Sea Lake, Washington County, MN (Google Earth Map)

Potential for P-Release, Curlyleaf Pondweed, and Eurasian Watermilfoil Growth in Sea Lake Based on Lake Sediment Characteristics

[Sediments Collected: August 23, 2016]

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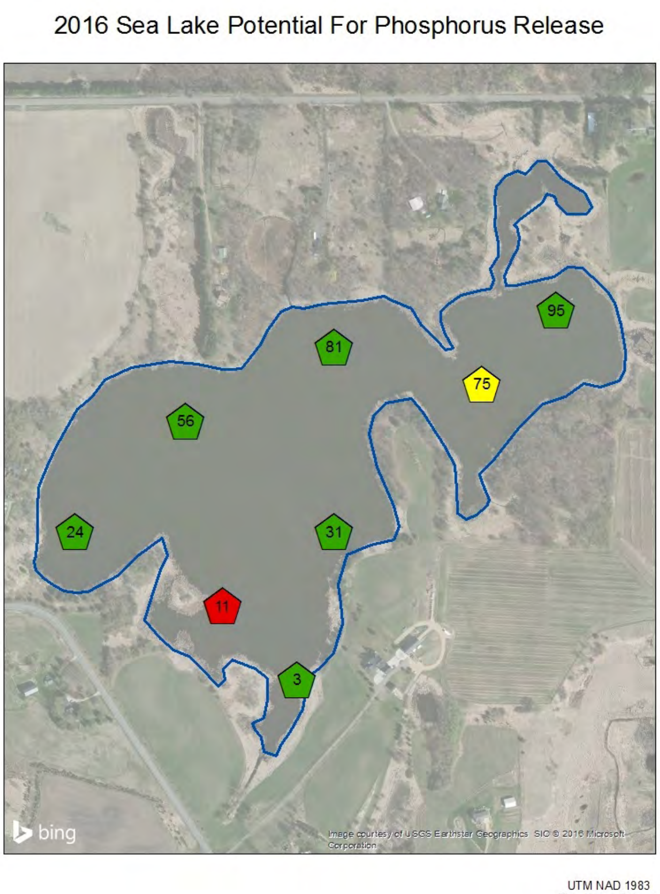
Summary

For managing nutrients and non-native plants it is helpful to know what the role of lake sediments might play. A technique developed by Blue Water Science predicts the type of growth of curlyleaf pondweed and Eurasian watermilfoil that can occur in a lake based on lake sediment characteristics. Also, sediment analyses results can give insights into the potential for lake sediment phosphorus release. This technique was applied to Sea Lake. Sea Lake sediments were collected from 8 sites around Sea Lake on August 23, 2016. The lake sediments were analyzed at the Soils Lab at the University of Minnesota.

Potential Sediment Phosphorus Release: A variety of factors contribute to elevated phosphorus levels in lakes and internal loading, including phosphorus release from lake sediments, can be a significant factor. 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. The ratio for the soil test results have been used in this report as well. That benchmark of 15:1 has been used to characterize the potential of Sea Lake sediments to release phosphorus. If the Fe:P ratio is greater than 15:1, p-release was considered to be low. If the Fe:P ratio was 7.5 to 15, p-release was considered to be moderate and if the Fe:P ratio was less than 7.5, p-release was considered to be high.



A second factor was also considered. If available phosphorus, as determined by Bray-P or Olsen-P, was 3 ppm or less, p-release was considered to be minor, regardless of the Fe:P ratio (derived from Nurnberg 1988).

Results for Sea Lake show only 1 sediment site (shown with a red pentagon) has a high potential for phosphorus release from sediments (Figure S1). At other sites sediment phosphorus release appears to be light to moderate (Figure S1).

Figure S1. Potential for lake sediment phosphorus release. Key: green = low, yellow = moderate, and red = high.

Curlyleaf Pondweed Growth Potential: Lake sediment sampling results from 2016 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).

Curlyleaf pondweed growth is predicted to produce mostly light to moderate growth (where plants may occasionally top out in a broken canopy) in Sea Lake (Figure S2).

Potential Curlyleaf Pondweed Growth

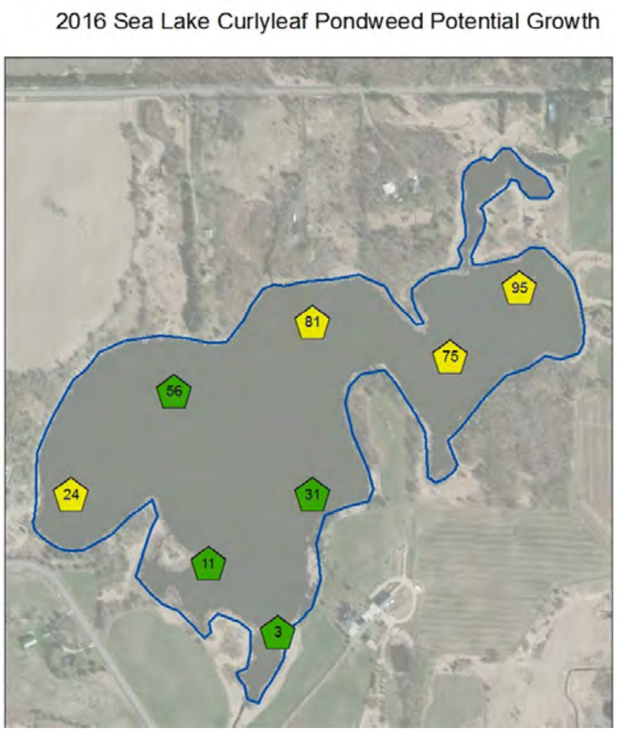


Figure S2. Sediment sample locations are shown with a pentagon. The pentagon color indicates the type of curlyleaf pondweed growth predicted to occur at that site. Key: green = light growth, yellow = moderate growth, and red = heavy growth.

Actual Curlyleaf Pondweed Growth - 2016

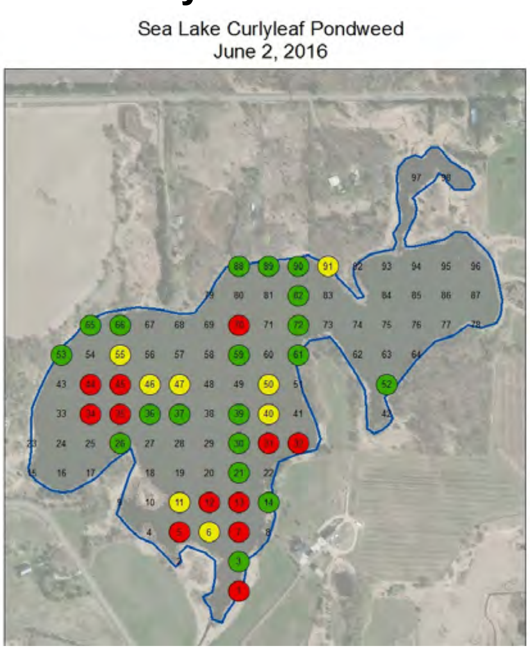


Figure S3. Actual curlyleaf pondweed coverage for June 2, 2016.
Key: green = light growth, yellow = moderate growth, and red = heavy growth.

Eurasian Watermilfoil Growth Potential: Lake sediment sampling results from 2016 have been used to predict lake bottom areas that have the potential to support three types of EWM growth. Eurasian watermilfoil has not been found in Sea Lake. Based on the key sediment parameters of exchangeable ammonia and organic matter (McComas, unpublished), a map was prepared that predicts what type of milfoil growth could be expected in the future in Sea Lake.

The sediment nitrogen conditions in Sea Lake are mostly high with several sediment samples over 10 ppm of nitrogen. Typically, sediments with high nitrogen are candidates for heavy milfoil growth. However, a number of the sediment sites, have a high percentage of organic matter. It has been found that Eurasian watermilfoil does not grow well in sediments with over 20% organic matter. Under current sediment conditions, a couple of areas in Sea Lake are predicted to produce heavy milfoil growth in the future.

Overall, the Sea Lake sediment survey results indicate a potential for mostly light growth of Eurasian watermilfoil in Sea Lake (shown with green pentagons) with a couple areas of the lake supporting heavy growth (shown with red pentagons).

Potential Eurasian Watermilfoil Growth

2016 Sea Lake Eurasian Watermilfoil Potential Growth

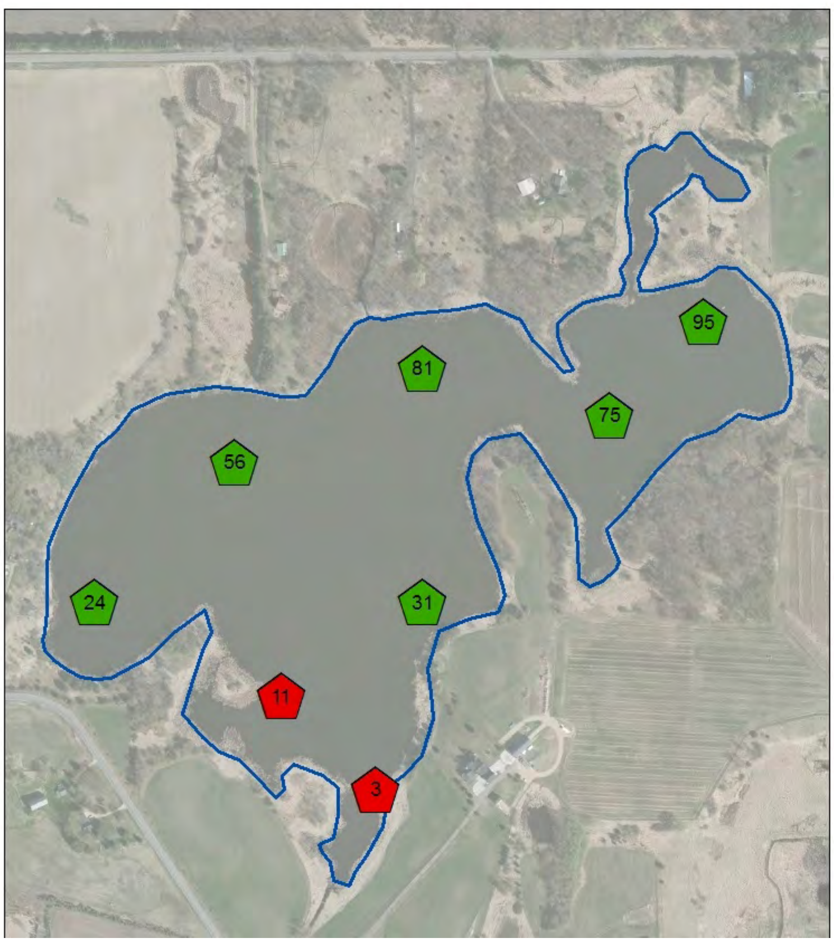


Figure S4. Sediment sample locations are shown with a pentagon. The pentagon color indicates the type of Eurasian watermilfoil growth predicted to occur at that site.
Key: green = light growth, yellow = moderate growth, and red = heavy growth.

Potential for P-Release, Curlyleaf Pondweed, and Eurasian Watermilfoil Growth in Sea Lake Based on Lake Sediment Characteristics

Introduction

For managing excessive phosphorus concentrations as well as managing non-native plants it is helpful to know what the role the lake sediments might play. A technique developed by Blue Water Science shows areas that might release phosphorus as well as areas that might produce nuisance growth of curlyleaf pondweed (CLP) and Eurasian watermilfoil (EWM) lake based on lake sediment characteristics. This technique was applied to Sea Lake.

Sea Lake sediments were collected from 8 sites around the lake on August 23, 2016. 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 8 lake sediment samples were collected from a water depth of 3 to 6 feet on August 23, 2016 by Blue Water Science. Samples were collected using a modified soil auger, 5.2 inches in diameter (Figure 1) and 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^oC

Figure 1. Soil auger used to collect lake sediments.

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 $\mu g/cm^3$.

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.

However lake sediment bulk density has wide variations but only a single scoop volume of 8.51 cm^3 was used for all lake sediment samples. This would not necessarily produce a consistent 10-gram sample. Therefore, for our reporting, we have used corrected 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

A total of 8 sediment sites were sampled around Sea Lake. Sediment sites and locations are shown in Table 2 and Figure 2.

Table 2. Sea Lake sediment sample locations and field observations on August 23, 2016.

Sediment Sample ID	Sample Depth (ft)
3	3
11	4
24	5
31	6
56	6
75	5
81	5
95	4

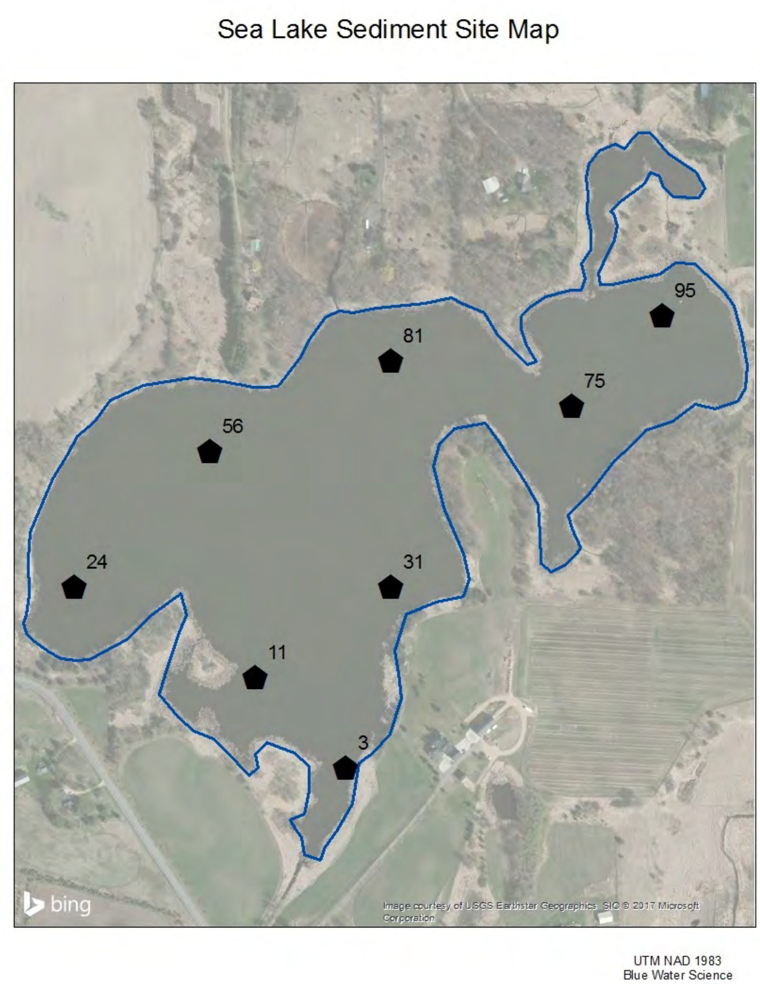


Figure 2. Sediment sample site locations.

Sea Lake sediment results are shown in Table 3. A total of 15 parameters were analyzed for each sediment sample. The results of unadjusted lake sediment data (lab data) are shown in the top table. Results of adjusted data taking into account the actual weight of the sediment sample are shown in the bottom table (adjusted data).

A low bulk density (less than 0.60 g/cm^3) indicates lake sediments are soft and mucky. Many of the Sea Lake samples had high organic matter content. For other parameters, like phosphorus and potassium, concentrations were variable and ranged from low to high. Nitrogen levels were fairly high in Sea Lake sediments.

Table 3. Sea Lake soil data. Sample were collected on August 23, 2016. Soil chemistry results are reported as µg/cm^3-dry which is equivalent to ppm except for organic matter (%) and pH (standard units).

Lab Data

Sample Name	Bray P (ppm)	Olsen P (ppm)	NH4OAc-K (ppm)	LOI OM (%)	Water pH	Hot Water Boron (ppm)	DTPA-Fe (ppm)	DTPA-Mn (ppm)	DTPA-Zn (ppm)	DTPA-Cu (ppm)	NH_4OAc-Ca (ppm)	NH_4OAc-Mg (ppm)	SO_4-S (ppm)	NH4-N (ppm)	10 gm Scoop Wt	10 gm Scoop Wt	10 gm Scoop Wt
Sea 3	12	8	140	11.05	5.85	0.472	356.41	40.793	6.700	2.348	1560.0	245.11	13	15.30	6.37	6.40	6.40
Sea 11	14	6	112	2.9	6.5	0.209	94.242	25.861	1.210	2.050	1286.3	231.19	15	12.93	9.97	9.96	9.93
Sea 24	7	4	213	25.6	5.8	0.709	451.78	38.333	8.593	3.172	1944.8	332.94	51	38.57	4.97	5.19	5.06
Sea 31	10	5	166	29.2	6.1	0.730	325.28	33.857	6.428	4.359	2327.2	393.59	67	14.51	4.86	4.95	4.94
Sea 56	12	6	173	33.6	5.9	0.917	306.34	35.801	9.017	3.365	2286.2	411.26	96	12.27	4.92	4.83	4.86
Sea 95	5	3	125	35.5	5.8	0.666	448.06	22.643	4.115	3.628	1794.0	305.48	24	20.40	4.01	3.99	4.11
Sea 75	32	23	152	24.7	5.9	0.902	412.23	70.521	5.820	3.182	1761.2	254.79	38	104.28	4.60	4.65	4.65
Sea 81	9	5	196	33.1	5.8	0.923	369.71	52.410	8.201	3.276	2333.0	402.59	40	28.92	5.55	5.53	5.48

Adjusted Data

Sample Name	Bulk Density (wt/8.51)	Bray P (ppm) adjusted	Olsen P (ppm) adjusted	K (ppm) adjusted	Organic matter (%)	Water pH	Boron (ppm) adjusted	Fe (ppm) adjusted	Mn (ppm) adjusted	Zn (ppm) adjusted	Cu (ppm) adjusted	Ca (ppm) adjusted	Mg (ppm) adjusted	SO_4-S (ppm) adjusted	NH4-N (ppm) adjusted	Fe/Mn	Average 10g Scoop
Sea 3	0.75	7.7	5.1	89	11.05	5.85	0.302	228	26.1	4.3	1.5	997	157	8.3	9.8	8.7	6.39
Sea 11	1.17	14	6.0	111	2.9	6.5	0.208	93.8	25.7	1.2	2.0	1280	230	14.9	12.9	3.6	9.95
Sea 24	0.60	3.6	2.0	108	25.6	5.8	0.360	229	19.4	4.4	1.6	987	169	25.9	19.6	11.8	5.07
Sea 31	0.58	4.9	2.5	82	29.2	6.1	0.359	160	16.6	3.2	2.1	1144	194	32.9	7.1	9.6	4.92
Sea 56	0.57	5.8	2.9	84	33.6	5.9	0.447	149	17.4	4.4	1.6	1113	200	46.8	6.0	8.6	4.87
Sea 95	0.47	2.0	1.2	50	35.5	5.8	0.269	181	9.1	1.7	1.5	724	123	9.7	8.2	19.8	4.04
Sea 75	0.54	15	11	70	24.7	5.9	0.418	191	32.7	2.7	1.5	816	118	17.6	48.3	5.8	4.63
Sea 81	0.65	5.0	2.8	108	33.1	5.8	0.509	204	28.9	4.5	1.8	1288	222	22.1	16.0	7.1	5.52

Potential Sediment Phosphorus Release in Sea Lake

Potential Sediment Phosphorus Release: Factors that will contribute to elevated lake phosphorus concentrations could lead to high cylindro concentrations. A variety of factors contribute to elevated phosphorus levels in lakes and internal loading, including phosphorus release from lake sediments, can be a significant factor. 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. The ratio for the soil test results have been used in this report as well. That benchmark of 15:1 has been used to characterize the potential of Sea Lake sediments to release phosphorus. If the Fe:P ratio is greater than 15:1, p-release was considered to be low. If the Fe:P ratio was 7.5 to 15, p-release was considered to be moderate and if the Fe:P ratio was less than 7.5, p-release was considered to be high.

A second factor was also considered. If available phosphorus, as determined by Bray-P or Olsen-P, was 3 ppm or less, p-release was considered to be minor, regardless of the Fe:P ratio (derived from Nurnberg 1988).

Results for Sea Lake show only 1 sediment site (shown with red pentagon) has a low Fe:P ratio which is correlated to high potential phosphorus release from sediments (Figure 3). At other sites sediment phosphorus release appears to be light to moderate (Table 4 and Figure 3).

Table 4. Lake sediment data for iron and phosphorus and the calculated Fe to P ratio. Samples were collected on August 23, 2016. The highest sediment phosphorus concentration of a site was used in the Fe/P ratio.

STANDARD SOIL TESTS						
Site	Depth (ft)	Iron (ppm)	Bray-P (ppm)	Olsen-P (ppm)	Fe/P	Sulfate (ppm)
3	3	228	7.7	5.1	29.6	8.3
11	4	93.8	14	6.0	6.7	14.9
24	5	229	3.6	2.0	63.6	25.9
31	6	160	4.9	2.5	32.7	32.9
56	6	149	5.8	2.9	25.7	46.8
75	5	191	15	11	12.7	17.6
81	5	204	5.0	2.8	40.8	22.1
95	4	181	2.0	1.2	90.5	9.7

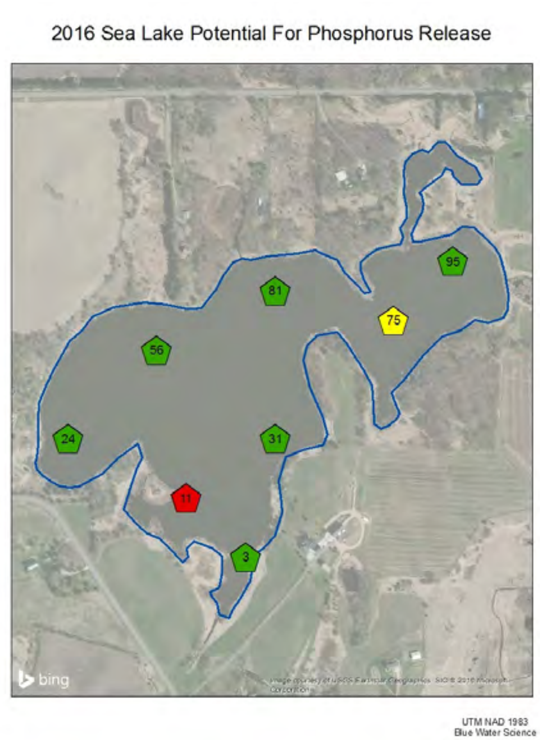


Figure 3. Potential P-release from the sediments in Sea Lake. Key: green = low potential, yellow = moderate potential, and red = high potential.

Curlyleaf Pondweed Growth Potential in Sea Lake

Sea Lake Status: Present in Sea Lake.

Curlyleaf Pondweed Growth Potential Based on Lake Sediments: Curlyleaf pondweed is present in Sea Lake. Research has found curlyleaf is limited or enhanced based on lake sediment characteristics. Based on lake sediment characteristics, curlyleaf has the potential to produce mostly moderate growth on an annual basis on a long term basis

Table 5. Sea Lake sediment data and ratings for potential growth of curlyleaf pondweed growth.

Site	Depth (ft)	pH (su)	Bulk Density (g/cm3 dry)	Organic Matter (%)	Fe:Mn Ratio	Potential for Curlyleaf Pondweed Growth
		<7.4	**>1.04**	**0.1-5**	**>4.5**	**Light (green)**
		7.4 - 7.7	**0.52 - 1.03**	**6-20**	**1.6 - 4.5**	**Moderate (yellow)**
		>7.7	**<0.51**	**>20**	**<1.6**	**Heavy (red)**
3	3	5.85	0.75	11.05	8.7	Light
11	4	6.5	1.17	2.9	3.6	Light
24	5	5.8	0.60	25.6	11.8	Moderate
31	6	6.1	0.58	29.2	9.6	Light
56	6	5.9	0.57	33.6	8.6	Light
75	5	5.9	0.54	24.7	5.8	Moderate
81	5	5.8	0.65	33.1	7.1	Moderate
95	4	5.8	0.47	35.5	19.8	Moderate

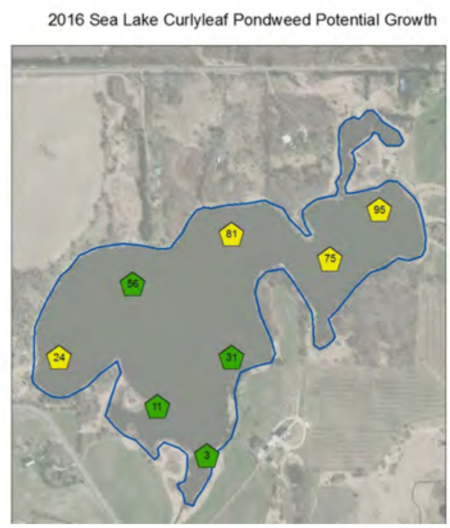


Figure 4. The color indicates the potential growth of curlyleaf pondweed. Key: green = light growth and yellow = moderate growth.

Examples of Curlyleaf Pondweed Growth Characteristics

Figure 5. Light growth (left) refers to non-nuisance growth that is mostly below the surface and is not a recreational or ecological problem. Moderate growth (middle) refers to growth that is just below the water surface. 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.

Actual curlyleaf pondweed growth in 2016 was greater than the predicted curlyleaf growth (Figure 6a and 6b). However, long term CLP growth predictions are for light to moderate growth based on lake sediment conditions. In the future, CLP growth will fluctuate from year to year but is not predicted to produce heavy growth on an annual basis.

Potential Curlyleaf Pondweed Growth

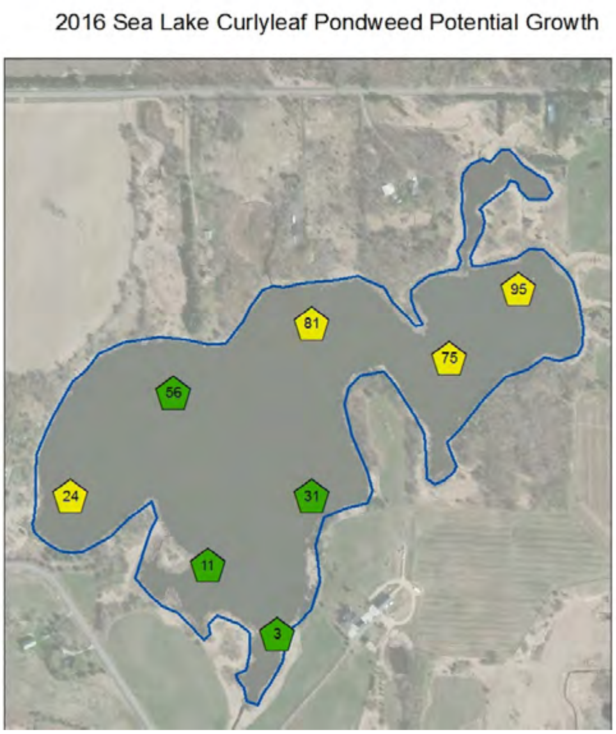


Figure 6a. Sediment sample locations are shown with a pentagon. The pentagon color indicates the type of curlyleaf pondweed growth predicted to occur at that site. Key: green = light growth, yellow = moderate growth, and red = heavy growth.

Actual Curlyleaf Pondweed Growth - 2016

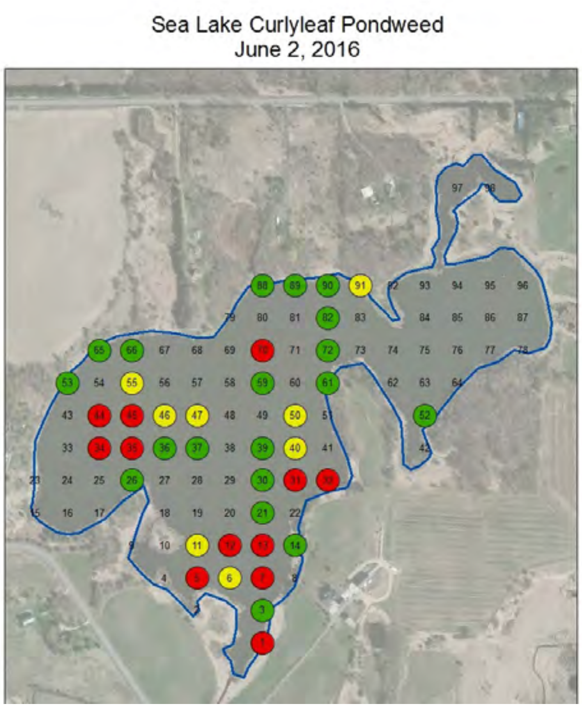


Figure 6b. Actual curlyleaf pondweed coverage for June 2, 2016.
Key: green = light growth, yellow = moderate growth, and red = heavy growth.

Eurasian Watermilfoil Growth Potential in Sea Lake

Sea Lake Status: Not present in Sea Lake.

Eurasian Watermilfoil (EWM) Growth Potential Based on Lake Sediments: Lake sediment sampling results from 2016 have been used to predict lake bottom areas that have the potential to support heavy EWM growth. Eurasian watermilfoil has not been observed in Sea Lake as of August 2016. The potential for milfoil growth, based on lake sediment sampling, would be mostly light growth. Heavy milfoil growth has been correlated with high sediment nitrogen condition and Sea Lake had high sediment nitrogen values at some sites sampled.

Table 6. Sea Lake sediment data and ratings for potential growth of Eurasian watermilfoil.

Site	Depth (ft)	NH_4 Conc (ppm)	Organic Matter (%)	Potential for EWM Growth
		<4	<0.5 and >20	Light (green)
		4 - 10	0.6 - 2 and 18 - 20	Moderate (yellow)
		>10	3 - 17	Heavy (red)
3	3	9.8	11.05	Heavy
11	4	12.9	2.9	Heavy
24	5	19.6	25.6	Light
31	6	7.1	29.2	Light
56	6	6.0	33.6	Light
75	5	48.3	24.7	Light
81	5	16.0	33.1	Light
95	4	8.2	35.5	Light

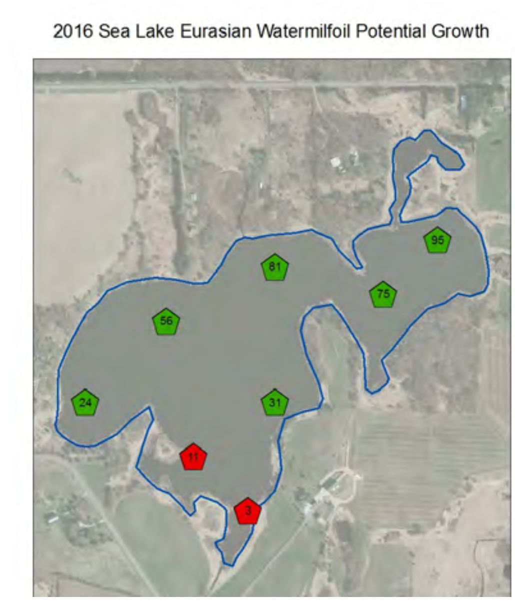


Figure 7. The color indicates the potential growth of EWM. Key: green = light growth and red= heavy growth.

Examples of Eurasian Watermilfoil Growth Characteristics

Figure 8. Light growth (left) refers to non-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%.