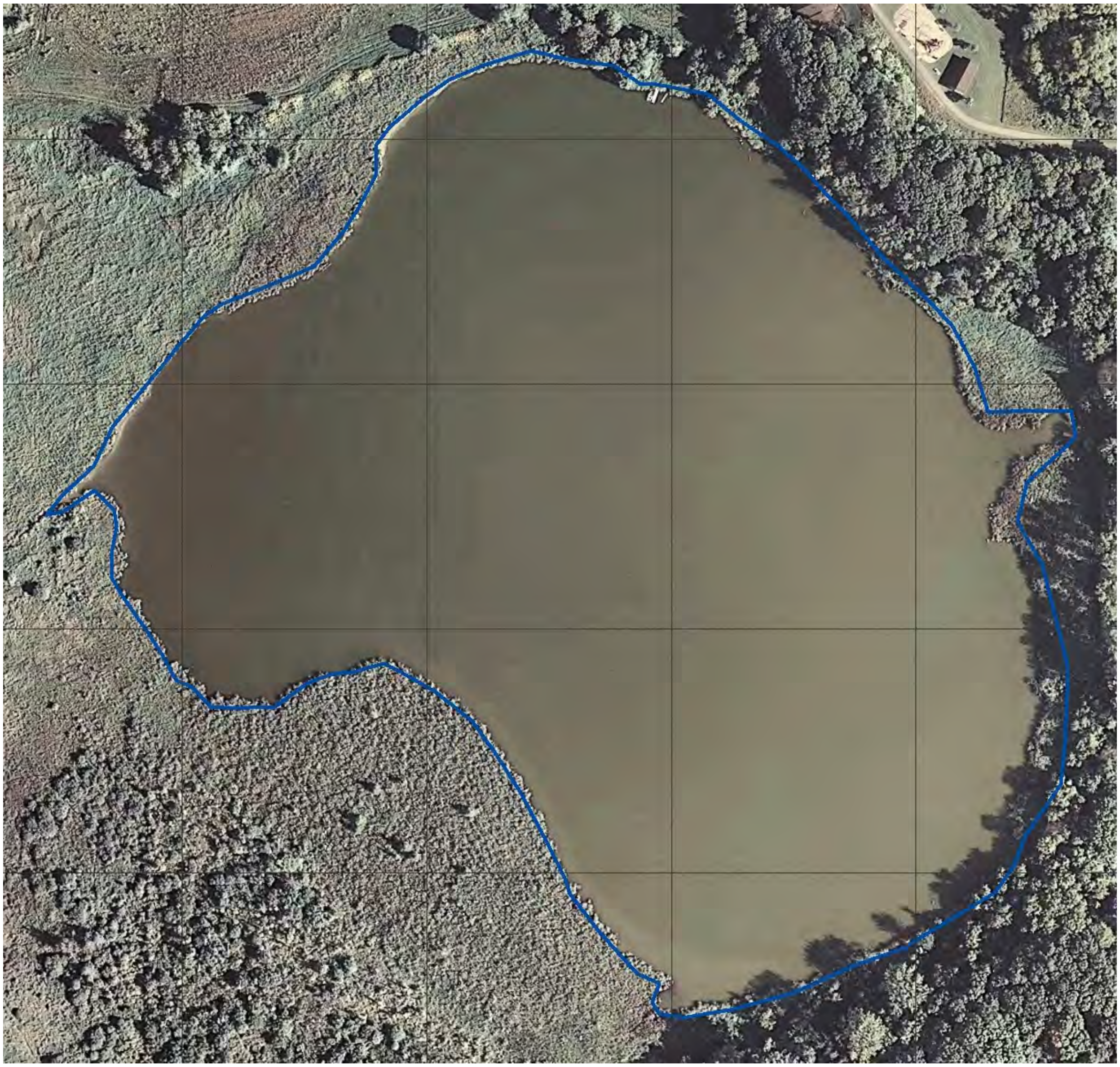

Arctic Lake, Scott County, Minnesota

Lake Sediment Fertility Assessment for Arctic Lake, Scott County, Minnesota

Lake Sediments Collected: September 18, 2012

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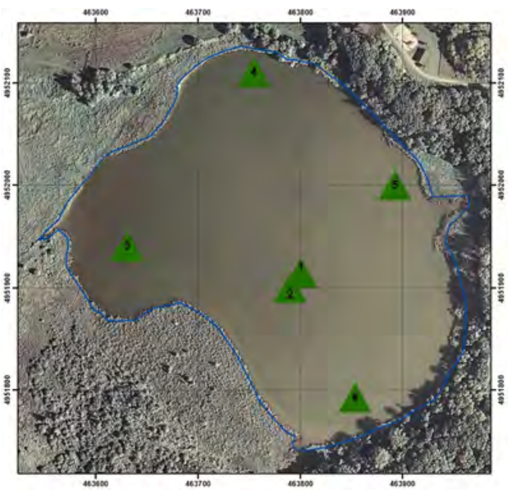
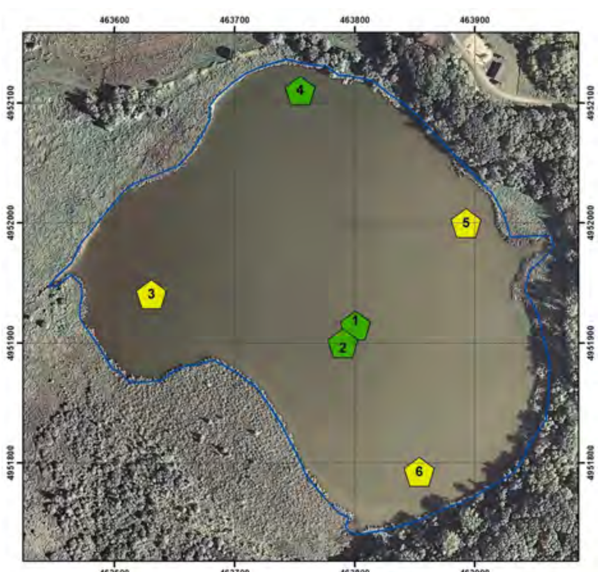
Summary

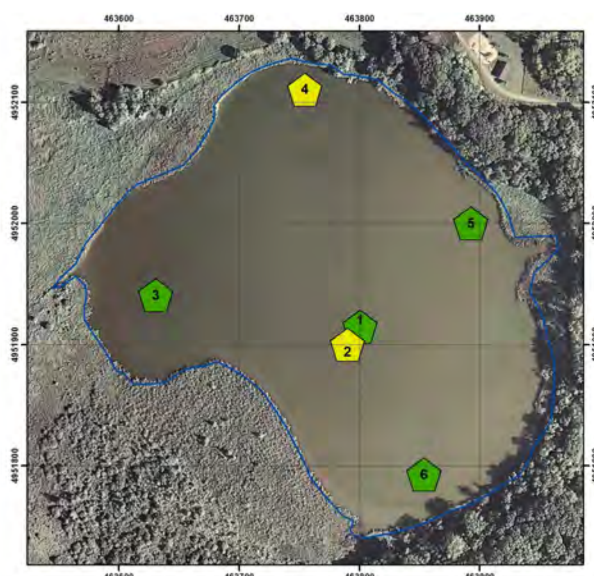


Sediment Phosphorus Release Potential Based on Fe:P Ratios: A variety of factors contribute to internal phosphorus loading in lakes. Research by Jensen et al (1992) found when a total iron to total phosphorus ratio was greater than 15 to 1, phosphorus release from lake sediments was minor. That benchmark has been used to characterize the potential of Arctic Lake sediments to release phosphorus. Results show the six sediment sites have a high Fe:P ratio in shallow and deep water and that phosphorus release from Arctic Lake sediments would appear to be light. (green triangles indicate low phosphorus release potential)

Growth Potential of Curlyleaf Pondweed and Eurasian Watermilfoil Based on Lake Sediment Characteristics for Arctic Lake: Lake sediments are known to influence non-native aquatic plant growth. It appears there are specific sediment characteristics that influence growth of curlyleaf pondweed and Eurasian watermilfoil.



Predicted Curlyleaf Growth: Light growth(green) to moderate growth (yellow) of curlyleaf is predicted for Arctic Lake, based on lake sediment characteristics of pH, iron content, and sediment bulk density



Predicted Eurasian Watermilfoil Growth: Mostly light growth (green) to moderate growth (yellow) of Eurasian watermilfoil is predicted for Arctic Lake, based on lake sediment characteristics of ammonia and organic matter.

Introduction

A variety of information can be acquired by analyzing lake sediments. For example, to determine potential internal phosphorus loading from lake sediments, the sediment iron to phosphorus ratio can be used. For managing non-native plants it is helpful to know where the plants have the potential to grow to nuisance conditions. A technique developed by Blue Water Science shows where nuisance growth of curlyleaf pondweed and Eurasian watermilfoil can occur in a lake based on lake sediment characteristics. This technique was applied to Arctic Lake.

Arctic Lake sediments were collected from six sites around the lake on September 18, 2012. The lake sediments were analyzed at the Soils lab at the University of Minnesota and results are presented in this report.

Methods

Lake Soil Collection: A total of six lake sediment samples were collected from the depth of 8 to 28 feet on September 18, 2012 by Steve McComas, Blue Water Science. Samples were collected using a modified soil auger, 5.2 inches in diameter (Figure 1) or a ponar sediment sampler. Soils were sampled to a depth of 6 inches. The lake soil from the sampler was transferred to 1-gallon zip-lock bags and delivered to the University of Minnesota soil testing laboratory.

Lake Soil Analysis: At the lab, sediment samples were air dried at room temperature, crushed and sieved through a 2 mm mesh sieve. Sediment samples were analyzed using standard agricultural soil testing methods. Fifteen parameters were tested for each soil sample. A summary of extractants and procedures is shown in Table 1. Routine soil test results are given on a weight per volume basis.

Table 1. Soil testing extractants used by University of Minnesota Crop Research Laboratory. These are standard extractants used for routine soil tests by most Midwestern soil testing laboratories (reference: Western States Laboratory Proficiency Testing Program: Soil and Plant Analytical Methods, 1996-Version 3).

Parameter	Extractant
P-Bray	0.025M HCL in 0.03M NH_4F
P-Olsen	0.5M $NaHCO_3$
NH_4-N	2N KCL
K, Ca, Mg	1N NH_4OA_c (ammonium acetate)
Fe, Mn, Zn, Cu	DTPA (diethylenetriamine pentaacetic acid)
B	Hot water
SO_4-S	$Ca(H_2PO_4)_2$
pH	water
Organic matter	Loss on ignition at 360°C

Figure 1. Soil auger used to collect lake sediments in shallow water.

Reporting Lake Soil Analysis Results: Lake soils and terrestrial soils are similar from the standpoint that both provide a medium for rooting and supply nutrients to the plant.

However, lake soils are also different from terrestrial soils. Lake soils (or sediments) are water logged, generally anaerobic and their bulk density ranges from being very light to very dense compared to terrestrial soils.

There has been discussion for a long time on how to express analytical results from soil sampling. Lake sediment research results are often expressed as grams of a substance per kilogram of lake sediment, commonly referred to as a weight basis (mg/kg). However, in the terrestrial sector, to relate plant production and potential fertilizer applications to better crop yields, soil results typically are expressed as grams of a substance per cubic foot of soil, commonly referred to as a weight per volume basis. Because plants grow in a volume of soil and not a weight of soil, farmers and producers typically work with results on a weight per volume basis.

That is the approach used here for lake sediment results: they are reported on a weight per volume basis or $\mu g/cm^3$ and are often reported in parts per million (ppm).

A bulk density adjustment was applied to lake sediment results as well. For agricultural purposes, in order to standardize soil test results throughout the Midwest, a standard scoop volume of soil has been used. The standard scoop is approximately a 10-gram soil sample. Assuming an average bulk density for an agricultural soil, a standard volume of a scoop has been a quick way to prepare soils for analysis, which is convenient when a farmer is waiting for results to prepare for a fertilizer program. It is assumed a typical silt loam and clay texture soil has a bulk density of 1.18 grams per cm^3. Therefore a scoop size of 8.51 cm^3 has been used to generate a 10-gram sample. It is assumed a sandy soil has a bulk density of 1.25 grams per cm^3 and therefore a 8.00 cm^3 scoop has been used to generate a 10-gram sample. Using this type of standard weight-volume measurement, the lab can use standard volumes of extractants and results are reported in ppm which is close to $\mu g/cm^3$. For all sediment results reported here a scoop volume of 8.51 cm^3 was used.

Although lake sediment bulk density has wide variations a scoop volume of 8.51 cm^3 was used for all lake sediment analyses. This would not necessarily produce a consistent 10-gram sample. Therefore, for our reporting, we have adjusted weight volume measurements and results have been adjusted based on the actual lake sediment bulk density. We used a standard scoop volume of 8.51 cm^3, but sediment samples were weighed. Because test results are based on the premise of a 10 gram sample, if our sediment sample was less than 10 grams, then the reported concentrations were adjusted down to account for the less dense bulk density. If a scoop volume weighed greater than 10.0 grams than the reported concentrations were adjusted up. For example, if a 10-gram scoop of lake sediment weighed 4.0 grams, then the correction factor is 4.00 g/ 10.00 g = 0.40. If the analytical result was 10 ppm based on 10 grams, then it should be 0.40 x 10 ppm = 4 ppm based on 4 grams. The results could be written as 4 ppm or 4 $\mu g/cm^3$. Likewise, if a 10-gram scoop of lake sediment weighed 12 grams, then the correction factor is 12.00 g / 10.00 g = 1.20. If the analytical result was 10 ppm based on a 10 gram scoop, then it should be 1.20 x 10 ppm = 12 ppm based on 12 grams. The result could be written as 12 ppm or 12 $\mu g/cm^3$. These are all dry weight determinations.

Results

Lake sediment results are based on mild extractions using standard soil testing methods. The results are broad indicators for phosphorus release and for the growth potential for terrestrial plants but lake soil analyses using these extractions appear to work for aquatic plants in general, and for curlyleaf pondweed and Eurasian watermilfoil in particular. However, there is some subjectivity in interpreting sediment results. In addition, there are many variables that influence plant growth on a year-to-year basis. Climatic factors and nutrient availability are two examples.

Arctic Lake sediment results are shown in Table 2. A total of 15 parameters were analyzed for each sediment sample. A low bulk density (less than 0.60 g/cm^3) indicates lake sediments are soft and mucky. Most of Arctic Lake samples had high organic matter content and a low bulk density. Sites 1, 2, and 3 were high in Olsen-phosphorus, but iron was very high as well (Table 2).

Table 2. Arctic Lake soil data. Sample were collected on September 18, 2012. Soil chemistry results have been adjusted for bulk density and are reported as μg/cm^3-dry which is equivalent to ppm except for organic matter (%) and pH (standard units).

Sample Number	Depth (ft)	Bulk Density (g/cm3)	Organic Matter (%) by L.O.I.	pH	Phosphorus Bray-P (ppm) (corr)	Phosphorus Olsen-P (ppm) (corr)	Boron (ppm) (corr)	Calcium Ca (ppm) (corr)	Copper Cu (ppm) (corr)	Iron Fe (ppm) (corr)	Potassium K (ppm) (corr)	Magnesium Mg (ppm) (corr)	Manganese Mn (ppm) (corr)	Ammonium Nitate NH4-N (ppm) (corr)	Sulfate SO4-S (ppm) (corr)	Zinc Zn (ppm) (corr)
1	28	0.59	21.3	7.4	1	18	0.57	2719	2.6	383	57	236	55	7.6	224	2.2
2	25	0.59	19.9	7.4	1	16	0.51	3080	2.4	328	49	248	37	5.9	263	3.6
3	12	0.65	35.3	7.4	1	16	0.94	3294	3.1	337	77	377	92	7.9	207	3.8
4	8	0.74	6.3	7.4	3	8	0.46	2250	2.3	190	39	193	30	4.6	106	2.7
5	16	0.25	41.0	7.1	<1	2	0.16	634	0.4	51	6	63	13	1.0	28	0.8
6	15	0.40	35.3	7.2	<1	6	0.36	1693	1.0	121	19	165	28	2.4	102	2.2

Phosphorus Release Potential

Phosphorus release from lake sediments has been well documented and there are a variety of ways to measure it. The approach used in this report uses limnological literature guidelines of iron to phosphorus ratios and p-release but also follows the interpretation that has been used in the agriculture area, where results are semi-quantitative and are indexed to empirical studies. That means, the exact mechanism of the mass of phosphorus released in a single season is uncertain, but we can make correlations with the data to other studies. In Arctic Lake because of the high sediment iron to phosphorus ratios, phosphorus release from lake sediments would be considered to be light on a lakewide basis.

A total of six sediment sites were sampled around Arctic Lake. Sediment sites and locations are shown in Figure 2.

Currently, the water quality in Arctic Lake is not very good. It appears the source of phosphorus is not from sediment release, rather it is likely from fish activities or watershed inputs.

Table 3. Arctic Lake sediment samples were collected on September 18, 2012. An iron to phosphorus (Fe:P) ratio of 15 or greater indicates a low phosphorus release potential.

Sample Site	Depth (ft)	Iron (ppm)	Bray-P (ppm)	Olsen-P (ppm)	Fe:P Ratio	P Release Potential
1	28	383	<1	18	21	Low
2	25	328	<1	16	21	Low
3	12	337	<1	16	21	Low
4	8	190	2.5	8	24	Low
5	16	51	<1	2	26	Low
6	15	121	<1	6	20	Low

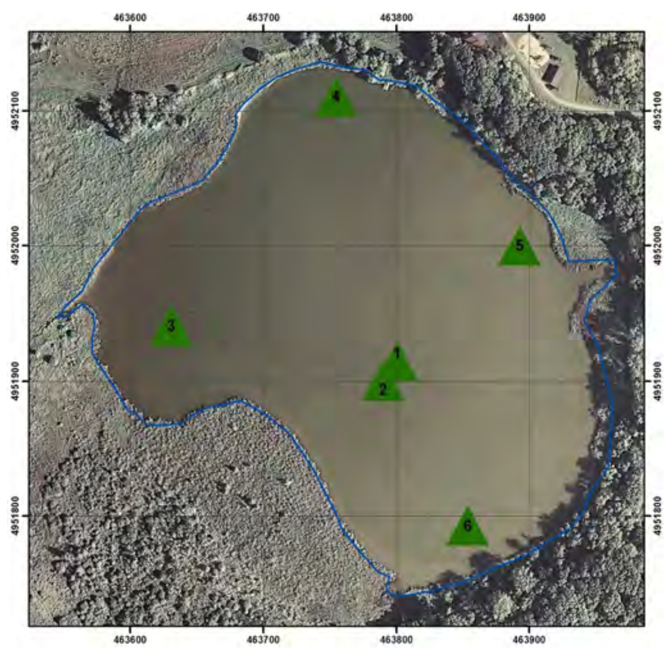


Figure 2. Lake sediment sample locations are shown with color squares. Colored squares represent phosphorus release potential at that site.
Key: Green = low; yellow = moderate; and red = high

Curlyleaf Pondweed Growth Potential in Arctic Lake

Lake sediment sampling results from 2012 have been used to predict lake bottom areas that have the potential to support three types of curlyleaf pondweed plant growth: light, moderate, or heavy. Based on the key sediment parameters of pH, the Fe:Mn ratio, sediment bulk density, and organic matter (McComas, unpublished), the predicted growth characteristics of curlyleaf pondweed are shown in Table 4 and Figure 2.

Curlyleaf pondweed growth is predicted to produce mostly light to moderate growth (where plant growth should not produce nuisance conditions) in Arctic Lake.

Table 4. Arctic Lake sediment data and ratings for potential curlyleaf pondweed growth.

Site	Depth (ft)	pH (su)	Fe:Mn Ratio	Bulk Density (g/cm^3 dry)	Organic Matter (%)	Potential for Curlyleaf Pondweed Growth
Light Growth		**<7.0**	**>6.0**	**>1.0**	**1 - 10 >60**	**Light (green)**
Moderate Growth		**7.0 - 7.6**	**1.6 - 6.0**	**0.52-1.00**	**10 - 20 50 - 60**	**Moderate (yellow)**
Heavy Growth		**>7.7**	**<1.6**	**<0.51**	**20 - 50**	**Heavy (red)**
1	28	7.4	7.0	0.59	21.3	Light
2	25	7.4	8.8	0.59	19.9	Light
3	12	7.4	3.7	0.65	35.3	Moderate
4	8	7.4	6.4	0.74	6.3	Light
5	16	7.1	4.0	0.25	41.0	Moderate
6	15	7.2	4.3	0.40	35.3	Moderate

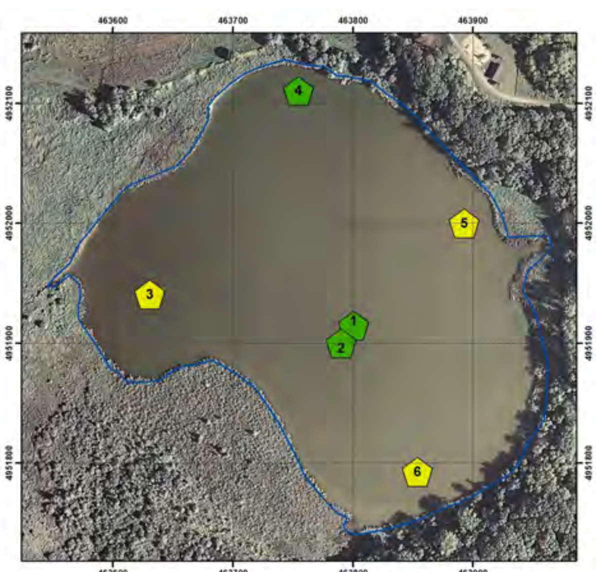
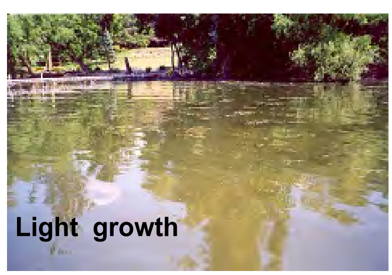


Figure 2. Sediment sample locations are shown with pentagons. The color indicates the type of curlyleaf pondweed growth predicted to occur at that site. Key: Green pentagons = light growth and yellow pentagons = moderate growth.



Light growth (left) refers to light nuisance growth that is mostly below the surface and is not a recreational or ecological problem. Heavy growth (right) refers to nuisance matting curlyleaf pondweed. This is the kind of nuisance growth predicted by high sediment pH and a sediment bulk density less than 0.51.

Eurasian Watermilfoil Growth Potential in Arctic Lake

Lake sediment sampling results from 2012 have been used to predict lake bottom areas that have the potential to support three types of EWM growth. Based on the key sediment parameters of NH_4 and organic matter (McComas, unpublished), a table and map were prepared that predict what type of milfoil growth could be expected in the future (Table 5 and Figure 3). Currently, no Eurasian watermilfoil has been observed in Arctic Lake.

The sediment nitrogen conditions in Arctic Lake indicate sediment sites would support mostly light to moderate milfoil growth. Also, high organic matter content of the lake sediments at several sites will likely limit heavy milfoil growth.

Table 5. Arctic Lake sediment data and ratings for potential EWM growth.

Site	Depth (ft)	NH_4 Conc (ppm)	Organic Matter (%)	Potential for EWM Growth
Light Growth		**<4**	**<4 & >20**	**Light (green)**
Moderate Growth		**5 - 9**	**18 - 20**	**Moderate (yellow)**
Heavy Growth		**>10**	**4 - 17**	**Heavy (red)**
1	28	7.7	21.3	Light
2	25	5.9	19.9	Moderate
3	12	7.9	35.3	Light
4	8	4.5	6.3	Moderate
5	16	1.0	41.0	Light
6	15	2.4	35.3	Light

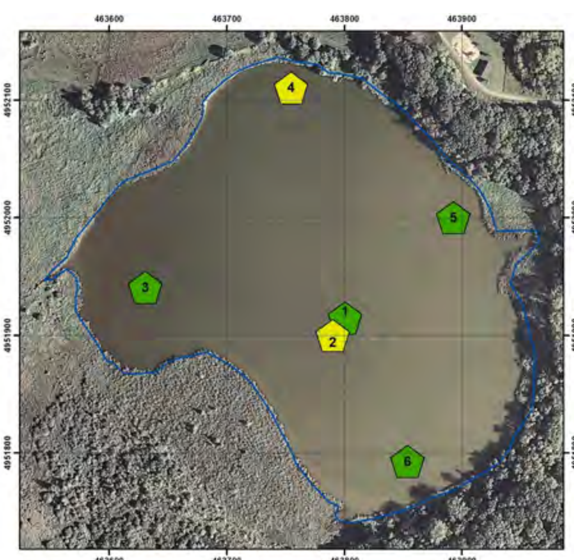
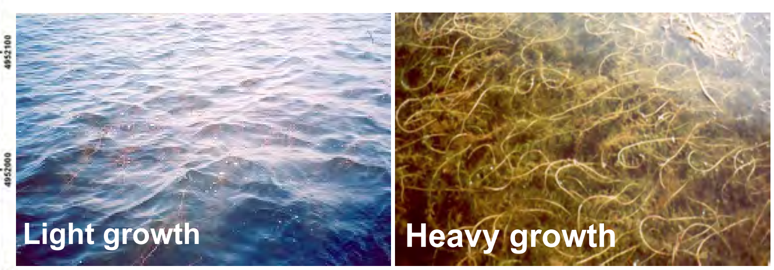


Figure 3. Sediment sample locations are shown with pentagons. The color indicates the type of Eurasian watermilfoil growth predicted to occur at that site. Key: Green pentagons = light growth and yellow pentagons = moderate growth.



Light growth (left) refers to light nuisance growth that is mostly below the surface and is not a recreational or ecological problem. Heavy growth (right) refers to nuisance matting Eurasian watermilfoil. This is the kind of nuisance growth predicted by high sediment nitrogen values and a sediment organic matter content less than 20%.