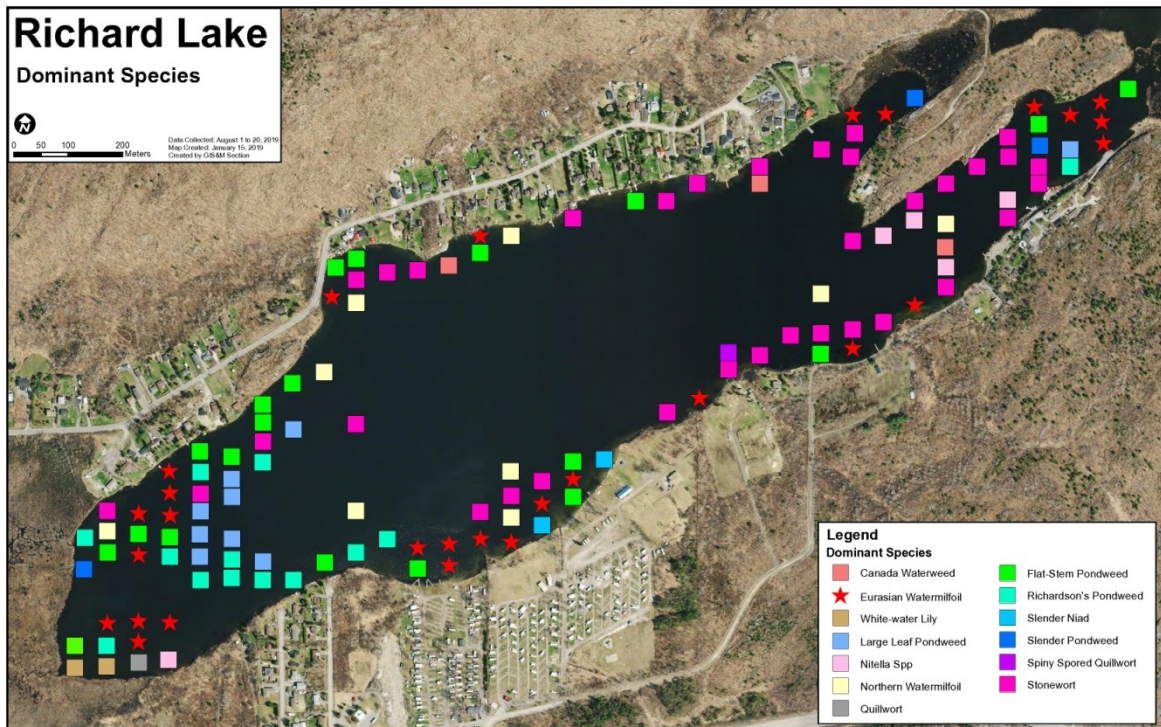


Figure 4. Dominant species on Richard Lake in August 2018. Invasive Eurasian Watermilfoil identified by the red star. Areas without a noticeably dominant species are blank.

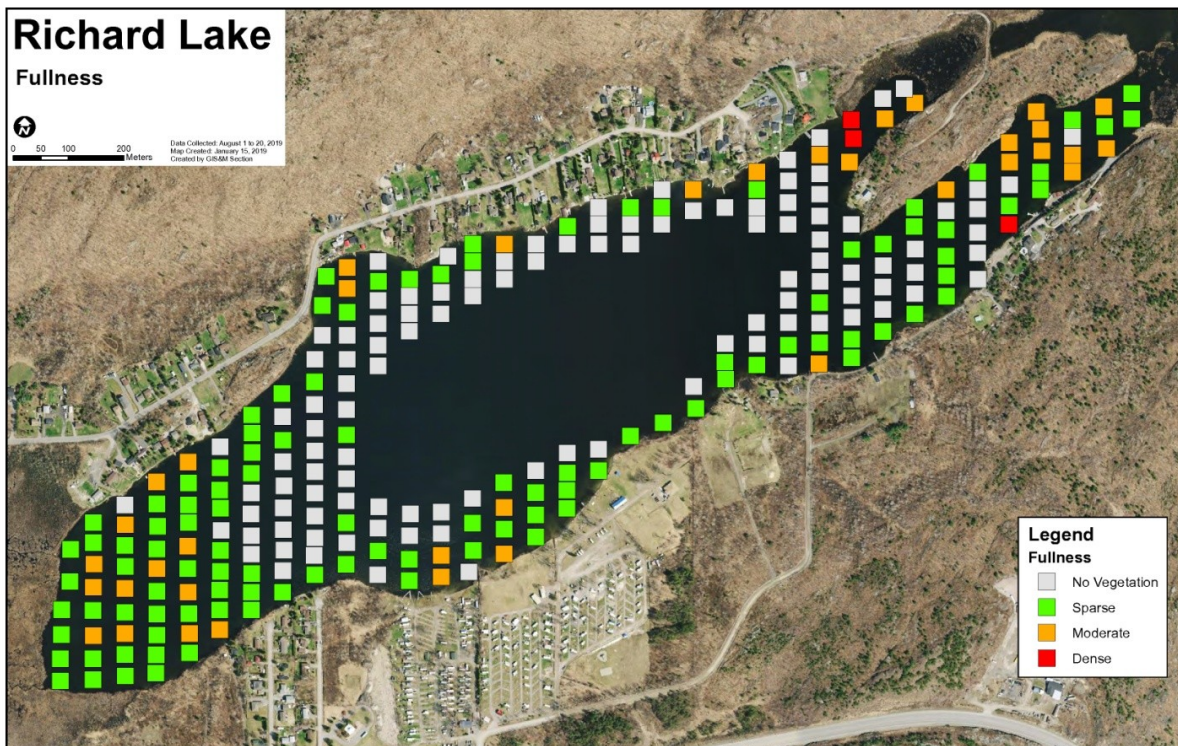


Figure 5. Fullness/Density of aquatic vegetation plant growth on Richard Lake, August 2018.

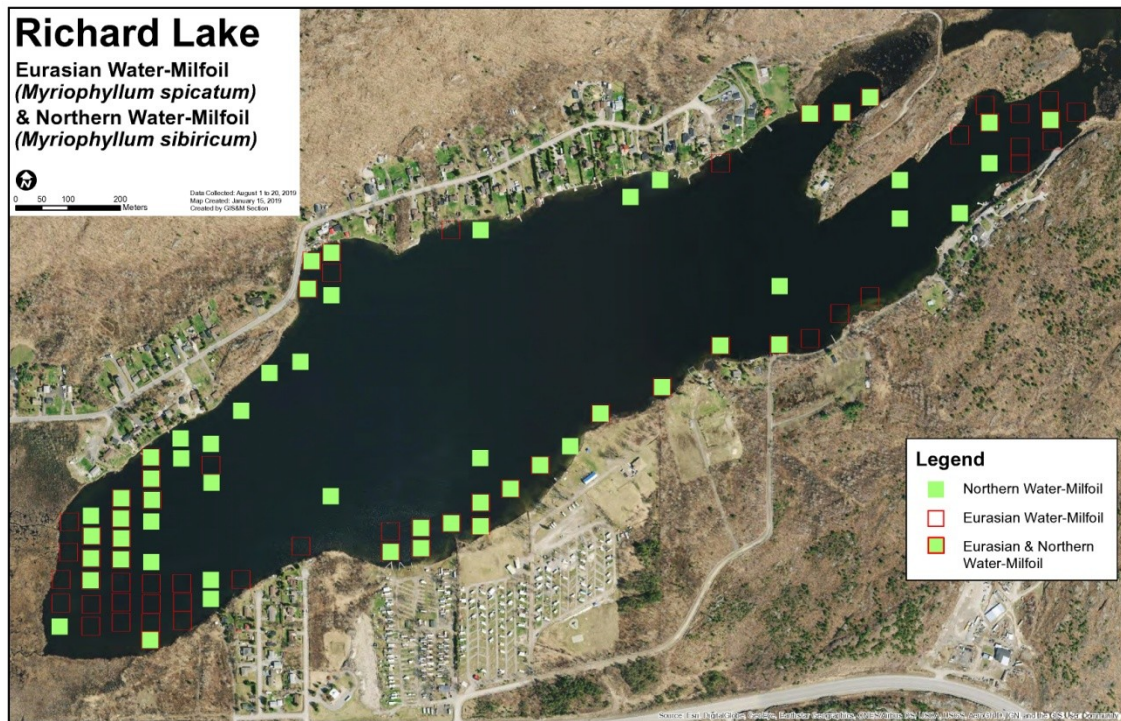


Figure 5. Occurrences of Eurasian Watermilfoil and Northern Watermilfoil in Richard Lake, August 2018.

Conclusion

The 2017 and 2018 aquatic vegetation mapping project on St. Charles Lake and Richard Lake has created a robust baseline for aquatic vegetation populations within these two area lakes. The data collected through this mapping project have helped in understanding the current extent of Eurasian Watermilfoil in St. Charles and Richard Lake and have provided information regarding species richness within these water bodies.

Most revealing to date is the relatively high number of sampling points where only native species were recorded. On both lakes this number is above 25% while the areas with monoculture stands of exclusively Eurasian Watermilfoil is below 8% on St. Charles Lake and just above 2% on Richard Lake. These results show that, although the Eurasian Watermilfoil is persistent within these water bodies, this invasive species does not appear to have established in large, widespread monospecific stands. The data also indicate that there are many sites that contain both Eurasian Watermilfoil and the native Northern Watermilfoil along with other native species.

These initial aquatic vegetation mapping surveys will serve as a baseline for future mapping efforts to reveal the dynamics of growth or decline of both Eurasian Watermilfoil and native aquatic plants in these lakes. Aquatic vegetation mapping will continue on other lakes that are affected by Eurasian Watermilfoil to serve as baselines for monitoring aquatic plant species within City lakes.

Sources

Hauxwell, J., S. Knight, K. Wagner, A. Mikulyuk, M. Nault, M. Porzky and S. Chase. 2010. Recommended baseline monitoring of aquatic plants in Wisconsin: sampling design, field and laboratory procedures, data entry and analysis, and applications. Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1068 2010. Madison, Wisconsin, USA

Garmin Ltd. "GPS Accuracy." GPS Accuracy, 2019, support.garmin.com/en-CA/?faq=aZc8RezeAb9LjCDpJpITY7.

Mikulyuk A, Hauxwell J, Rassmussen P, Knight S, Wagner KI, Nault ME, Ridgely D. 2010. Testing a methodology for assessing plant communities in temperate inland lakes. *Lake Reserv Manage* 26:54–62.

Appendix A

Coordinates

St. Charles Lake Waypoints 1/2

ID	UTM NAD83 (Easting)	UTM NAD83 (Northing)	Date Sampled
1	498434.980	5144090.661	8-Aug-17
2	498383.299	5144058.555	8-Aug-17
3	498428.085	5144065.450	8-Aug-17
4	498331.859	5144033.749	8-Aug-17
5	498383.704	5144033.749	8-Aug-17
6	498428.085	5144033.749	8-Aug-17
7	498472.466	5144033.749	8-Aug-17
8	498516.846	5144033.749	8-Aug-17
9	498558.793	5144031.316	8-Aug-17
10	498294.943	5144002.048	7-Aug-17
11	498339.324	5144002.048	7-Aug-17
12	498383.704	5144002.048	7-Aug-17
13	498428.085	5144002.048	7-Aug-17
14	498472.466	5144002.048	7-Aug-17
15	498516.846	5144002.048	7-Aug-17
16	498561.227	5144002.048	7-Aug-17
17	498218.550	5143972.327	7-Aug-17
18	498249.573	5143975.295	7-Aug-17
19	498294.943	5143970.348	7-Aug-17
20	498339.324	5143970.348	7-Aug-17
21	498383.704	5143970.348	7-Aug-17
22	498428.085	5143970.348	7-Aug-17
23	498472.466	5143970.348	7-Aug-17
24	498516.846	5143970.348	7-Aug-17
25	498561.227	5143970.348	7-Aug-17
26	498597.901	5143967.914	7-Aug-17
27	498206.182	5143938.647	7-Aug-17
28	498250.563	5143938.647	7-Aug-17
29	498294.943	5143938.647	7-Aug-17
30	498339.324	5143938.647	7-Aug-17
31	498383.704	5143938.647	7-Aug-17
32	498428.085	5143938.647	7-Aug-17
33	498472.466	5143938.647	7-Aug-17
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35	498561.227	5143938.647	7-Aug-17
36	498601.650	5143938.647	7-Aug-17
37	498214.106	5143909.242	7-Aug-17
38	498250.563	5143906.947	7-Aug-17
39	498294.943	5143906.947	7-Aug-17
40	498339.324	5143906.947	7-Aug-17
41	498383.704	5143906.947	7-Aug-17
42	498428.085	5143906.947	7-Aug-17
43	498472.466	5143906.947	7-Aug-17
44	498516.846	5143906.947	7-Aug-17
45	498561.227	5143906.947	7-Aug-17
46	498599.524	5143906.136	7-Aug-17
47	498661.861	5143912.389	7-Aug-17
48	498701.623	5143909.548	7-Aug-17
49	498250.563	5143875.246	7-Aug-17
50	498294.943	5143875.246	7-Aug-17
51	498339.324	5143875.246	7-Aug-17

ID	UTM NAD83 (Easting)	UTM NAD83 (Northing)	Date Sampled
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53	498428.085	5143875.246	7-Aug-17
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55	498516.846	5143875.246	7-Aug-17
56	498561.227	5143875.246	7-Aug-17
57	498649.988	5143875.246	7-Aug-17
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59	498732.002	5143879.153	7-Aug-17
60	498826.890	5143870.299	8-Aug-17
61	498605.607	5143875.246	7-Aug-17
62	498428.085	5143843.546	7-Aug-17
63	498472.466	5143843.546	7-Aug-17
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69	498738.749	5143843.546	7-Aug-17
70	498783.130	5143843.546	7-Aug-17
71	498827.510	5143843.546	7-Aug-17
72	498871.891	5143843.546	7-Aug-17
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77	498472.466	5143811.845	7-Aug-17
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80	498605.607	5143811.845	7-Aug-17
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85	498827.510	5143811.845	7-Aug-17
86	498871.891	5143811.845	7-Aug-17
87	498916.271	5143811.845	7-Aug-17
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99	498738.749	5143780.145	3-Aug-17
100	498827.510	5143780.145	3-Aug-17
101	498783.130	5143780.145	3-Aug-17
102	498871.891	5143780.145	3-Aug-17

ID	UTM NAD83 (Easting)	UTM NAD83 (Northing)	Date Sampled
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112	498561.227	5143748.444	3-Aug-17
113	498605.607	5143748.444	3-Aug-17
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118	498827.510	5143748.444	3-Aug-17
119	498871.891	5143748.444	3-Aug-17
120	498916.271	5143748.444	3-Aug-17
121	498960.652	5143748.444	3-Aug-17
122	499005.033	5143748.444	3-Aug-17
123	499049.413	5143748.444	3-Aug-17
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129	498649.988	5143716.744	8-Aug-17
130	498694.368	5143716.744	8-Aug-17
131	498738.749	5143716.744	8-Aug-17
132	498783.130	5143716.744	8-Aug-17
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138	498549.563	5143679.098	8-Aug-17
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140	498694.368	5143685.043	8-Aug-17
141	498738.749	5143685.043	8-Aug-17
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145	499095.011	5143678.959	3-Aug-17
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147	499182.555	5143685.043	3-Aug-17
148	499226.935	5143692.146	3-Aug-17
149	499271.316	5143685.043	3-Aug-17
150	498389.386	5143661.155	3-Aug-17
151	498428.085	5143653.343	3-Aug-17
152	498466.382	5143649.693	3-Aug-17
153	498524.761	5143653.343	3-Aug-17

St. Charles Lake Waypoints 2/2

ID	UTM NAD83 (Easting)	UTM NAD83 (Northing)	Date Sampled	ID	UTM NAD83 (Easting)	UTM NAD83 (Northing)	Date Sampled	ID	UTM NAD83 (Easting)	UTM NAD83 (Northing)	Date Sampled
154	498561.227	5143653.343	3-Aug-17	205	499049.413	5143589.942	2-Aug-17	256	498561.227	5143494.840	2-Aug-17
155	498649.988	5143653.343	3-Aug-17	206	499093.794	5143589.942	2-Aug-17	257	498605.607	5143494.840	2-Aug-17
156	498694.368	5143653.343	3-Aug-17	207	499138.174	5143589.942	2-Aug-17	258	498649.988	5143494.840	2-Aug-17
157	498738.749	5143653.343	3-Aug-17	208	499182.555	5143589.942	2-Aug-17	259	498694.368	5143494.840	2-Aug-17
158	498783.130	5143653.343	3-Aug-17	209	499226.935	5143589.942	2-Aug-17	260	498729.964	5143499.252	2-Aug-17
159	498827.510	5143653.343	3-Aug-17	210	499271.316	5143589.942	2-Aug-17	261	498786.780	5143500.518	2-Aug-17
160	498871.891	5143653.343	3-Aug-17	211	499306.425	5143594.774	2-Aug-17	262	498827.510	5143494.840	2-Aug-17
161	498916.271	5143653.343	3-Aug-17	212	498398.693	5143558.241	2-Aug-17	263	498871.891	5143494.840	2-Aug-17
162	498960.652	5143653.343	3-Aug-17	213	498428.085	5143558.241	2-Aug-17	264	498916.271	5143494.840	2-Aug-17
163	499049.413	5143653.343	3-Aug-17	214	498472.466	5143558.241	2-Aug-17	265	498960.652	5143494.840	2-Aug-17
164	499093.794	5143653.343	3-Aug-17	215	498516.846	5143558.241	2-Aug-17	266	499005.033	5143494.840	2-Aug-17
165	499138.174	5143653.343	3-Aug-17	216	498561.227	5143558.241	2-Aug-17	267	499043.735	5143494.840	2-Aug-17
166	499182.555	5143653.343	3-Aug-17	217	498605.607	5143558.241	2-Aug-17	268	499104.745	5143495.246	2-Aug-17
167	499227.646	5143656.184	3-Aug-17	218	498649.988	5143558.241	2-Aug-17	269	499138.174	5143494.840	2-Aug-17
168	499271.316	5143653.343	3-Aug-17	219	498694.368	5143558.241	2-Aug-17	270	499182.555	5143494.840	2-Aug-17
169	498394.760	5143623.773	3-Aug-17	220	498738.749	5143558.241	2-Aug-17	271	499226.935	5143494.840	2-Aug-17
170	498428.085	5143621.642	3-Aug-17	221	498783.130	5143558.241	2-Aug-17	272	498516.846	5143459.677	2-Aug-17
171	498472.466	5143621.642	3-Aug-17	222	498827.510	5143558.241	2-Aug-17	273	498561.227	5143463.140	2-Aug-17
172	498516.846	5143621.642	3-Aug-17	223	498871.891	5143558.241	2-Aug-17	274	498605.607	5143463.140	2-Aug-17
173	498561.227	5143621.642	3-Aug-17	224	498916.271	5143558.241	2-Aug-17	275	498649.988	5143463.140	2-Aug-17
174	498605.607	5143621.642	3-Aug-17	225	498960.652	5143558.241	2-Aug-17	276	498694.368	5143463.140	2-Aug-17
175	498649.988	5143621.642	3-Aug-17	226	499005.033	5143558.241	2-Aug-17	277	498831.468	5143464.129	2-Aug-17
176	498694.368	5143621.642	3-Aug-17	227	499049.413	5143558.241	2-Aug-17	278	498871.891	5143463.140	1-Aug-17
177	498738.749	5143621.642	3-Aug-17	228	499093.794	5143558.241	2-Aug-17	279	498916.271	5143463.140	1-Aug-17
178	498783.130	5143621.642	3-Aug-17	229	499138.174	5143558.241	2-Aug-17	280	498960.652	5143463.140	1-Aug-17
179	498827.510	5143621.642	3-Aug-17	230	499182.555	5143558.241	2-Aug-17	281	499011.522	5143460.301	1-Aug-17
180	498871.891	5143621.642	3-Aug-17	231	499226.935	5143558.241	2-Aug-17	282	499138.174	5143463.140	1-Aug-17
181	498916.271	5143621.642	3-Aug-17	232	499271.316	5143558.241	2-Aug-17	283	499182.555	5143463.140	1-Aug-17
182	498960.652	5143621.642	3-Aug-17	233	499312.501	5143558.596	2-Aug-17	284	499226.935	5143463.140	1-Aug-17
183	499005.033	5143621.642	3-Aug-17	234	498428.085	5143526.541	2-Aug-17	285	498552.817	5143434.407	1-Aug-17
184	499049.413	5143621.642	3-Aug-17	235	498472.466	5143531.982	2-Aug-17	286	498614.485	5143431.439	1-Aug-17
185	499093.794	5143621.642	3-Aug-17	236	498516.846	5143526.541	2-Aug-17	287	498654.959	5143431.439	1-Aug-17
186	499138.174	5143621.642	3-Aug-17	237	498561.227	5143526.541	2-Aug-17	288	498702.891	5143431.084	1-Aug-17
187	499182.555	5143621.642	3-Aug-17	238	498605.607	5143526.541	2-Aug-17	289	498871.891	5143431.439	1-Aug-17
188	499231.552	5143621.642	3-Aug-17	239	498649.988	5143526.541	2-Aug-17	290	498907.859	5143427.579	1-Aug-17
189	499277.708	5143621.642	3-Aug-17	240	498694.368	5143526.541	2-Aug-17	291	499172.661	5143438.365	1-Aug-17
190	498389.788	5143589.942	2-Aug-17	241	498738.749	5143526.541	2-Aug-17	292	499212.749	5143437.929	1-Aug-17
191	498428.085	5143589.942	2-Aug-17	242	498783.130	5143526.541	2-Aug-17	293	498620.824	5143399.739	1-Aug-17
192	498472.466	5143589.942	2-Aug-17	243	498827.510	5143526.541	2-Aug-17	294	498660.291	5143399.739	1-Aug-17
193	498516.846	5143589.942	2-Aug-17	244	498871.891	5143526.541	2-Aug-17	295	498704.315	5143399.739	1-Aug-17
194	498561.227	5143589.942	2-Aug-17	245	498916.271	5143526.541	2-Aug-17	296	498875.801	5143405.071	1-Aug-17
195	498605.607	5143589.942	2-Aug-17	246	498960.652	5143526.541	2-Aug-17	297	498620.709	5143368.038	31-Jul-17
196	498649.988	5143589.942	2-Aug-17	247	499005.033	5143526.541	2-Aug-17	298	498661.007	5143367.683	31-Jul-17
197	498694.368	5143589.942	2-Aug-17	248	499049.413	5143526.541	2-Aug-17	299	498707.876	5143368.749	31-Jul-17
198	498738.749	5143589.942	2-Aug-17	249	499093.794	5143526.541	2-Aug-17	300	498640.746	5143335.982	31-Jul-17
199	498783.130	5143589.942	2-Aug-17	250	499138.174	5143526.541	2-Aug-17	301	498685.482	5143336.338	31-Jul-17
200	498827.510	5143589.942	2-Aug-17	251	499182.555	5143526.541	2-Aug-17	302	498721.455	5143337.099	31-Jul-17
201	498871.891	5143589.942	2-Aug-17	252	499226.935	5143526.541	2-Aug-17	303	498649.988	5143304.637	31-Jul-17
202	498916.271	5143589.942	2-Aug-17	253	499271.316	5143526.541	2-Aug-17	304	498694.368	5143304.637	31-Jul-17
203	498960.652	5143589.942	2-Aug-17	254	499310.750	5143523.572	2-Aug-17				
204	499005.033	5143589.942	2-Aug-17	255	498516.846	5143494.840	2-Aug-17				

Richard Lake Waypoints 1/2

ID	UTM NAD83 (Easting)	UTM NAD83 (Northing)	Date Sampled
1	505644	5142197	1-Aug-18
2	505703	5142199	1-Aug-18
3	505762	5142206	1-Aug-18
4	505817	5142211	1-Aug-18
5	505644	5142237	1-Aug-18
6	505703	5142237	1-Aug-18
7	505761	5142245	1-Aug-18
8	505818	5142244	1-Aug-18
9	505878	5142248	1-Aug-18
10	505646	5142281	1-Aug-18
11	505704	5142279	1-Aug-18
12	505761	5142283	1-Aug-18
13	505819	5142280	1-Aug-18
14	505878	5142283	1-Aug-18
15	505933	5142290	1-Aug-18
16	505647	5142326	1-Aug-18
17	505761	5142321	1-Aug-18
18	505819	5142318	1-Aug-18
19	505877	5142319	1-Aug-18
20	505933	5142326	1-Aug-18
21	505990	5142326	1-Aug-18
22	505703	5142325	1-Aug-18
23	505819	5142360	1-Aug-18
24	505876	5142358	1-Aug-18
25	505933	5142362	1-Aug-18
26	505990	5142358	1-Aug-18
27	506047	5142358	8-Aug-18
28	505704	5142367	1-Aug-18
29	505761	5142365	1-Aug-18
30	505875	5142401	1-Aug-18
31	505934	5142396	1-Aug-18
32	505991	5142392	1-Aug-18
33	506047	5142397	8-Aug-18
34	506105	5142390	8-Aug-18
35	506219	5142390	8-Aug-18
36	506276	5142379	9-Aug-18
37	506334	5142386	9-Aug-18
38	506384	5142395	9-Aug-18
39	505705	5142409	1-Aug-18
40	505762	5142405	1-Aug-18
41	505819	5142401	1-Aug-18
42	505934	5142434	8-Aug-18
43	505990	5142427	8-Aug-18
44	506049	5142435	8-Aug-18
45	506104	5142425	8-Aug-18
46	506162	5142409	8-Aug-18
47	506220	5142433	8-Aug-18
48	506276	5142418	9-Aug-18
49	506334	5142425	15-Aug-18
50	506392	5142434	9-Aug-18

ID	UTM NAD83 (Easting)	UTM NAD83 (Northing)	Date Sampled
51	506448	5142428	9-Aug-18
52	505704	5142448	1-Aug-18
53	505761	5142443	1-Aug-18
54	505819	5142437	1-Aug-18
55	505875	5142442	8-Aug-18
56	505990	5142461	8-Aug-18
57	506105	5142457	8-Aug-18
58	506163	5142448	8-Aug-18
59	506277	5142461	9-Aug-18
60	506334	5142465	15-Aug-18
61	506448	5142473	15-Aug-18
62	506505	5142459	9-Aug-18
63	505704	5142485	8-Aug-18
64	505762	5142481	8-Aug-18
65	505820	5142478	8-Aug-18
66	505876	5142485	8-Aug-18
67	505935	5142471	8-Aug-18
68	506048	5142472	8-Aug-18
69	506220	5142475	8-Aug-18
70	506278	5142501	9-Aug-18
71	506334	5142504	15-Aug-18
72	506391	5142484	15-Aug-18
73	506505	5142499	9-Aug-18
74	505761	5142517	8-Aug-18
75	505819	5142519	8-Aug-18
76	505876	5142517	8-Aug-18
77	505934	5142511	8-Aug-18
78	505989	5142501	8-Aug-18
79	506048	5142512	8-Aug-18
80	506105	5142497	8-Aug-18
81	506162	5142485	8-Aug-18
82	506221	5142514	8-Aug-18
83	506391	5142529	15-Aug-18
84	506448	5142513	15-Aug-18
85	506562	5142511	9-Aug-18
86	505818	5142559	8-Aug-18
87	505876	5142557	8-Aug-18
88	505933	5142544	8-Aug-18
89	505990	5142539	8-Aug-18
90	506049	5142552	8-Aug-18
91	506105	5142539	8-Aug-18
92	506162	5142525	8-Aug-18
93	506447	5142558	15-Aug-18
94	506505	5142540	15-Aug-18
95	506562	5142544	9-Aug-18
96	505875	5142595	8-Aug-18
97	505933	5142585	8-Aug-18
98	505990	5142575	8-Aug-18
99	506047	5142596	8-Aug-18
100	506105	5142578	8-Aug-18

ID	UTM NAD83 (Easting)	UTM NAD83 (Northing)	Date Sampled
101	506162	5142565	8-Aug-18
102	506505	5142580	15-Aug-18
103	506562	5142576	15-Aug-18
104	506619	5142580	9-Aug-18
105	505933	5142623	8-Aug-18
106	505991	5142613	8-Aug-18
107	506162	5142605	8-Aug-18
108	506562	5142612	15-Aug-18
109	506619	5142619	9-Aug-18
110	505991	5142648	8-Aug-18
111	506047	5142635	8-Aug-18
112	506105	5142616	8-Aug-18
113	506677	5142643	9-Aug-18
114	505990	5142681	8-Aug-18
115	506046	5142678	8-Aug-18
116	506105	5142657	8-Aug-18
117	506162	5142645	8-Aug-18
118	506736	5142667	9-Aug-18
119	506045	5142720	8-Aug-18
120	506104	5142700	8-Aug-18
121	506162	5142691	8-Aug-18
122	506795	5142693	9-Aug-18
123	506104	5142741	8-Aug-18
124	506162	5142738	8-Aug-18
125	506791	5142733	9-Aug-18
126	506849	5142746	9-Aug-18
127	506105	5142782	8-Aug-18
128	506163	5142782	8-Aug-18
129	506219	5142770	9-Aug-18
130	506848	5142777	9-Aug-18
131	506906	5142772	9-Aug-18
132	506963	5142770	15-Aug-18
133	507018	5142774	15-Aug-18
134	506118	5142826	8-Aug-18
135	506163	5142826	8-Aug-18
136	506219	5142808	9-Aug-18
137	506848	5142811	9-Aug-18
138	506906	5142810	9-Aug-18
139	506963	5142808	15-Aug-18
140	507019	5142812	15-Aug-18
141	507077	5142785	20-Aug-18
142	506219	5142847	9-Aug-18
143	506276	5142833	9-Aug-18
144	506905	5142849	9-Aug-18
145	507019	5142848	15-Aug-18
146	507077	5142819	20-Aug-18
147	507134	5142833	20-Aug-18
148	506118	5142880	8-Aug-18
149	506163	5142868	8-Aug-18
150	506276	5142865	9-Aug-18

Richard Lake Waypoints 2/2

ID	UTM NAD83 (Easting)	UTM NAD83 (Northing)	Date Sampled
151	506333	5142865	15-Aug-18
152	506963	5142849	15-Aug-18
153	507019	5142885	15-Aug-18
154	507078	5142859	20-Aug-18
155	507134	5142873	20-Aug-18
156	507192	5142865	20-Aug-18
157	506163	5142911	8-Aug-18
158	506219	5142889	9-Aug-18
159	506276	5142897	9-Aug-18
160	506334	5142904	15-Aug-18
161	506391	5142897	15-Aug-18
162	506963	5142890	15-Aug-18
163	507077	5142898	15-Aug-18
164	507134	5142914	20-Aug-18
165	507192	5142902	20-Aug-18
166	507249	5142897	20-Aug-18
167	506163	5142949	8-Aug-18
168	506220	5142924	9-Aug-18
169	506276	5142928	9-Aug-18
170	506333	5142937	15-Aug-18
171	506391	5142928	15-Aug-18
172	506448	5142928	15-Aug-18
173	506963	5142928	15-Aug-18
174	507020	5142924	15-Aug-18
175	507192	5142940	20-Aug-18
176	507249	5142934	20-Aug-18
177	507306	5142928	20-Aug-18
178	506125	5142933	8-Aug-18
179	506219	5142960	9-Aug-18
180	506346	5142970	15-Aug-18
181	506391	5142960	15-Aug-18
182	506448	5142960	15-Aug-18
183	506505	5142960	15-Aug-18
184	507020	5142962	15-Aug-18
185	507076	5142940	15-Aug-18
186	507134	5142953	20-Aug-18
187	507248	5142970	20-Aug-18
188	507305	5142976	20-Aug-18
189	506391	5142992	15-Aug-18
190	506448	5142992	15-Aug-18
191	506505	5142992	15-Aug-18
192	506562	5142992	15-Aug-18
193	506619	5142992	15-Aug-18
194	506677	5142992	15-Aug-18
195	507020	5143000	15-Aug-18
196	507077	5142982	15-Aug-18
197	507134	5142992	20-Aug-18
198	507192	5142983	20-Aug-18
199	507305	5143013	20-Aug-18
200	506562	5143024	15-Aug-18

ID	UTM NAD83 (Easting)	UTM NAD83 (Northing)	Date Sampled
201	506619	5143024	15-Aug-18
202	506677	5143024	15-Aug-18
203	506734	5143024	15-Aug-18
204	506906	5143024	15-Aug-18
205	506963	5143024	15-Aug-18
206	507020	5143039	15-Aug-18
207	507077	5143024	15-Aug-18
208	507191	5143020	20-Aug-18
209	507249	5143014	20-Aug-18
210	507363	5143024	20-Aug-18
211	506619	5143055	15-Aug-18
212	506677	5143055	15-Aug-18
213	506734	5143055	15-Aug-18
214	506791	5143049	15-Aug-18
215	506848	5143055	15-Aug-18
216	506906	5143055	15-Aug-18
217	506963	5143064	15-Aug-18
218	507192	5143055	20-Aug-18
219	507249	5143049	20-Aug-18
220	507306	5143052	20-Aug-18
221	507363	5143058	20-Aug-18
222	506734	5143087	15-Aug-18
223	506791	5143087	15-Aug-18
224	506906	5143087	15-Aug-18
225	507020	5143079	15-Aug-18
226	507249	5143087	20-Aug-18
227	507306	5143087	20-Aug-18
228	507420	5143087	20-Aug-18
229	506906	5143119	15-Aug-18
230	506963	5143103	15-Aug-18
231	507020	5143116	15-Aug-18
232	507306	5143119	20-Aug-18
233	507364	5143096	20-Aug-18
234	507420	5143119	20-Aug-18
235	507478	5143119	20-Aug-18
236	506962	5143141	15-Aug-18
237	507020	5143150	15-Aug-18
238	507074	5143137	15-Aug-18
239	507364	5143137	20-Aug-18
240	507478	5143150	20-Aug-18
241	507539	5143162	20-Aug-18
242	507020	5143182	15-Aug-18
243	507081	5143180	15-Aug-18
244	507363	5143173	20-Aug-18
245	507422	5143158	20-Aug-18
246	507478	5143184	NA
247	507077	5143214	15-Aug-18
248	507138	5143216	15-Aug-18
249	507420	5143197	20-Aug-18
250	507478	5143214	20-Aug-18

ID	UTM NAD83 (Easting)	UTM NAD83 (Northing)	Date Sampled
251	507536	5143202	20-Aug-18
252	507585	5143216	20-Aug-18
253	507134	5143253	NA
254	507192	5143245	15-Aug-18
255	507412	5143229	20-Aug-18
256	507534	5143238	20-Aug-18
257	507585	5143262	20-Aug-18
258	507173	5143271	NA
259	505661	5142378	1-Aug-18
260	505663	5142436	1-Aug-18

Appendix B

St. Charles Lake Vegetation Mapping Results

St Charles Lake

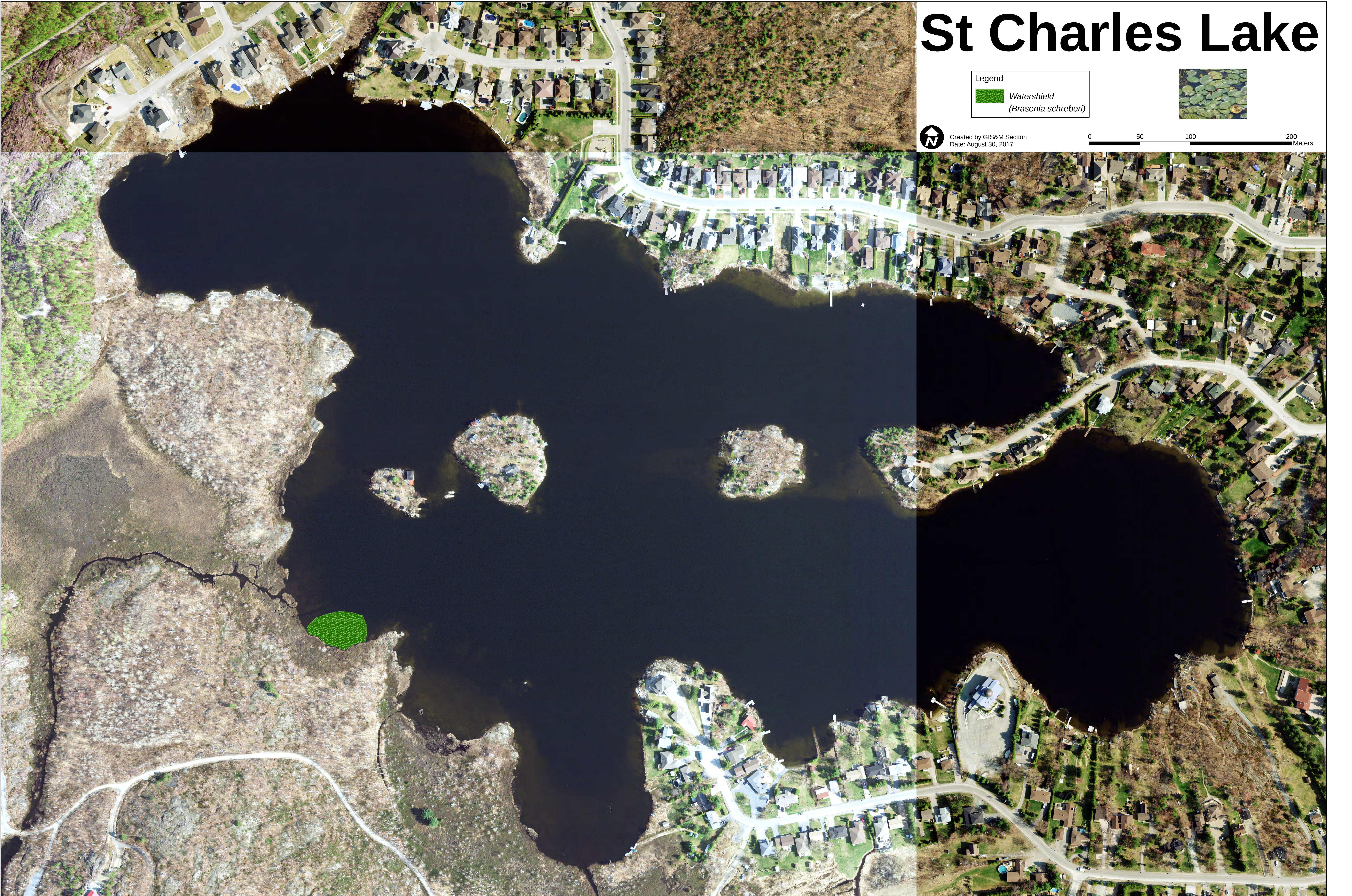
Legend

Watershield
(*Brasenia schreberi*)



Created by GIS&M Section
Date: August 30, 2017

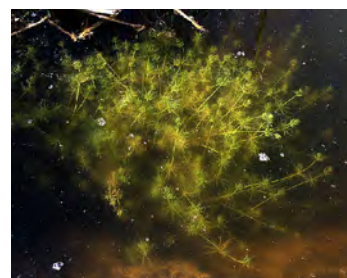
0 50 100 200
Meters



St Charles Lake

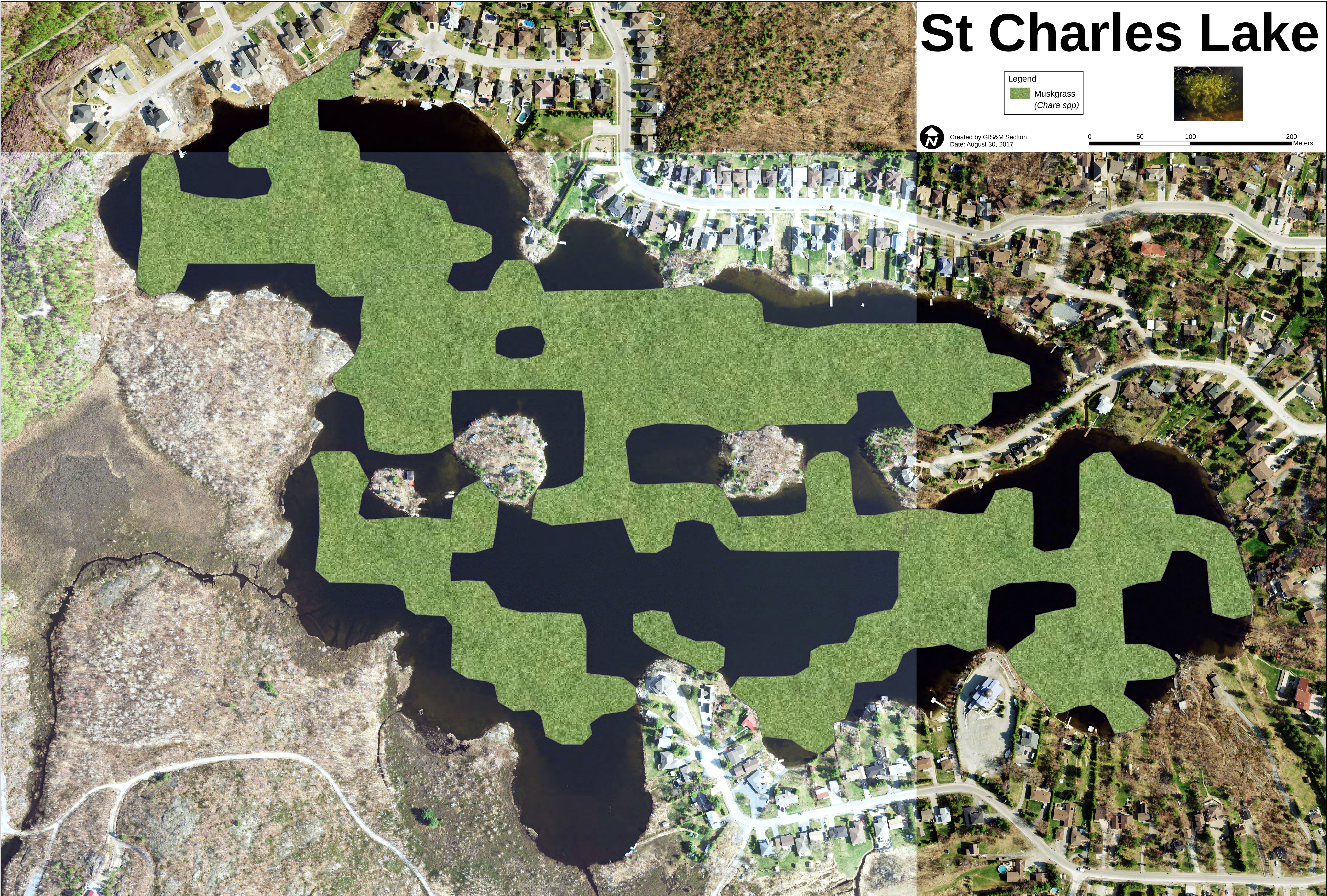
Legend

Muskgrass
(*Chara spp*)



Created by GIS&M Section
Date: August 30, 2017

0 50 100 200 Meters



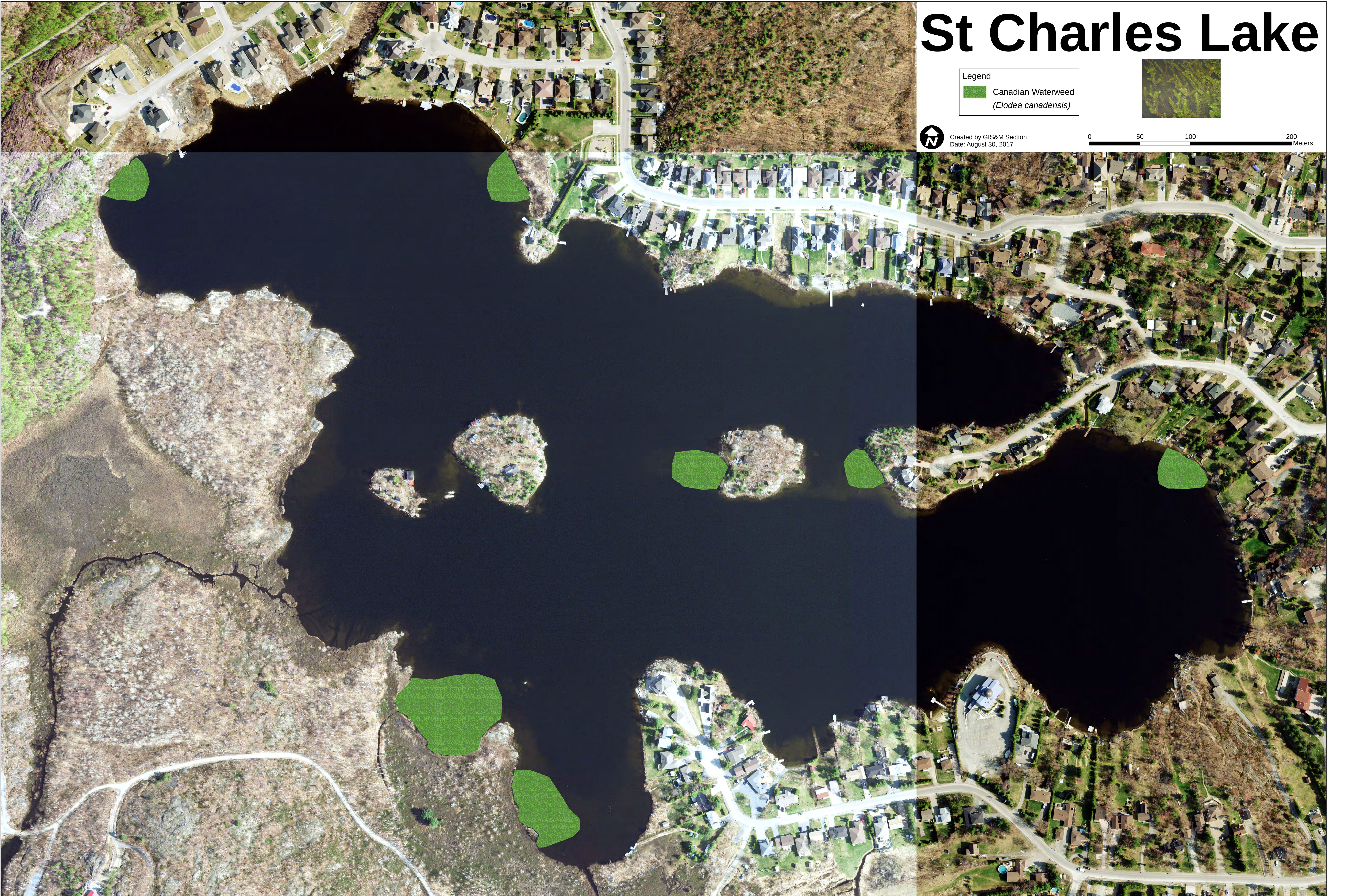
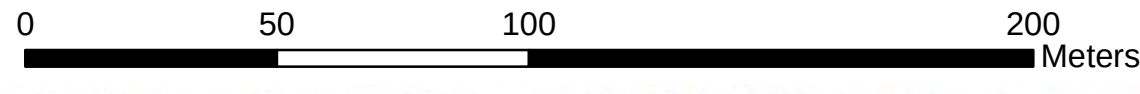
St Charles Lake

Legend

Canadian Waterweed
(*Elodea canadensis*)



Created by GIS&M Section
Date: August 30, 2017



St Charles Lake

Legend



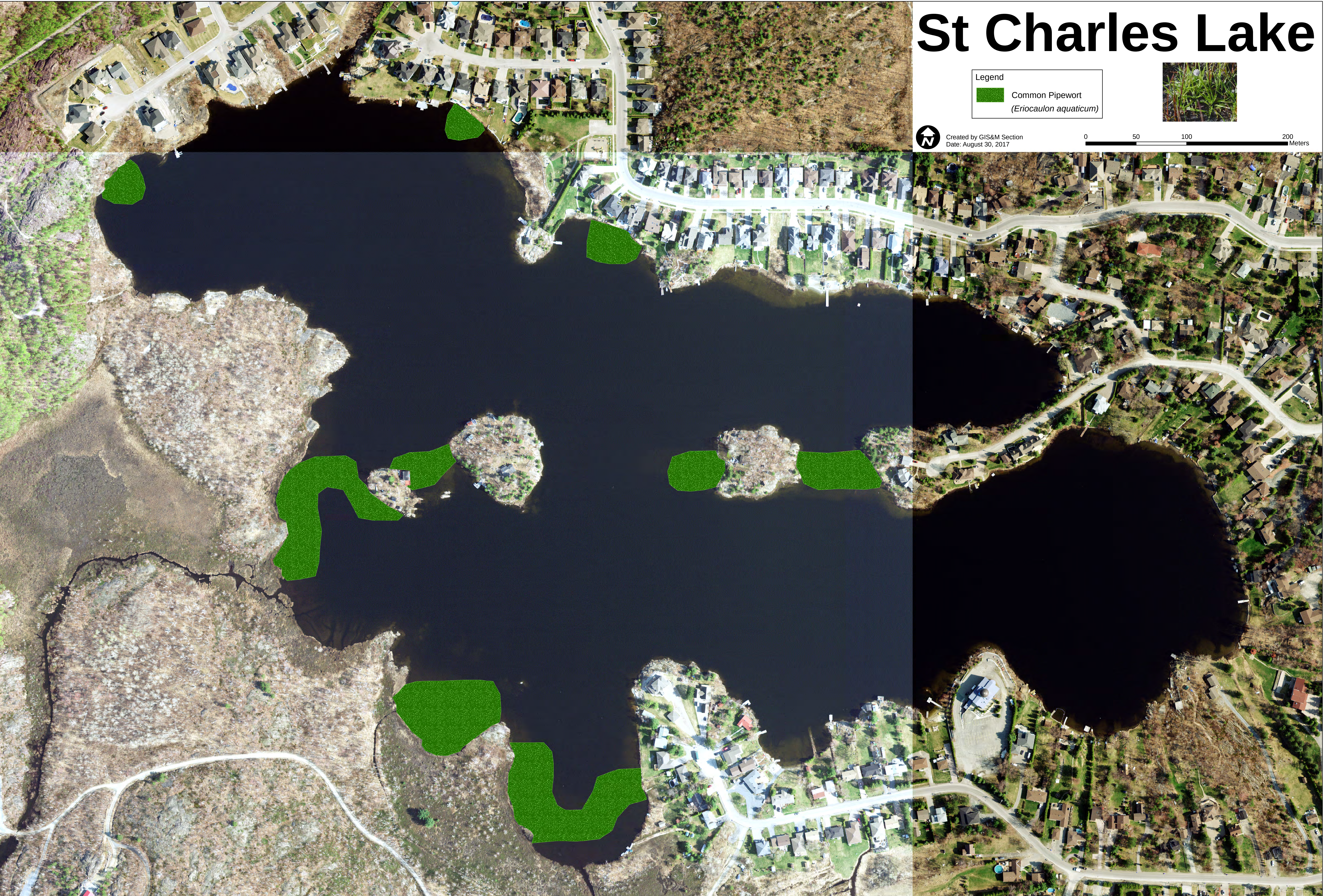
Common Pipewort
(Eriocaulon aquaticum)





Created by GIS&M Section
Date: August 30, 2017

0 50 100 200
Meters



St Charles Lake

Legend

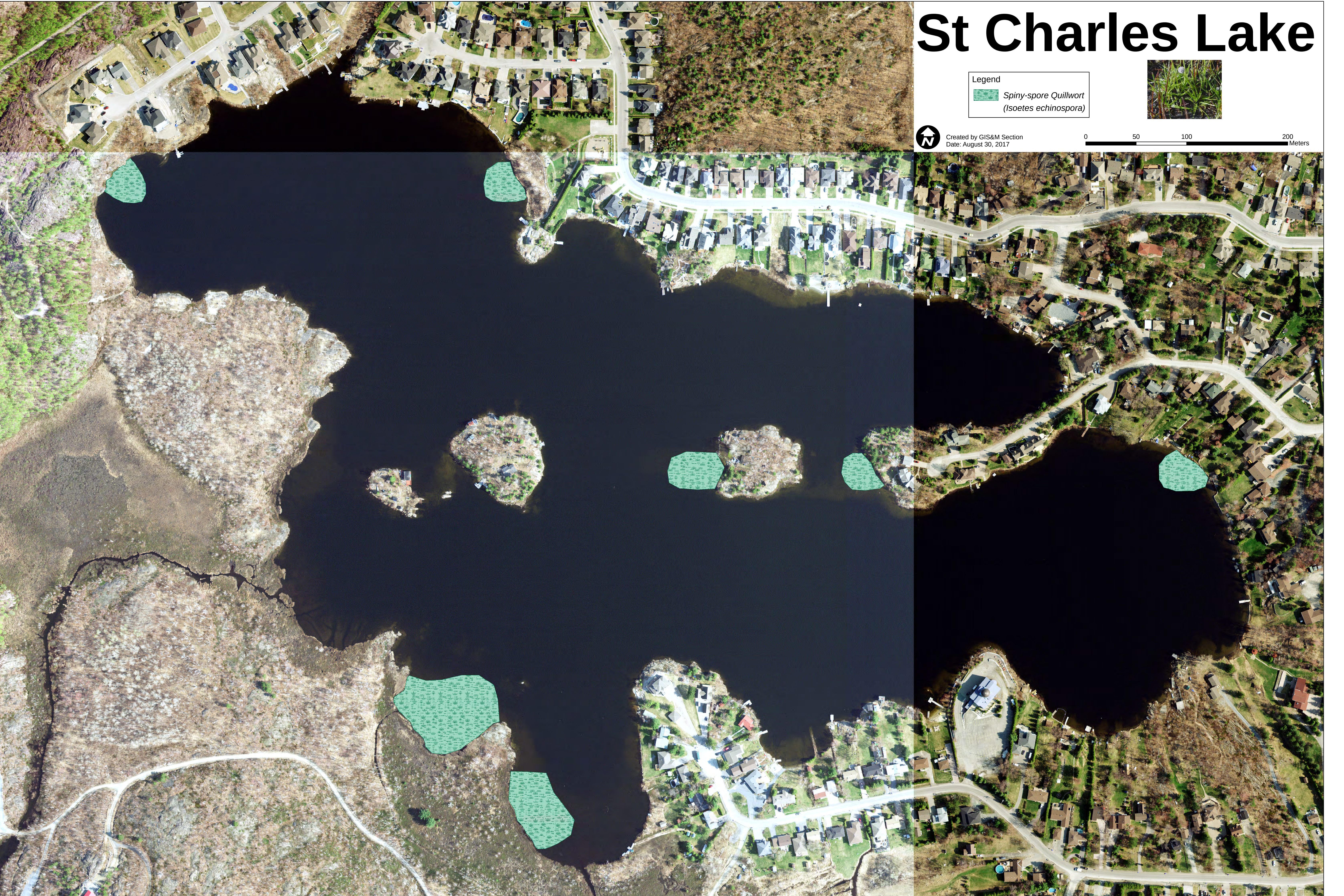
Spiny-spore Quillwort
(*Isoetes echinospora*)



Created by GIS&M Section
Date: August 30, 2017

050100200

Meters



St Charles Lake

Legend

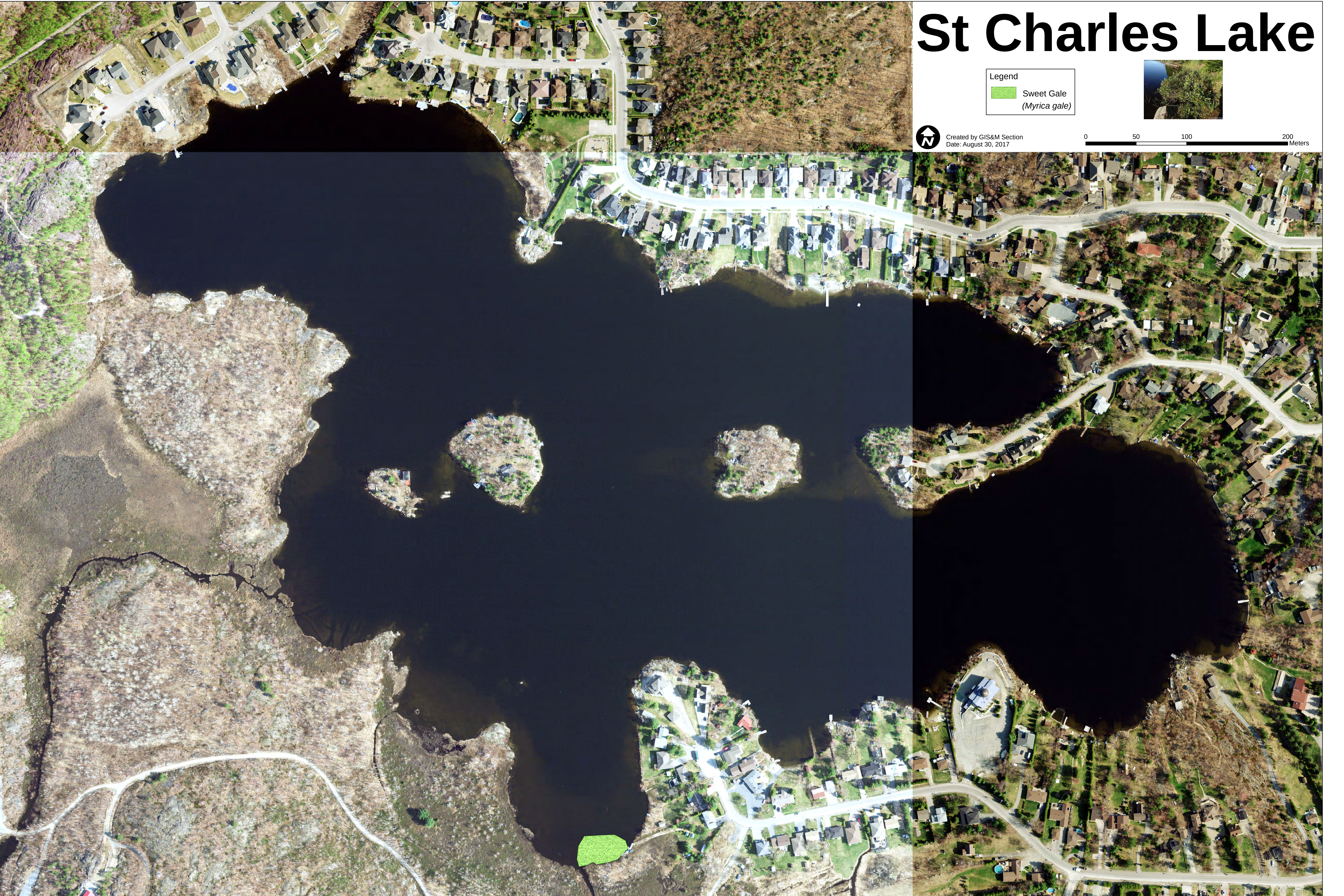
Sweet Gale
(Myrica gale)



Created by GIS&M Section
Date: August 30, 2017

050100200

Meters



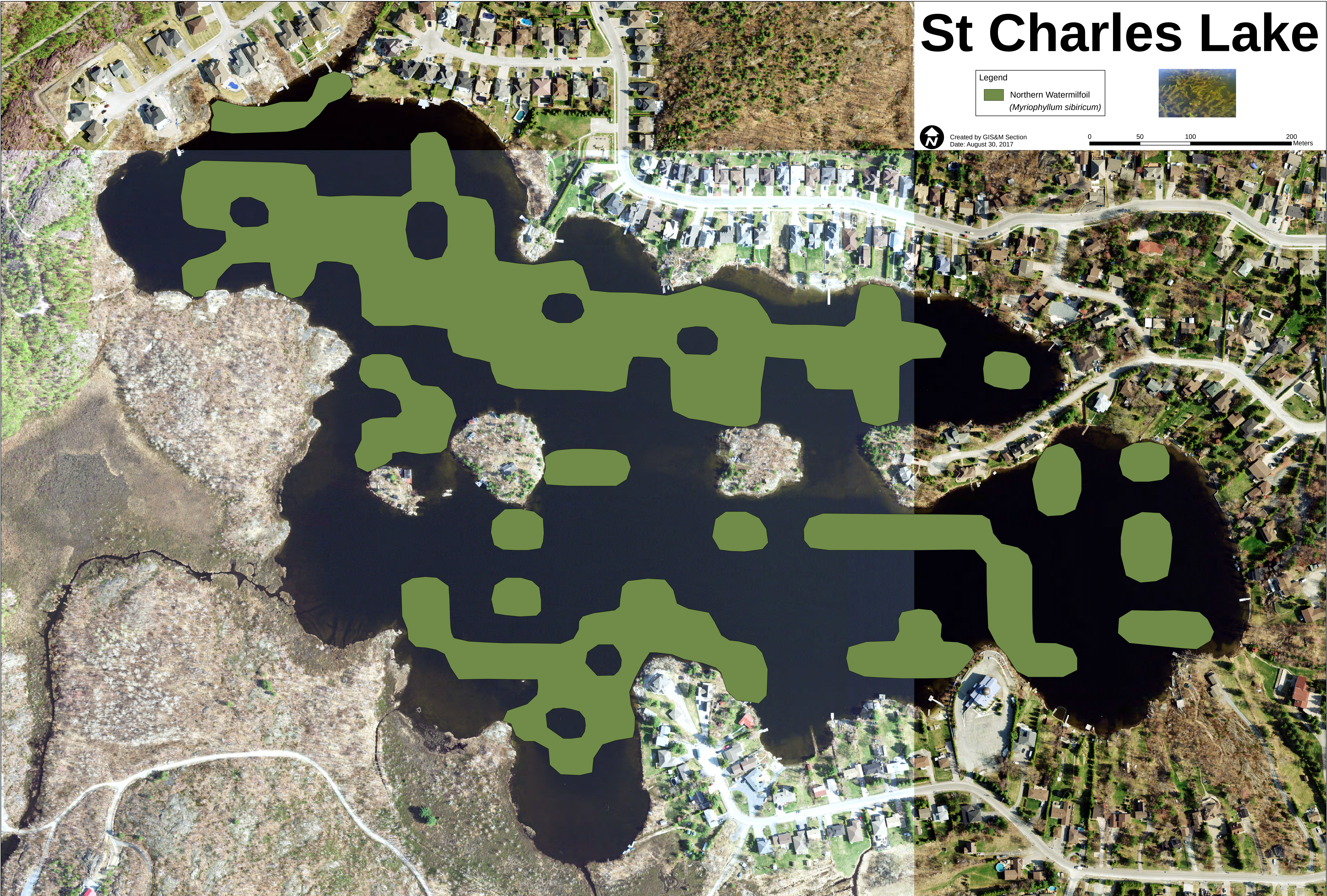
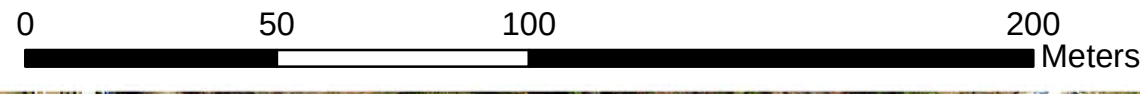
St Charles Lake

Legend

Northern Watermilfoil
(Myriophyllum sibiricum)



Created by GIS&M Section
Date: August 30, 2017



St Charles Lake

Legend

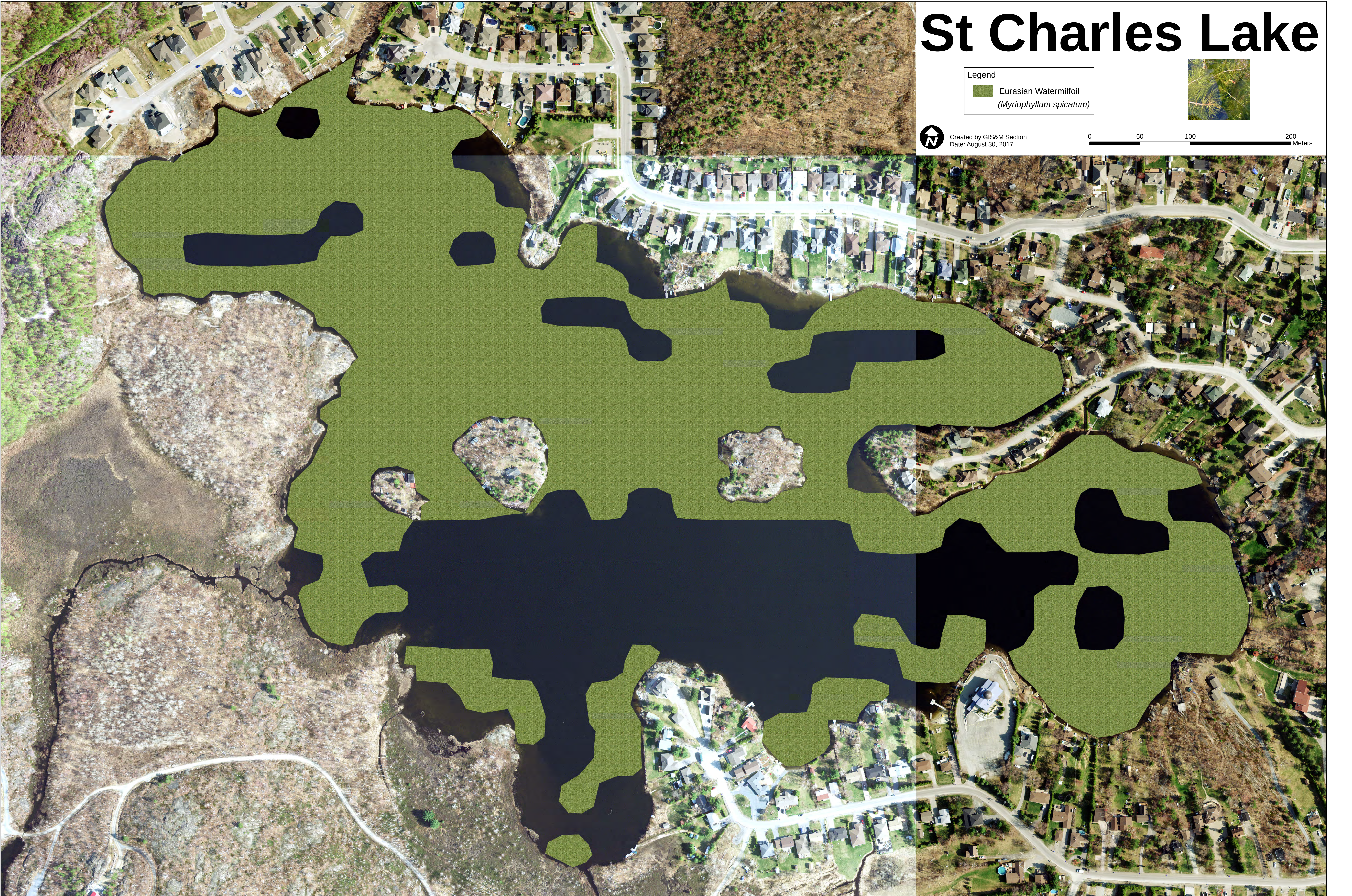
Eurasian Watermilfoil
(*Myriophyllum spicatum*)



Created by GIS&M Section
Date: August 30, 2017

050100200

Meters



St Charles Lake

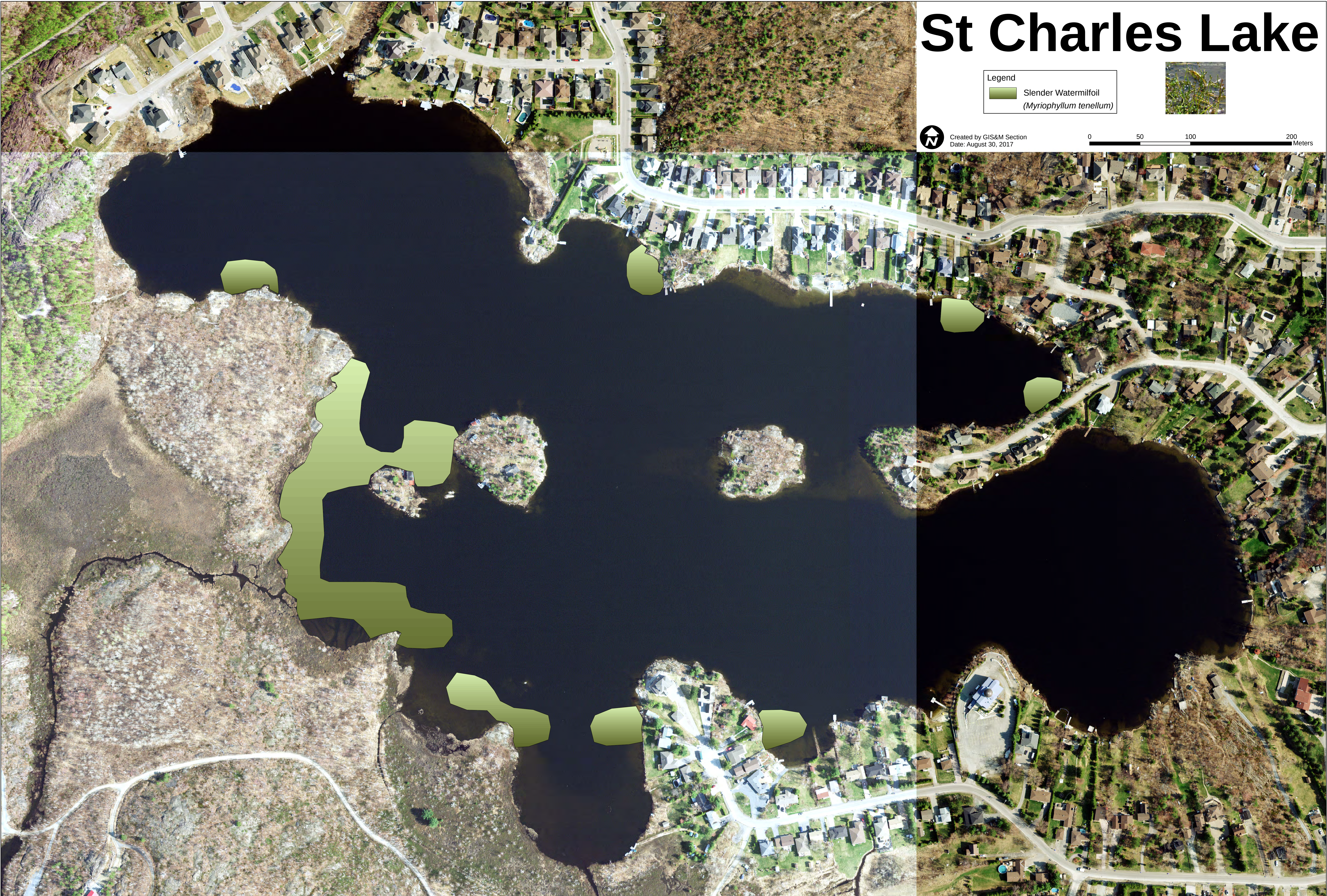
Legend

Slender Watermilfoil
(Myriophyllum tenellum)



Created by GIS&M Section
Date: August 30, 2017

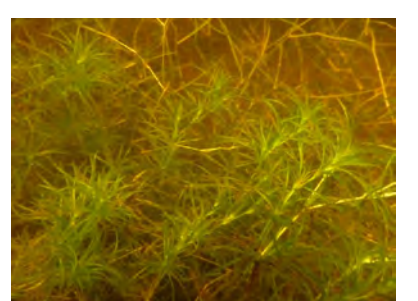
0 50 100 200
Meters



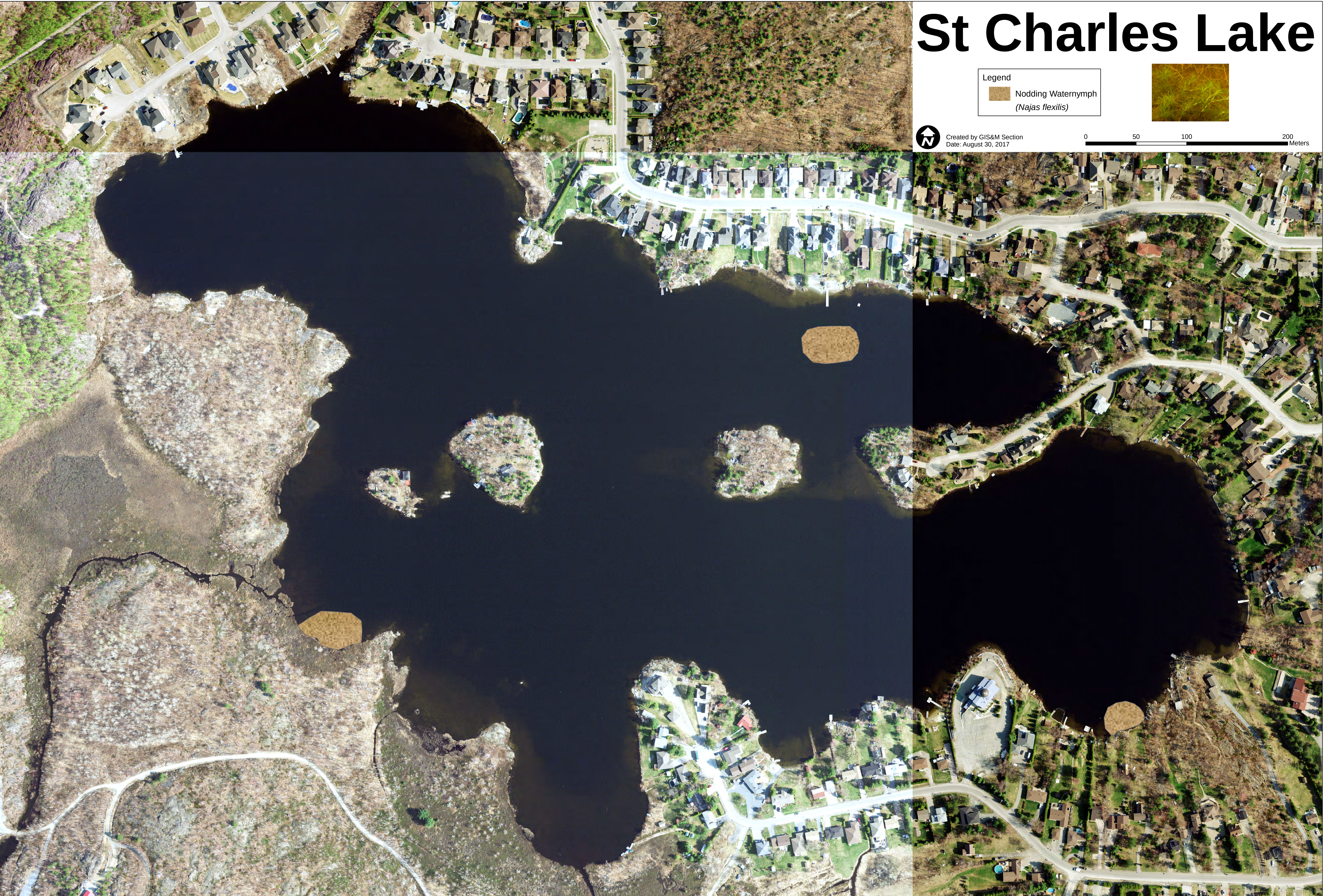
St Charles Lake

Legend

Nodding Waternymph
(*Najas flexilis*)



Created by GIS&M Section
Date: August 30, 2017



St Charles Lake

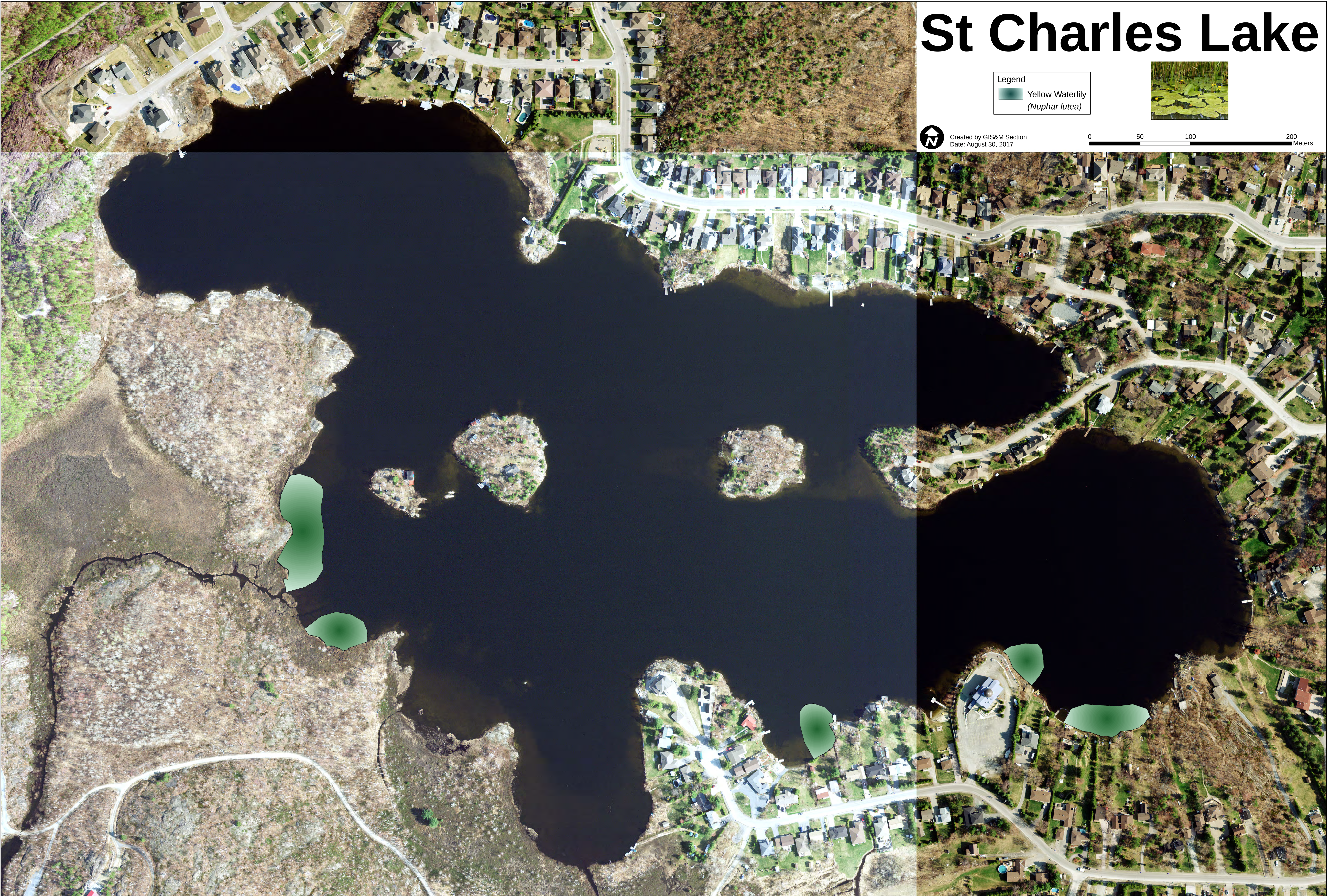
Legend

Yellow Waterlily
(*Nuphar lutea*)



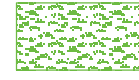
Created by GIS&M Section
Date: August 30, 2017

0 50 100 200
Meters



St Charles Lake

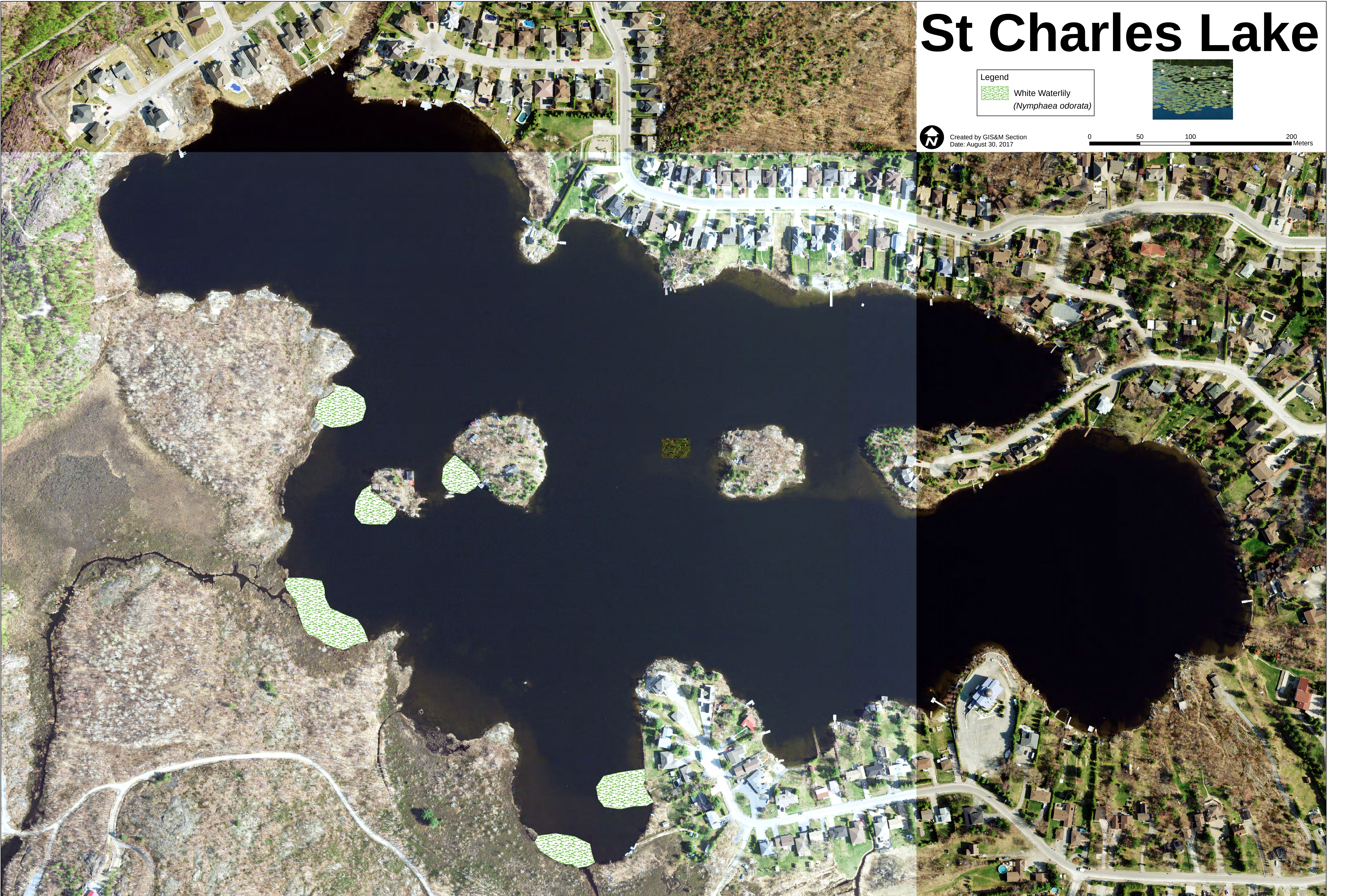
Legend



White Waterlily
(*Nymphaea odorata*)



Created by GIS&M Section
Date: August 30, 2017



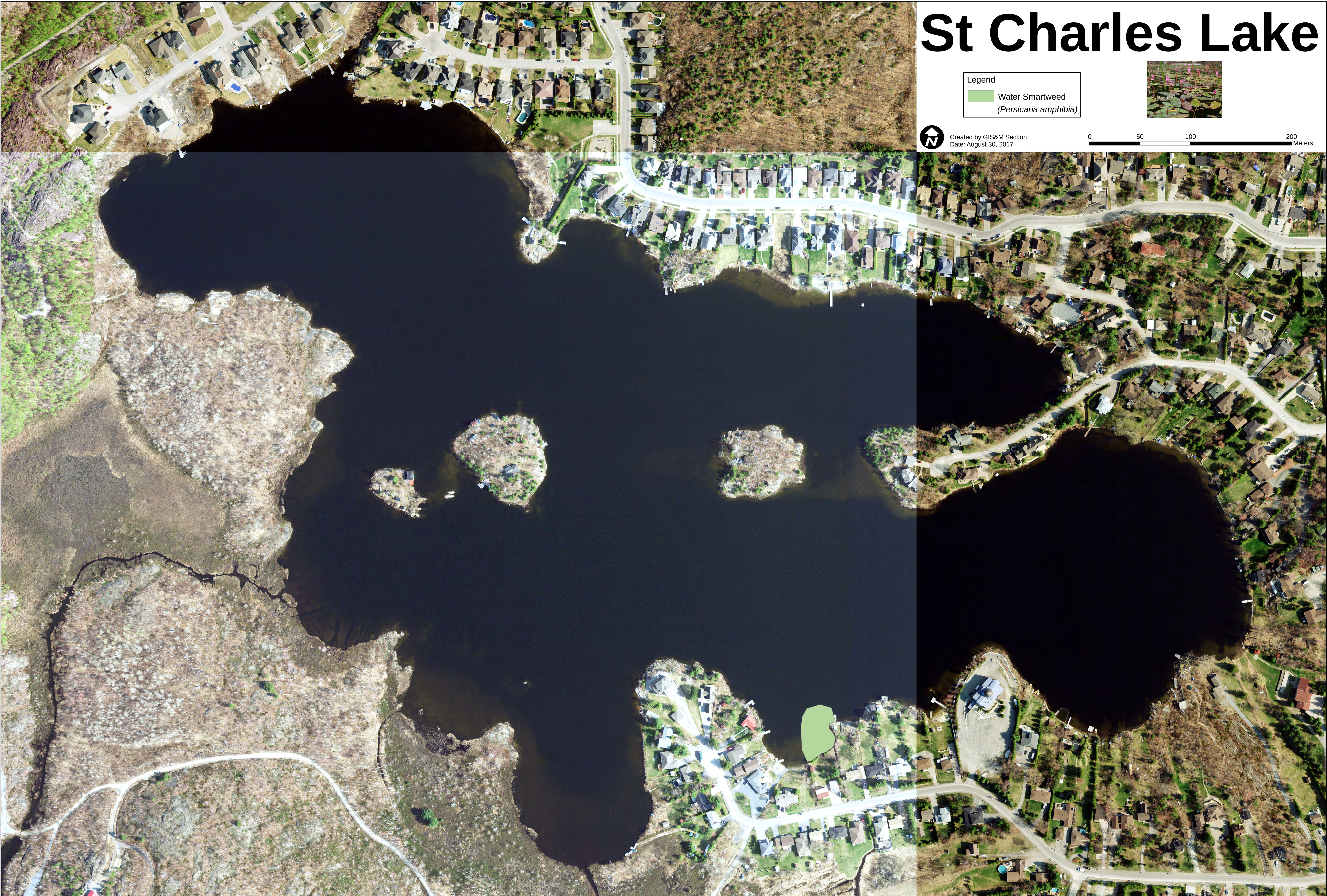
St Charles Lake

Legend

Water Smartweed
(*Persicaria amphibia*)



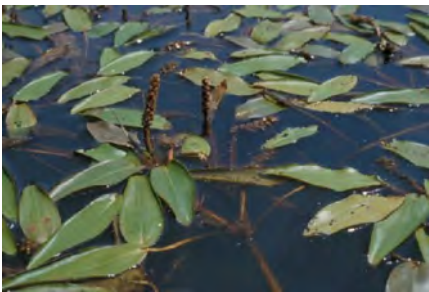
Created by GIS&M Section
Date: August 30, 2017



St Charles Lake

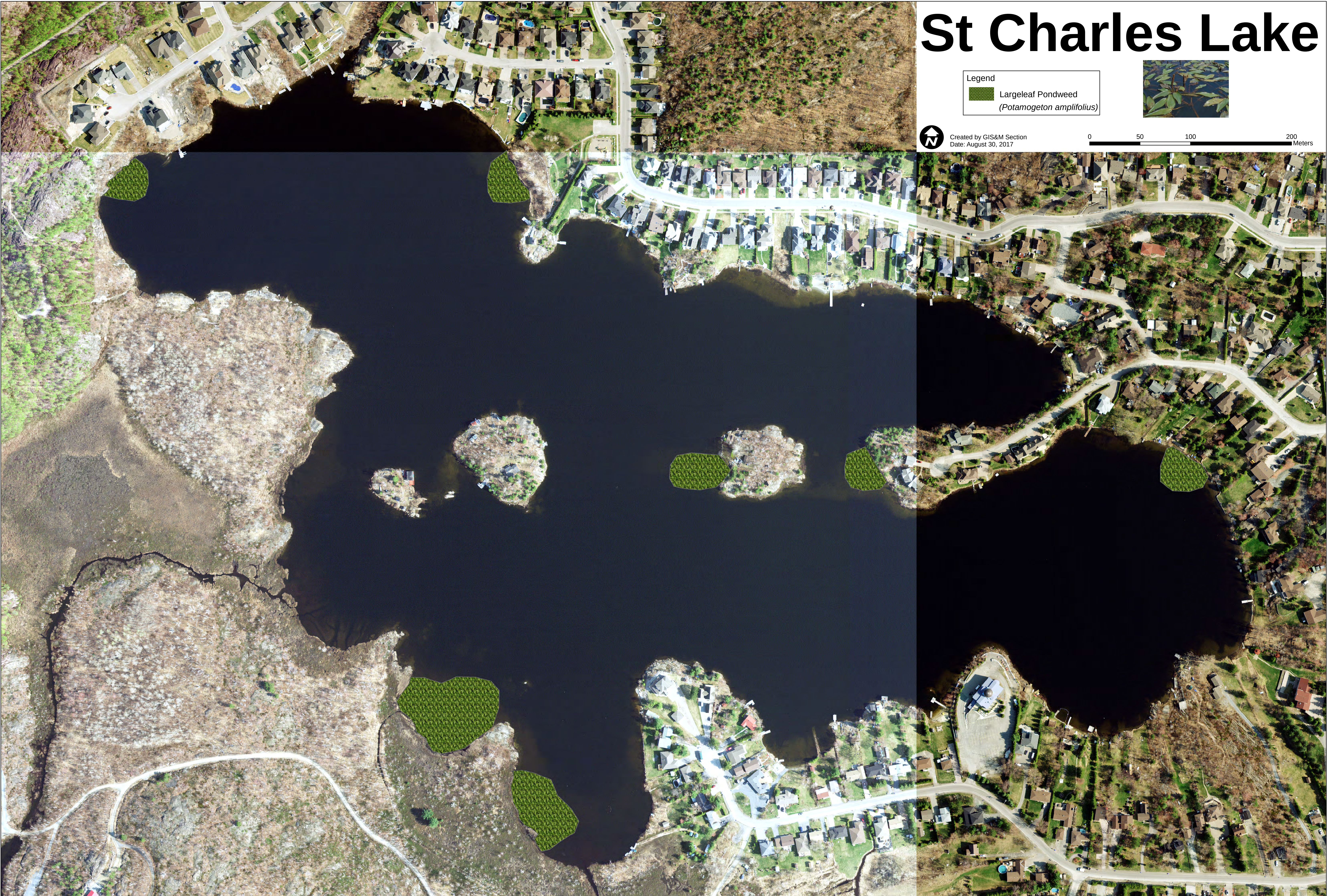
Legend

Largeleaf Pondweed
(Potamogeton amplifolius)



Created by GIS&M Section
Date: August 30, 2017

0 50 100 200
Meters



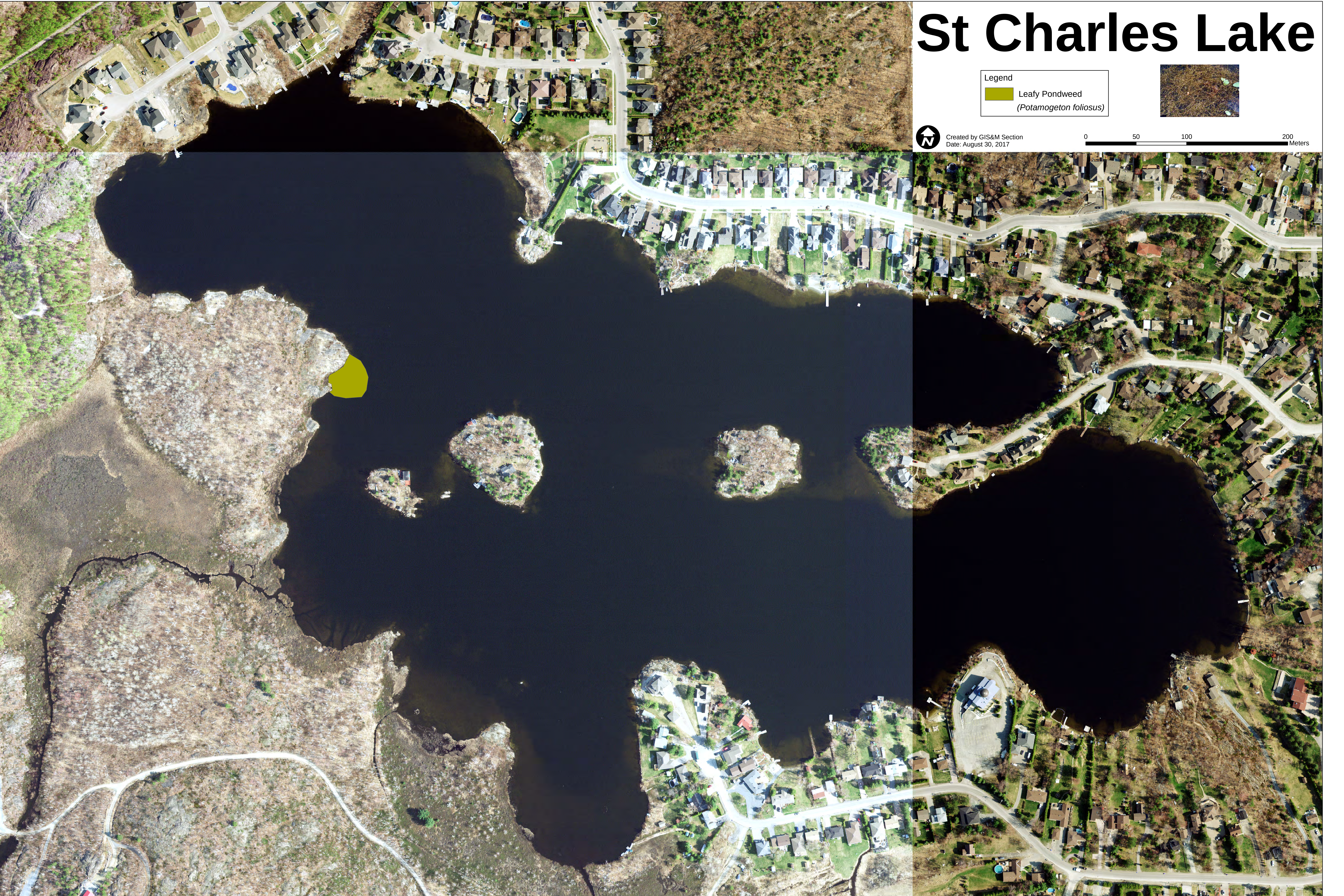
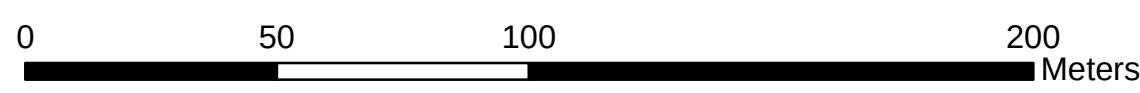
St Charles Lake

Legend

Leafy Pondweed
(*Potamogeton foliosus*)



Created by GIS&M Section
Date: August 30, 2017



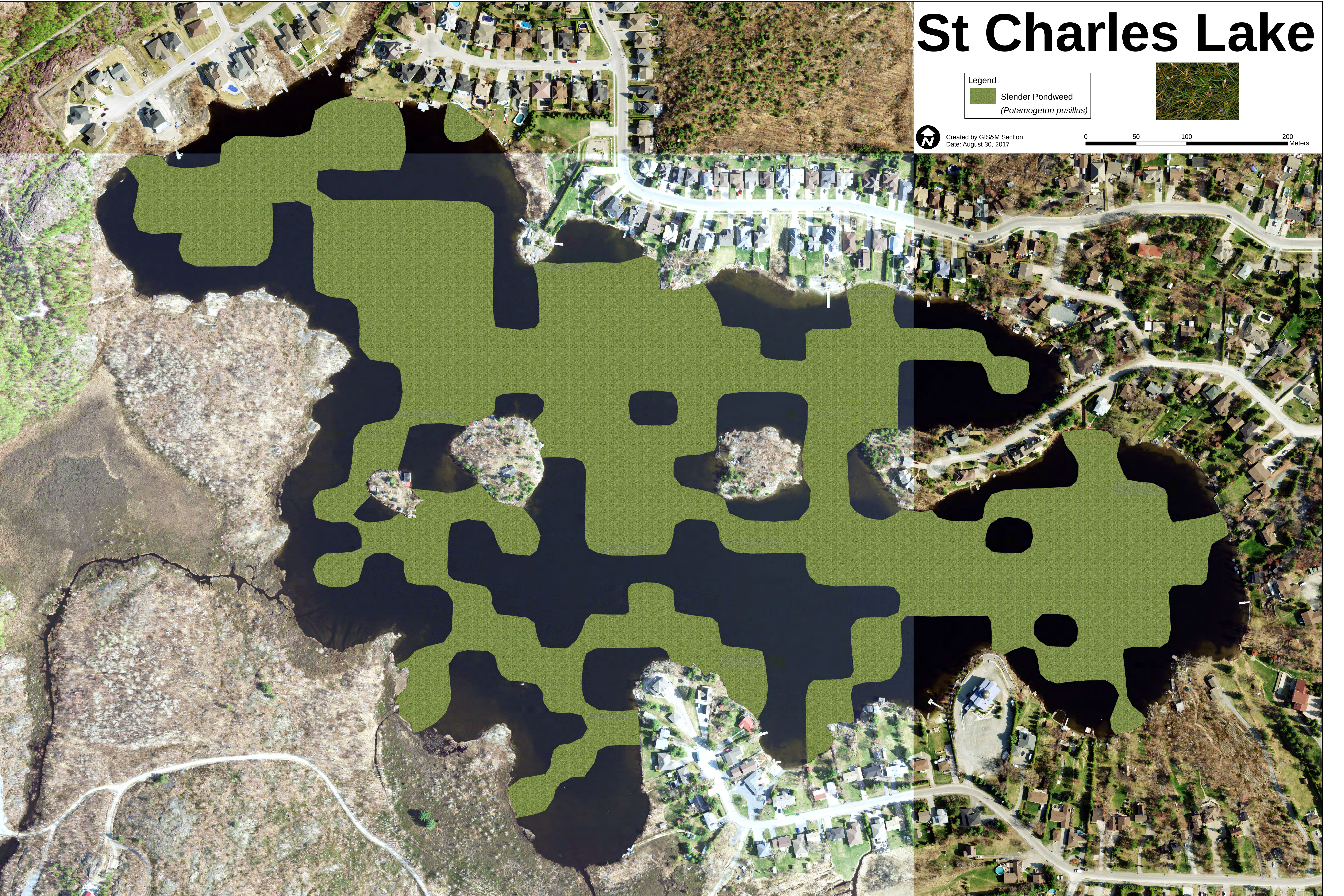
St Charles Lake

Legend

Slender Pondweed
(*Potamogeton pusillus*)



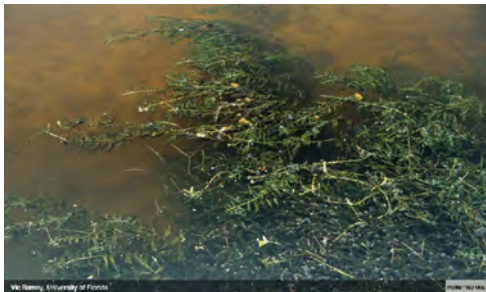
Created by GIS&M Section
Date: August 30, 2017



St Charles Lake

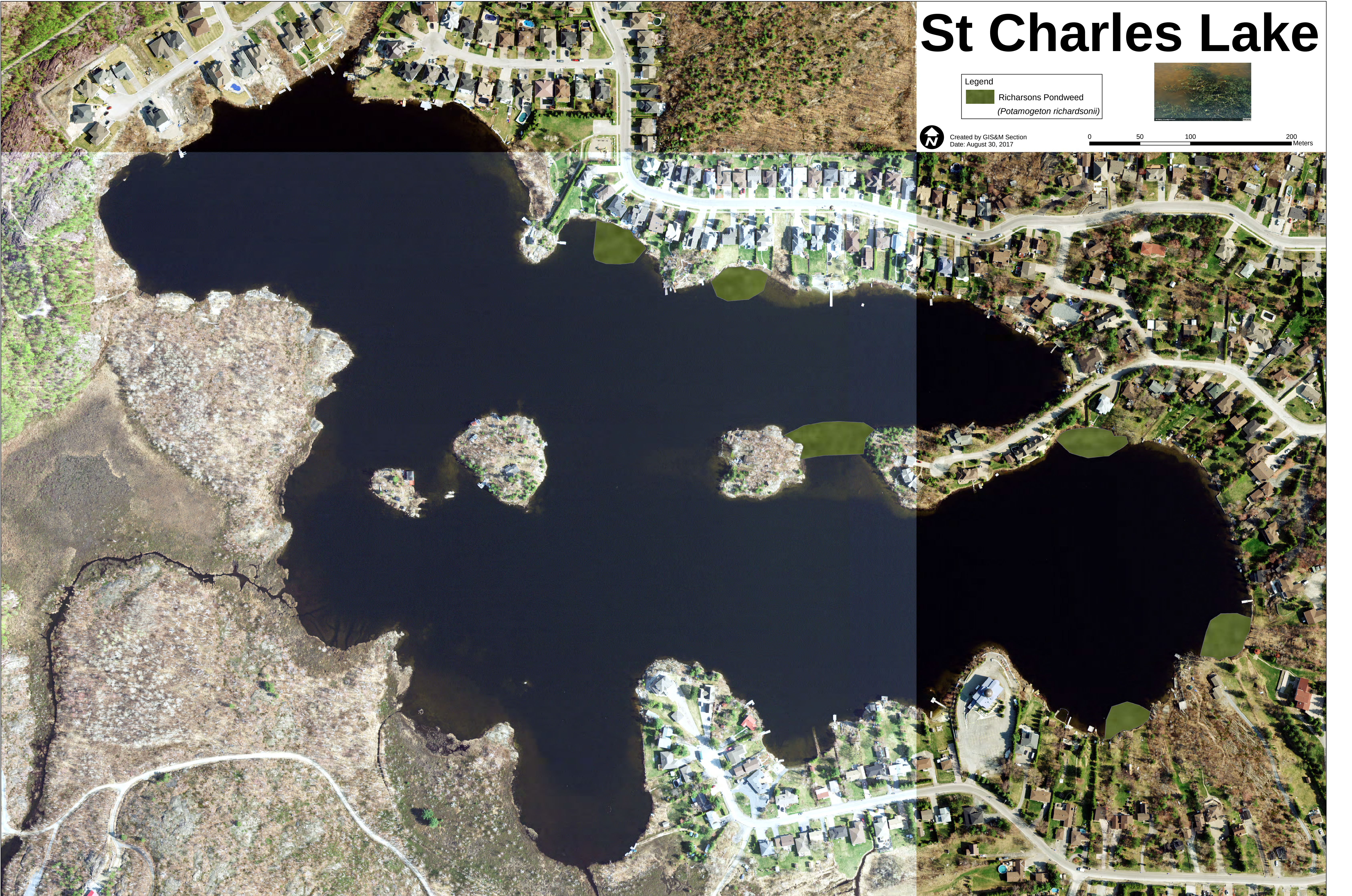
Legend

 Richarsons Pondweed
(*Potamogeton richardsonii*)



Created by GIS&M Section
Date: August 30, 2017

0 50 100 200 Meters



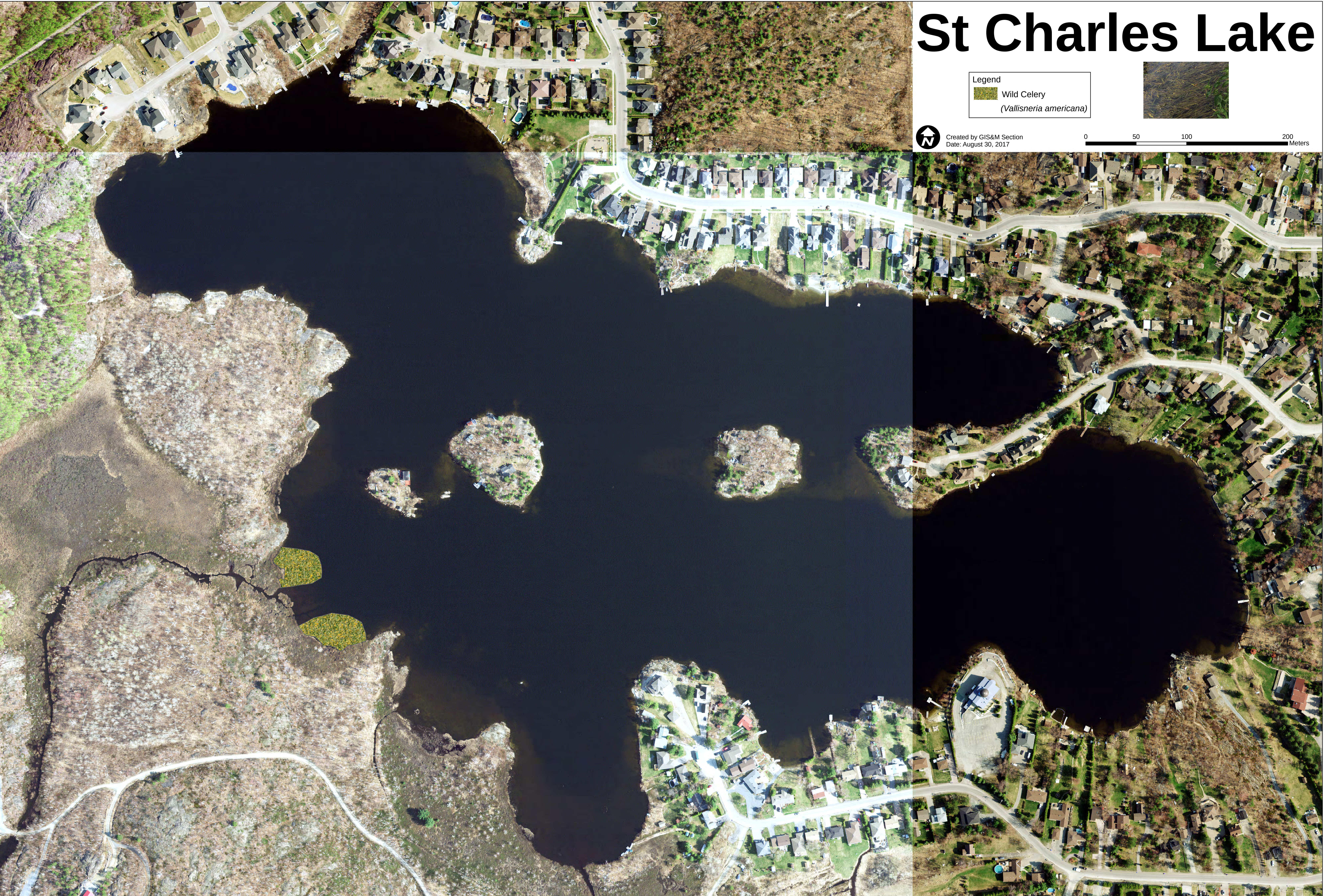
St Charles Lake

Legend

Wild Celery
(*Vallisneria americana*)



Created by GIS&M Section
Date: August 30, 2017



Appendix C

Richard Lake Vegetation Mapping Results

Richard Lake

Canada Waterweed
(*Elodea canadensis*)

 Canada Waterweed Present



0 50 100 200
Meters

Data Collected: August 1 to 20, 2019
Map Created: January 15, 2019
Created by GIS&M Section



Richard Lake

Eurasian Water-Milfoil
(*Myriophyllum spicatum*)

 Eurasian Water-Milfoil Present



0 50 100 200
Meters

Data Collected: August 1 to 20, 2019
Map Created: January 15, 2019
Created by GIS&M Section



Richard Lake

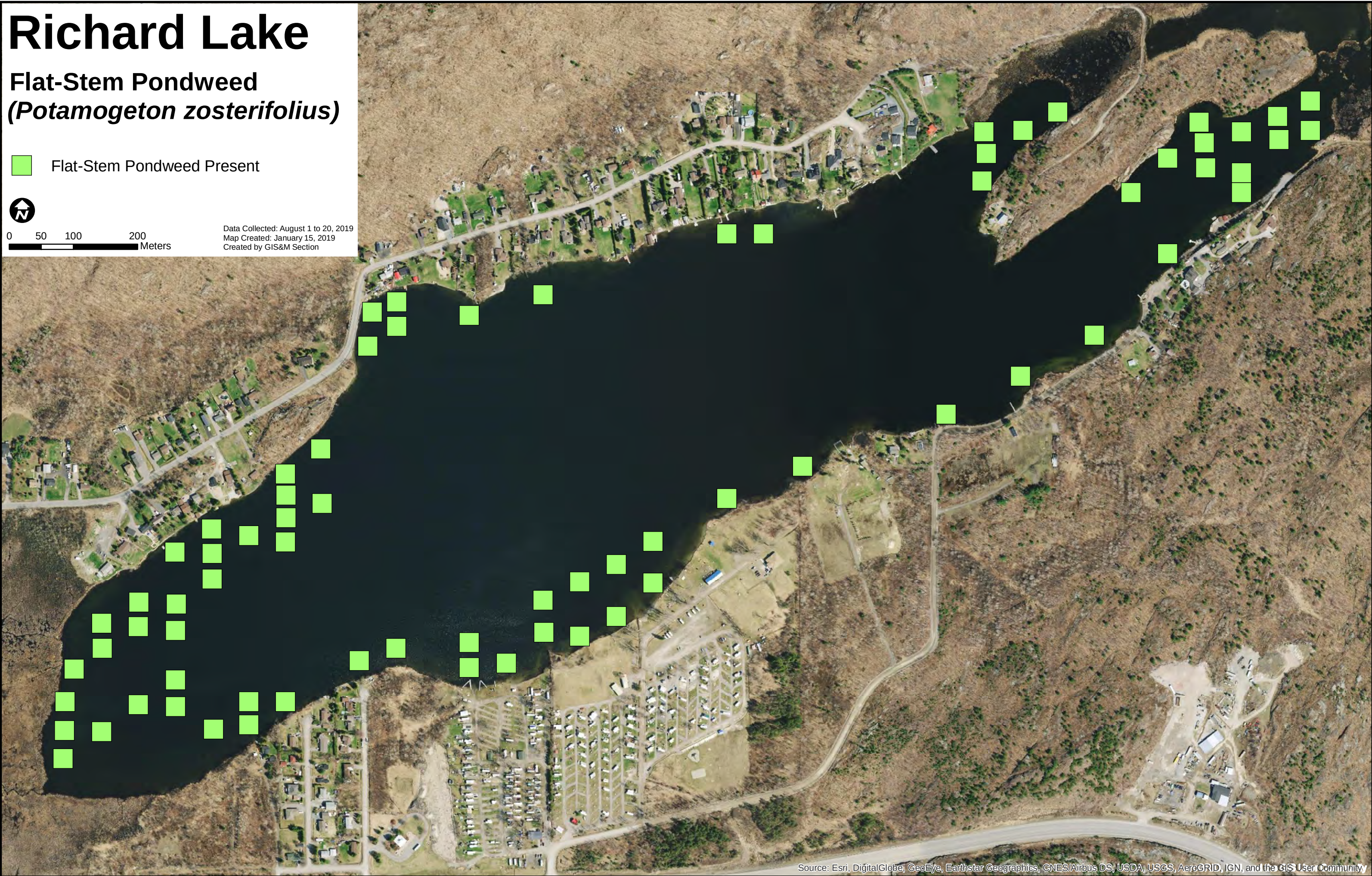
Flat-Stem Pondweed
(*Potamogeton zosterifolius*)

 Flat-Stem Pondweed Present



0 50 100 200
Meters

Data Collected: August 1 to 20, 2019
Map Created: January 15, 2019
Created by GIS&M Section



Richard Lake

Illinois Pondweed
(*Potamogeton illinoensis*)

 Illinois Pondweed Present



0 50 100 200
Meters

Data Collected: August 1 to 20, 2019
Map Created: January 15, 2019
Created by GIS&M Section



Richard Lake

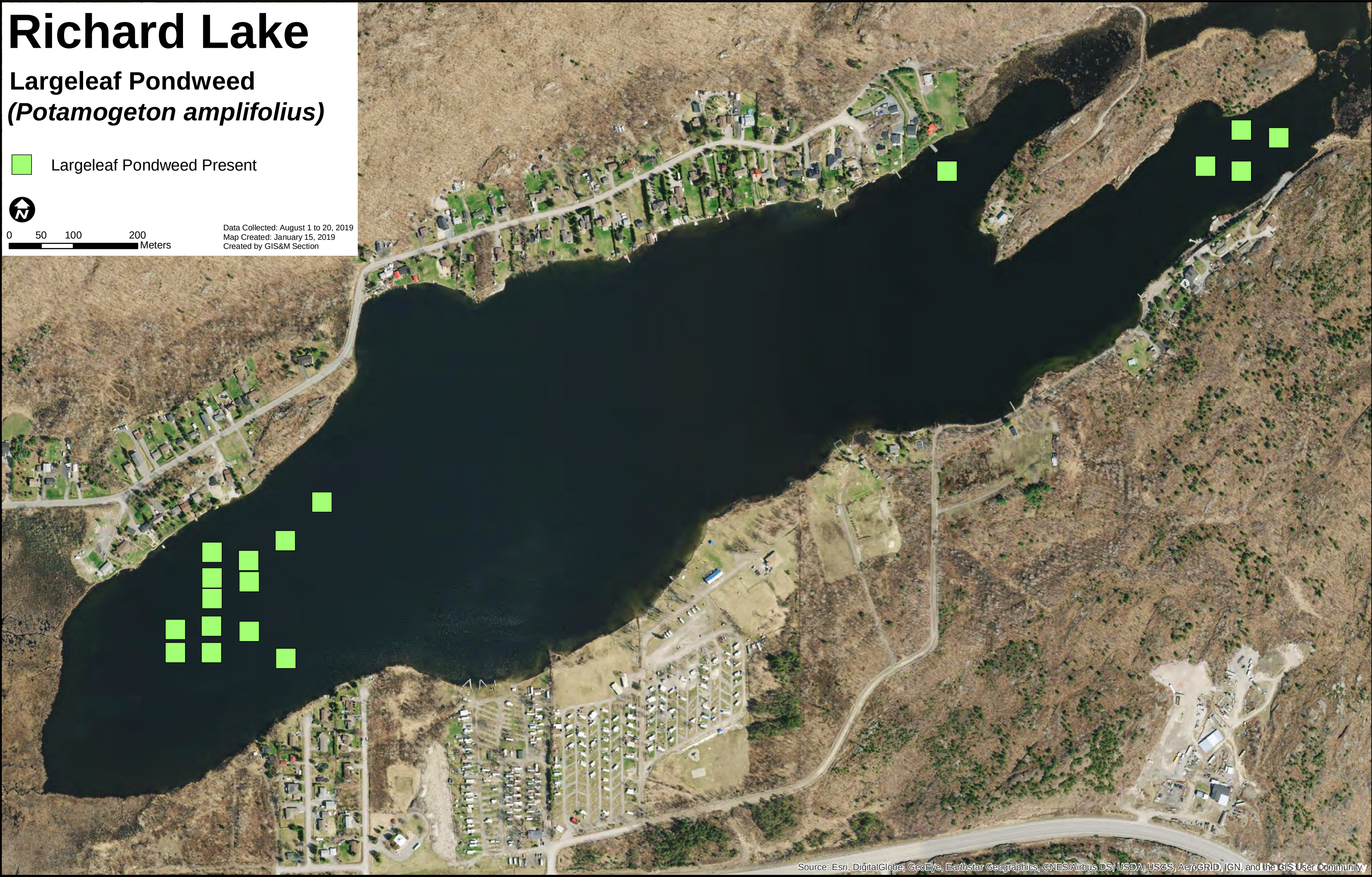
Largeleaf Pondweed
(*Potamogeton amplifolius*)

 Largeleaf Pondweed Present



0 50 100 200
Meters

Data Collected: August 1 to 20, 2019
Map Created: January 15, 2019
Created by GIS&M Section



Richard Lake

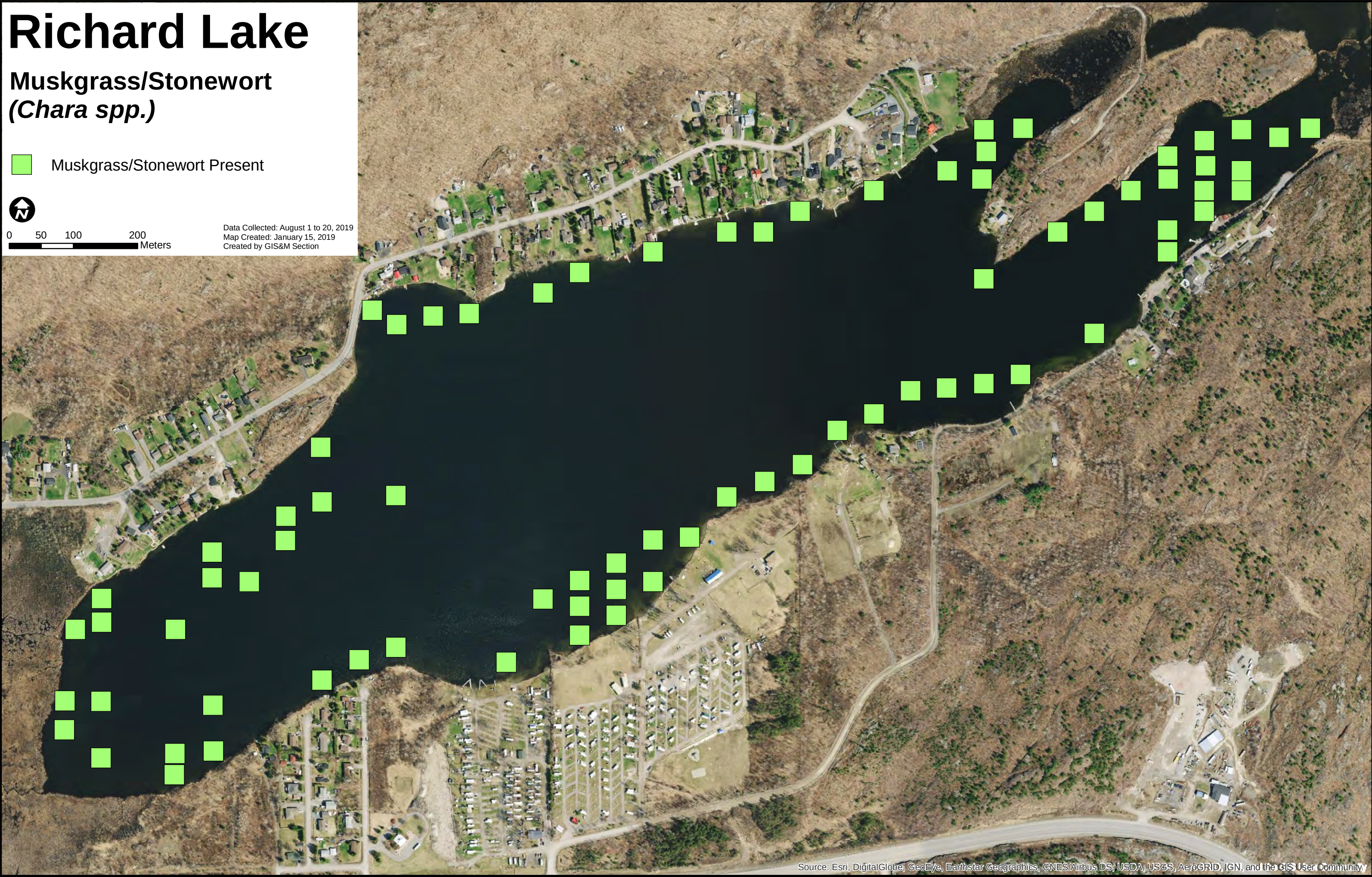
Muskgrass/Stonewort
(*Chara spp.*)

 Muskgrass/Stonewort Present



0 50 100 200
Meters

Data Collected: August 1 to 20, 2019
Map Created: January 15, 2019
Created by GIS&M Section



Richard Lake

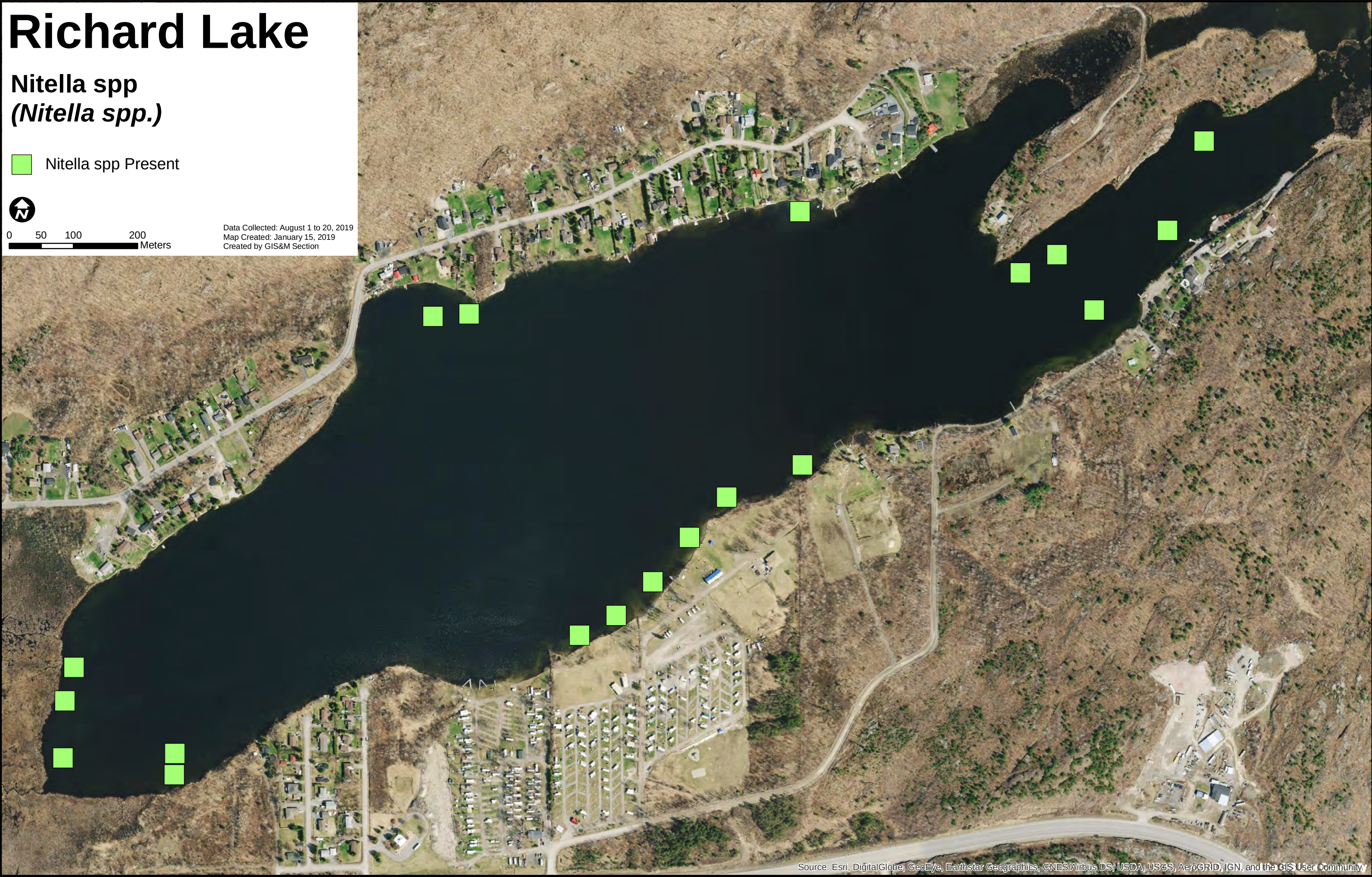
Nitella spp
(*Nitella spp.*)

 Nitella spp Present



0 50 100 200
Meters

Data Collected: August 1 to 20, 2019
Map Created: January 15, 2019
Created by GIS&M Section



Richard Lake

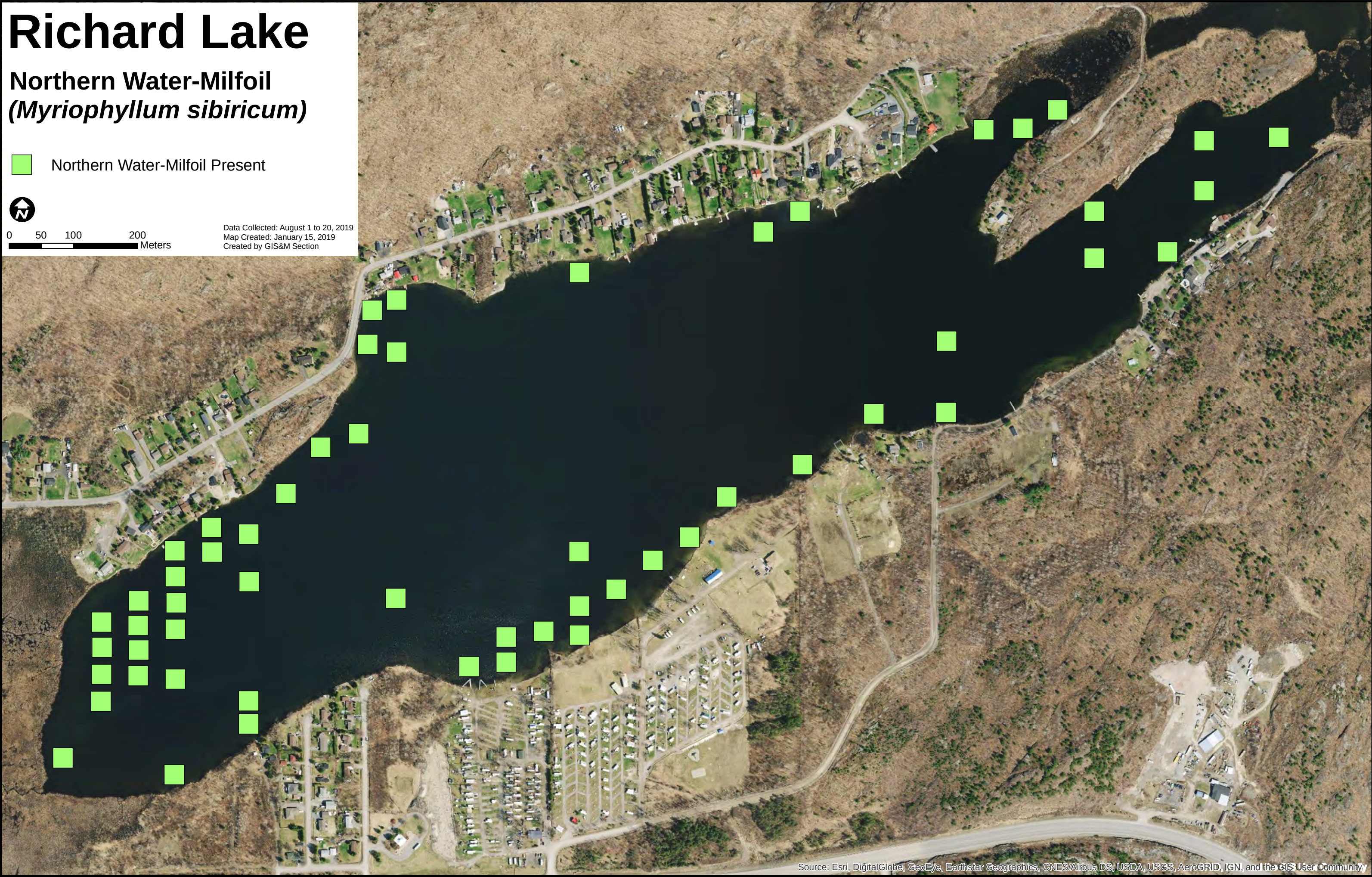
Northern Water-Milfoil
(*Myriophyllum sibiricum*)

 Northern Water-Milfoil Present



0 50 100 200
Meters

Data Collected: August 1 to 20, 2019
Map Created: January 15, 2019
Created by GIS&M Section



Richard Lake

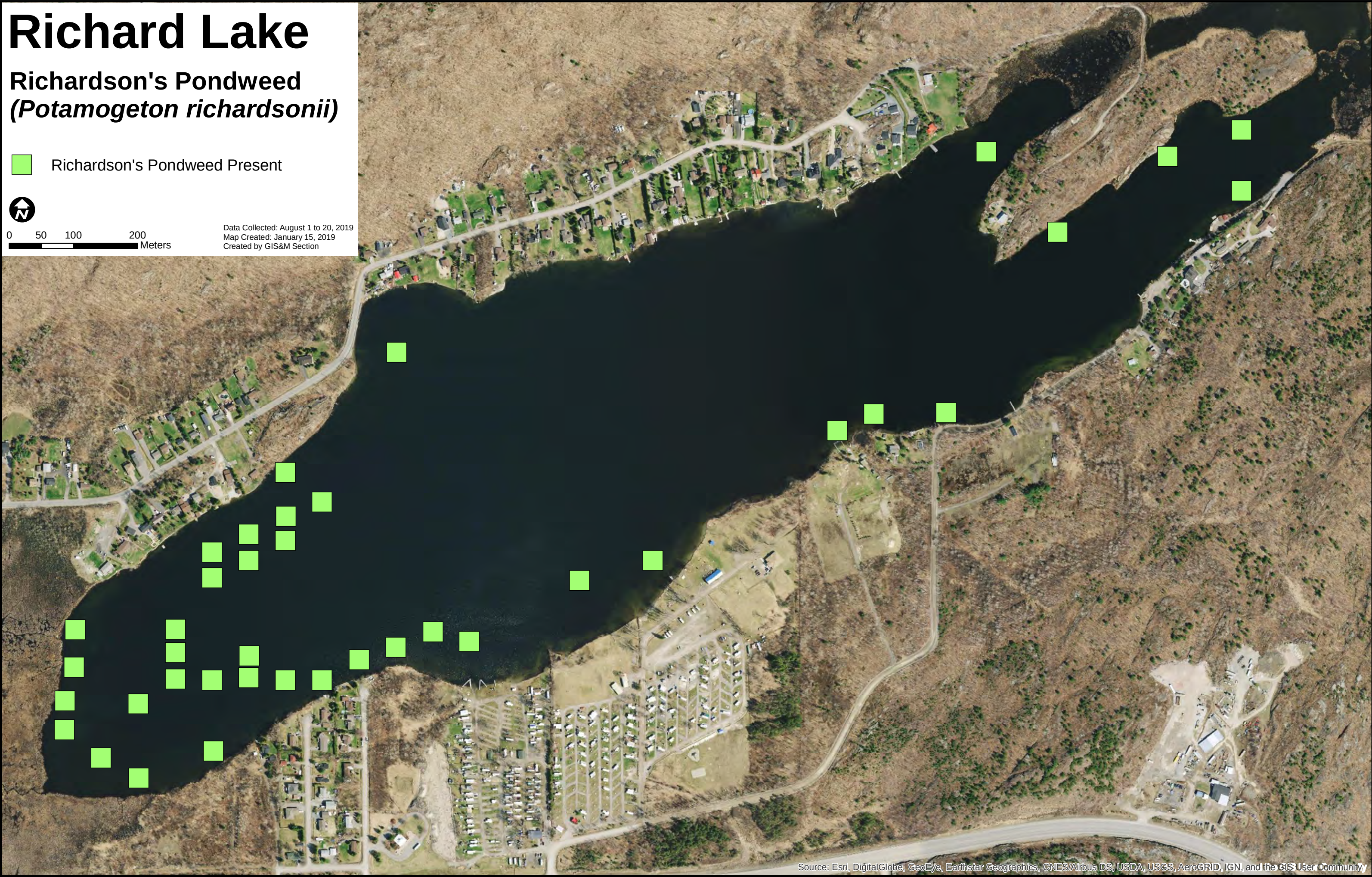
Richardson's Pondweed
(*Potamogeton richardsonii*)

 Richardson's Pondweed Present



0 50 100 200
Meters

Data Collected: August 1 to 20, 2019
Map Created: January 15, 2019
Created by GIS&M Section



Richard Lake

Slender Naiad
(*Najas flexilis*)

 Slender Naiad Present



0 50 100 200
Meters

Data Collected: August 1 to 20, 2019
Map Created: January 15, 2019
Created by GIS&M Section



Richard Lake

Slender Pondweed
(*Potamogeton pusillus*)

 Slender Pondweed Present



0 50 100 200
Meters

Data Collected: August 1 to 20, 2019
Map Created: January 15, 2019
Created by GIS&M Section



Richard Lake

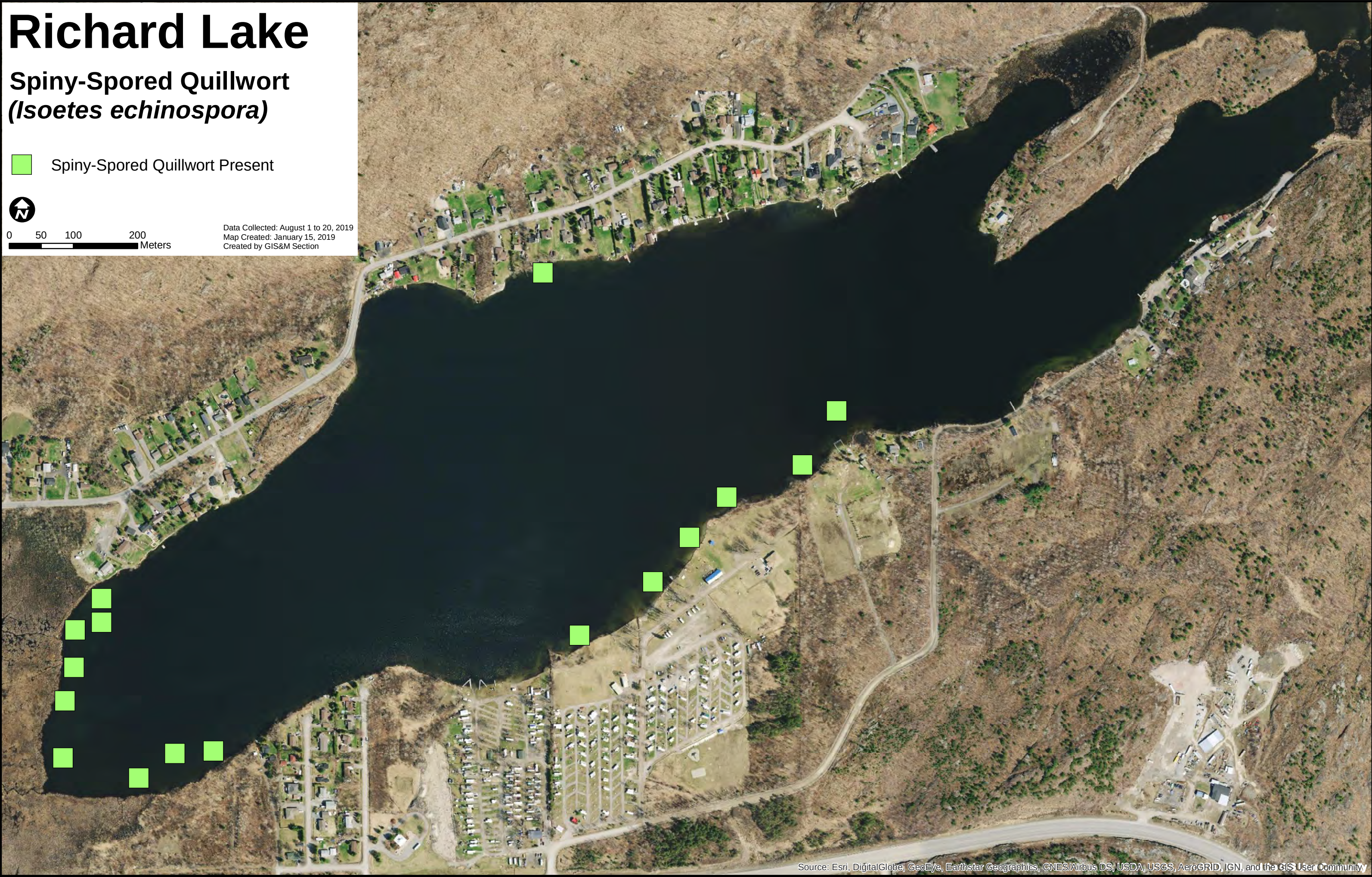
Spiny-Spored Quillwort (*Isoetes echinospora*)

 Spiny-Spored Quillwort Present



0 50 100 200
Meters

Data Collected: August 1 to 20, 2019
Map Created: January 15, 2019
Created by GIS&M Section



Richard Lake

Tapegrass
(*Vallisneria americana*)

 Tapegrass Present



0 50 100 200
Meters

Data Collected: August 1 to 20, 2019
Map Created: January 15, 2019
Created by GIS&M Section



Richard Lake

White Water-Lily
(*Nymphaea odorata*)

 White Water-Lily Present



0 50 100 200
Meters

Data Collected: August 1 to 20, 2019
Map Created: January 15, 2019
Created by GIS&M Section



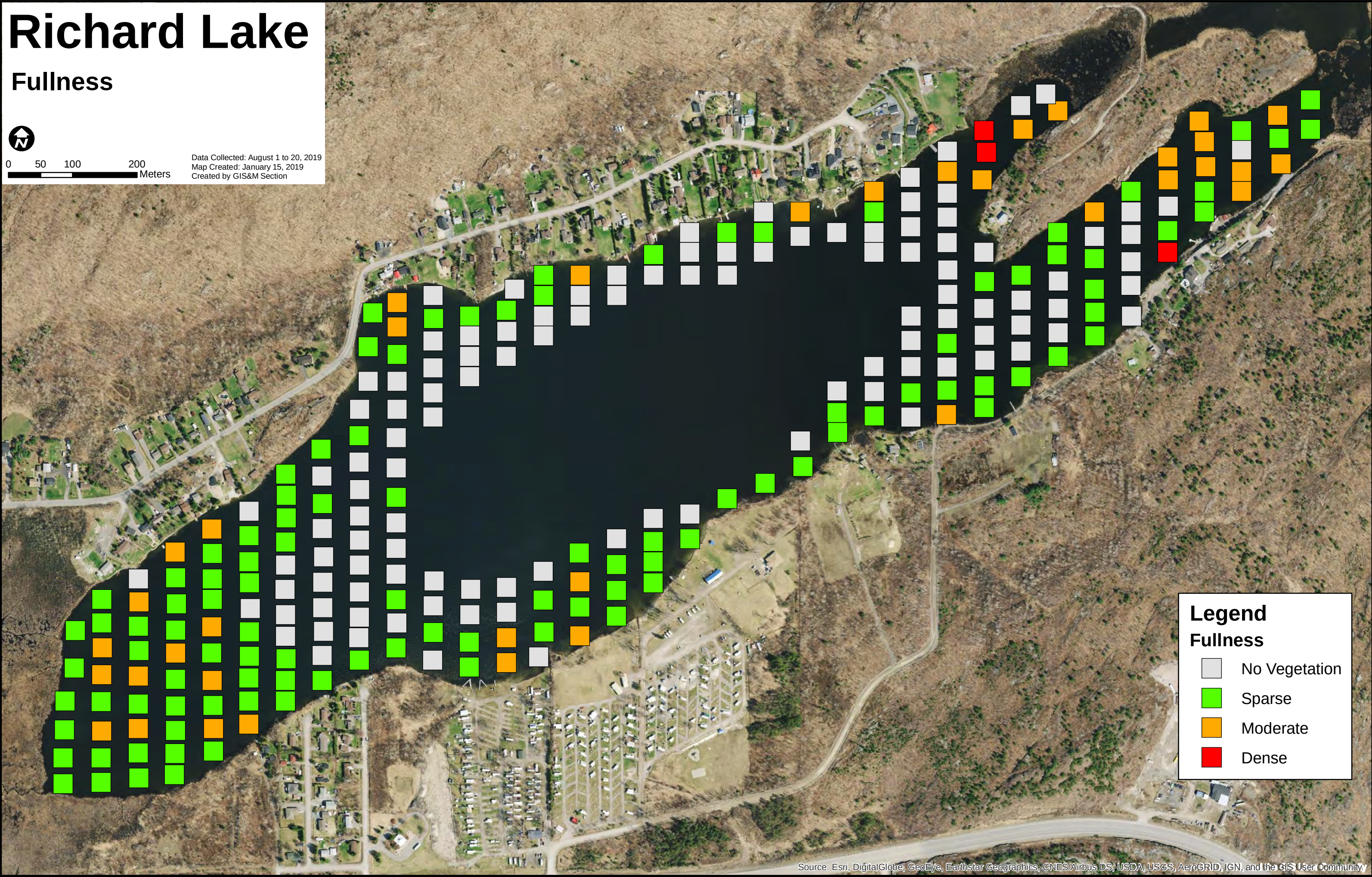
Richard Lake

Fullness



0 50 100 200
Meters

Data Collected: August 1 to 20, 2019
Map Created: January 15, 2019
Created by GIS&M Section



Legend

Fullness

-  No Vegetation
-  Sparse
-  Moderate
-  Dense

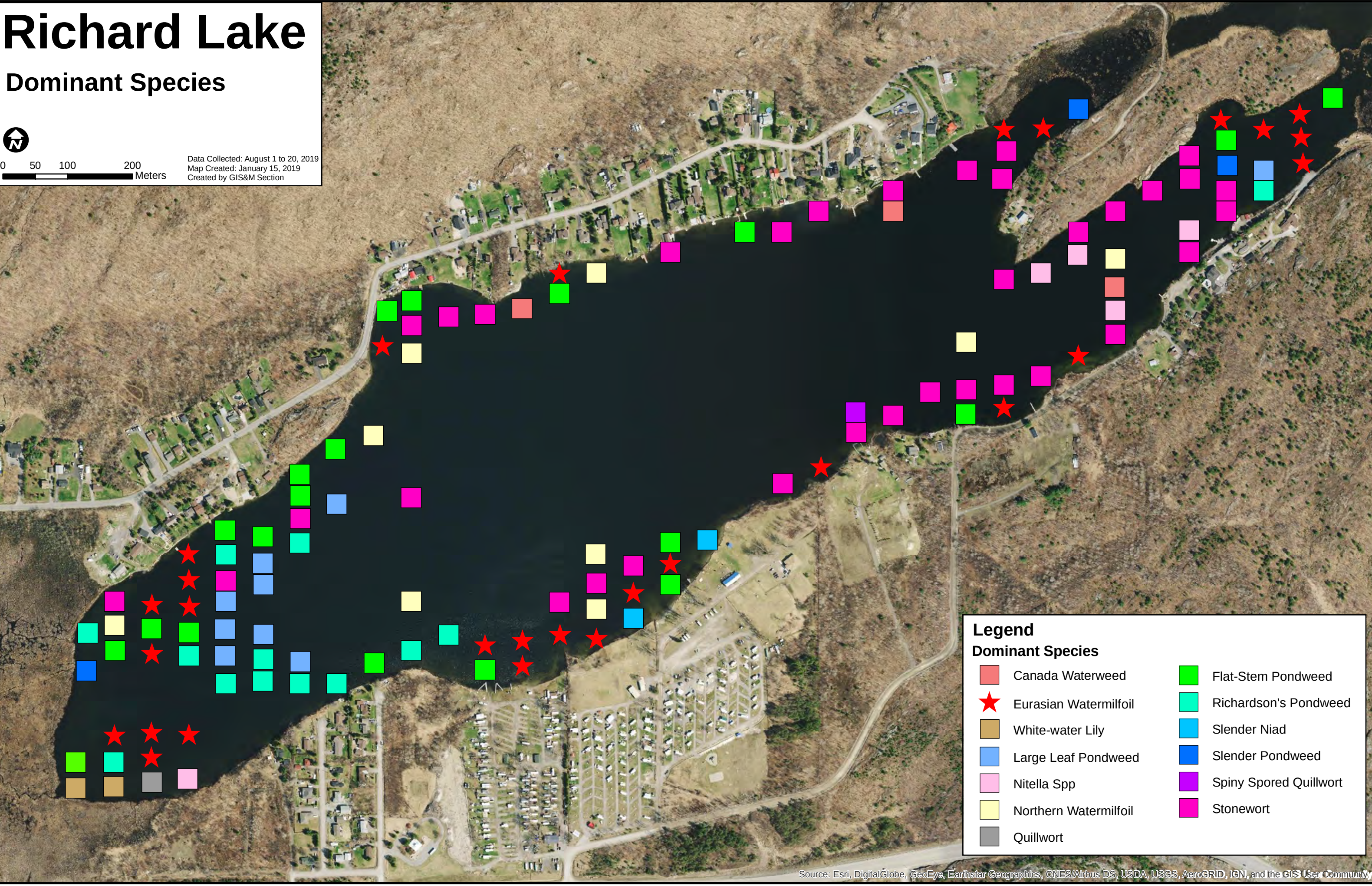
Richard Lake

Dominant Species



0 50 100 200
Meters

Data Collected: August 1 to 20, 2019
Map Created: January 15, 2019
Created by GIS&M Section



Legend

Dominant Species

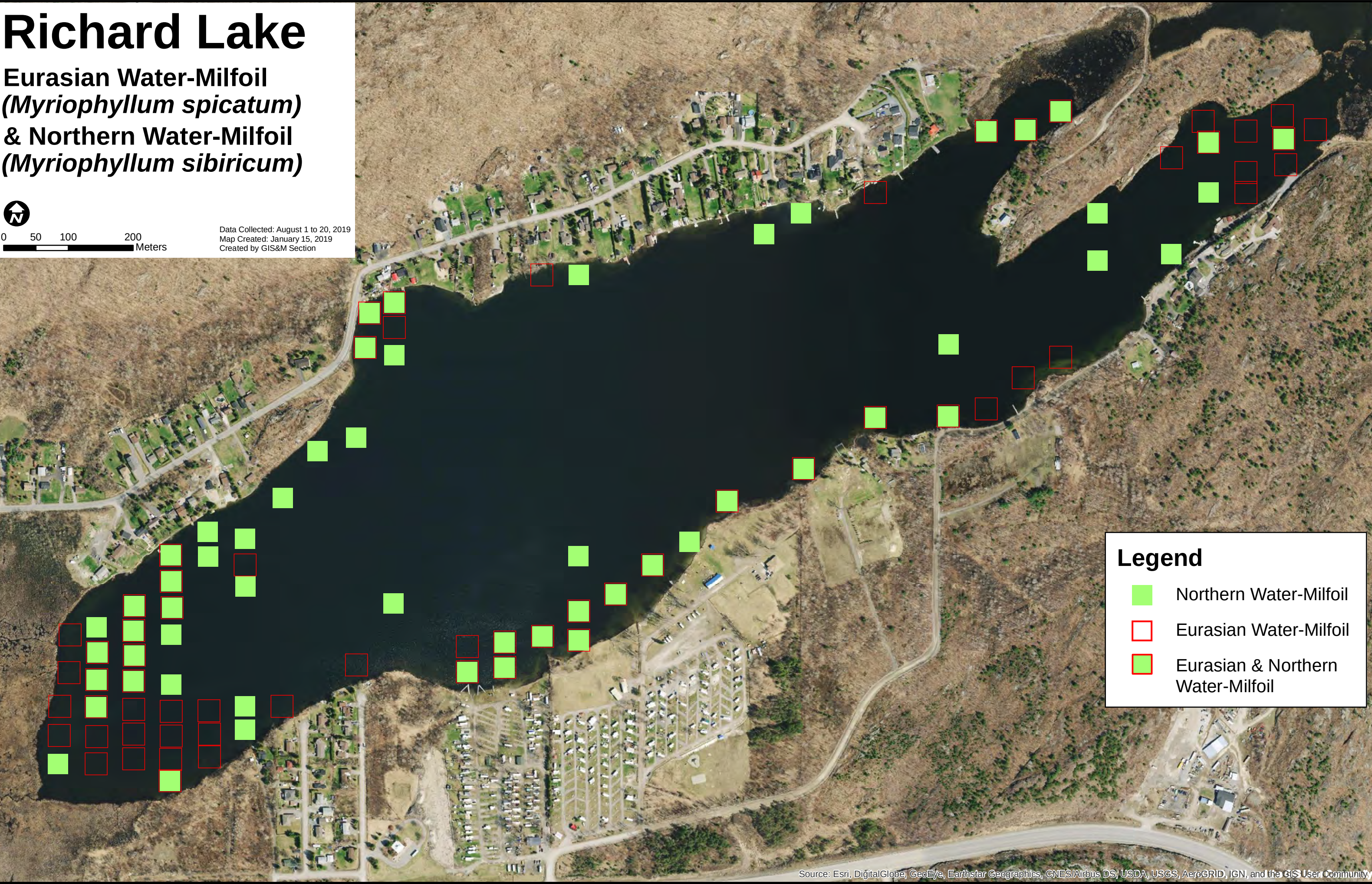
- | | |
|-----------------------|------------------------|
| Canada Waterweed | Flat-Stem Pondweed |
| Eurasian Watermilfoil | Richardson's Pondweed |
| White-water Lily | Slender Niad |
| Large Leaf Pondweed | Slender Pondweed |
| Nitella Spp | Spiny Spored Quillwort |
| Northern Watermilfoil | Stonewort |
| Quillwort | |

Richard Lake

Eurasian Water-Milfoil
(*Myriophyllum spicatum*)
& Northern Water-Milfoil
(*Myriophyllum sibiricum*)



Data Collected: August 1 to 20, 2019
Map Created: January 15, 2019
Created by GIS&M Section



Legend

- Northern Water-Milfoil
- Eurasian Water-Milfoil
- Eurasian & Northern Water-Milfoil