AQUATIC MACROPHYTE SURVEY OF COOK'S BAY, LAKE SIMCOE, AUGUST 2006

File No. 160940049

Stantec

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April 2007

Executive Summary

An inventory of the aquatic plants of Cooks Bay was conducted in August of 2006, for contrast to data collected in 1984 and 1987, and to provide a baseline against future change. Samples were collected along transects radiating from near shore (1 m) to 9 m of water along the west, south and east shorelines of Cooks Bay. Samples were collected using a standard Ponar grab. Routine water quality parameters (dissolved oxygen, temperature, pH) were measured where plant samples were collected. A qualitative mapping inventory of emergent vegetation was also conducted.

Macrophyte growths in Cooks Bay are dense enough to have had significant effects on water quality. Dissolved oxygen levels were observed to be significantly depressed in localized areas such as offshore from Gilford (west side of the bay) during early morning. Associated with the low dissolved oxygen levels was lower pH. Super-saturation of dissolved oxygen levels were also observed in Cooks Bay in mid- to late-afternoon sampling periods.

Total macrophyte biomass of Cooks Bay has increased somewhat since the arrival of zebra mussels in 1995. Neil *et al*. (1988) reported an average standing crop wet weight biomass of 1.2 kg/m^2 for the survey in 1987, with plants limited to water depths of < 6 to 8 m. In this 2006 survey, average biomass (across all stations) was 1.4 kg/m^2, while plants were not found in water deeper than 8.5 m, while the greatest densities were in < 4 m, consistent with the 1997 survey.

The distributions of the various plant species varied with depth in a typical fashion. The stonewort *Chara*, flat-stemmed pondweed and tapegrass were limited to shallower waters of about < 4 m, whereas coontail and *Elodea canadensis* were less restricted, and abundant at up to 7 m.

Management options for the control of macrophytes are limited to manual harvesting, nutrient reduction, biological control, and chemical treatment. Manual harvesting is ongoing in Cooks Bay along the eastern shoreline. The bay, however, is simply too large to implement a large-scale harvesting operation, though local control will provide temporary relief of unaesthetic buildups. Nutrient inputs have and will continue to be minimized. Biological and chemical control options are infeasible on such a large scale.

Additional information is needed to more fully understand the linkages and potentially negative interactions between macrophyte growths and the quality of habitat for benthic macroinvertebrates and fish in Cooks Bay. Additional information is also needed to understand the factors limiting the growth of macrophytes, and the potential to reduce macrophyte growths through reduction in nutrient loads. Continued monitoring of the macrophyte beds in Cooks Bay at two- to three-year intervals, in the long term would provide data that could be used to demonstrate changes in standing stock biomass, and the influence of mitigation actions (if any are taken).

Glossary

Baseline Data – Data used to set a benchmark or baseline, against which future trends will be assessed.

Bathymetric Map – a map of the lake floor showing the terrain as contour lines **Biota** – the

total collection of organisms of a geographic region or a time period

Chemical Correspondence Analysis (CCA) – widely used method for direct gradient analysis, best developed by C.J.F. ter Braak. CCA assumes that species have unimodal distributions along environmental gradients. (http://ordination.okstate.edu/glossary.htm#C)

Catchment Area – The entire area from which drainage is received by a river or a lake; most generally used in reference to surface runoff. It is a region of land where water from rain or snow melt drains downhill into a body of water, such as a river, lake, dam, estuary, wetland, sea or ocean. A catchment area is seperated topographically from adjacent basins by a ridge, hill or mountain, which is known as a water divide. Other terms for a Catchment Area include *watershed*, *catchment*, *catchment area*, *drainage area*, *drainage basin*, *river basin* and *water basin*.

CO_2 – Carbon dioxide is a chemical compound composed of one carbon and two oxygen atoms.

Conductivity – is a measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge). Organic compounds like oil, phenol, alcohol, and sugar do not conduct electrical current very well and therefore have a low conductivity when in water. Conductivity is also affected by temperature: the warmer the water, the higher the conductivity. For this reason, conductivity is reported as conductivity at 25 degrees Celsius (25 C). The basic unit of measurement of conductivity is the mho or siemens. Conductivity is measured in micromhos per centimeter (µmhos/cm) or microsiemens per centimeter (µs/cm).

Dissolved Oxygen (DO) – Oxygen that is "dissolved" in water. Dissolved oxygen is an important indicator of a water body's ability to support aquatic life. Fish "breathe" by absorbing dissolved oxygen through their gills. Oxygen enters the water by absorption directly from the atmosphere or by aquatic plant and algae photosynthesis. Oxygen is removed from the water by respiration and decomposition of organic matter.

Emergent Vegetation – Aquatic plants that are rooted in lake or river sediments, but that extend above the water surface into the air.

Geodatabase – a database with extensions for storing, querying, and manipulating geographic information and spatial data. Also known as a spatial database.

GIS – a Geographic Information System is a tool that allows users to create interactive queries (user created searches), analyze the spatial information, edit data, maps, and present the results of all these operations.

IKONOS – commercial earth observation satellite, and was the first to collect publicly available high-resolution imagery at 1- and 4-meter resolution.

Invertebrate – Animals without backbones.

Macrophyte – Aquatic plant.

NAD83 – North American Datum of 1983. The North American Datum is the official reference ellipsoid used for the primary geodetic network in North America. Currently, in the fields of cartography and land-use; there are two North American Datums in use: North American Datum of 1927 (NAD 27) and North American Datum of 1983 (NAD 83). Both are geodetic reference systems, but each is based on different measurements. The North American Datum of 1983 was created to meet requirements for better accuracy and more precision.

Ordination – is a method, in multivariate analysis, complementary to dataclustering, and used mainly in exploratory data analysis (rather than in hypothesis testing). Ordination orders objects that are characterized by values on multiple variables (i.e multivariate objects) so that similar objects are near each other and dissimilar objects are further from each other. These relationships between the objects, on each of several axes (one for each variable), are then characterized numerically and/or graphically. Many ordination techniques exist, including principal components analysis (PCA), non-metric multidimensional scaling (NMDS), correspondence analysis and its derivatives (CA, DCA, CCA), Bray-Curtis ordination, and redundancy analysis (RA), among others.

pH – is a measure of the acidity or basicity of a solution. Solutions with a pH less than 7 are considered acidic, while those with a pH greater than 7 are considered basic. pH 7 is defined as neutral because it is the pH of pure waterat 25 °C.

Photic Zone – is the depth of the water, whether in a lake or an ocean, that is exposed to sufficient sunlight for photosynthesis to occur. The depth of the photic zone (or sometimes called the euphotic zone) can be greatly affected by seasonal turbidity. The transparency of the water, which determines the depth of the Euphotic zone, is simply measured with a Secchi disk.

Photosynthetic Activity – is the synthesis of glucose from sunlight, carbon dioxide and water, with oxygen as a waste product. It is arguably the most important biochemical pathway known; nearly all life depends on it. It is an extremely complex process, comprised of many coordinated biochemical reactions. It occurs in higher plants, phytoplankton, algae, and some bacteria.

Secchi disc – a device used to measure water transparency in open waters of lakes, bays, and the ocean. The pattern shown in the image is drawn or painted onto a card or acrylic, mounted on a pole or line, and lowered slowly down in the water. The depth at which the pattern on the disk is no longer visible is taken as a measure of the transparency of the water. This measure is known as the Secchi depth and is related to water turbidity.

Standard Ponar Grab – a commonly used sampler that is very versatile for all types of hard bottoms such as sand, gravel and clay. It can be used in streams, lakes reservoirs and the ocean. (http://www.rickly.com/as/bottomgrab.htm)

Tributary – a stream or river that flows into another river or body of water but which may not flow directly into the sea. A confluence is where two or more tributaries or rivers flow together.

Turbidity – A measure of water clarity. Water that is more turbid typically has a higher concentration of suspended particulate materials.

UTM – The Universal Transverse Mercator (UTM) coordinate system is a grid-based method of specifying locations on the surface of the Earth. It is used to identify locations on the earth, but differs from the traditional method of latitude and longitude in several respects.

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1.0 Introduction

1.1 STUDY AREA

Lake Simcoe is the largest lake in southern Ontario, with the exception of the Great Lakes. It is a dimictic, hardwater lake connected to the Trent-Severn Waterway, which drains into Georgian Bay. The fish community is diverse with some 55 species including lake trout (*Salvelinus namaycush*), lake whitefish (*Coregonus clupeaformis*) and lake herring (*Coregonus artedii*). These coldwater fishes, along with northern pike (*Esox lucius*), yellow perch (*Perca flavescens*) and smallmouth bass (*Micropterus dolomieu*) are of major social and economic importance for the area. The Lake Simcoe watershed has been influenced by human activities for over 200 years (Evans *et al*., 1996). Forty-three percent of the 2914 km^2 of terrestrial area in the basin is agricultural (Eimers *et al*. 2005). This land use is concentrated along the Holland River and includes a large area of cultivated marsh that empties into Cook's Bay at the south end of the lake. While only 5% of Lake Simcoe's terrestrial catchment is urban, the population has doubled in the past two decades and projections suggest further growth (Eimers *et al*, 2005).

Cook's Bay, at the south end of Lake Simcoe, is shallow (average depth of 3.4 m) and receives inputs from several tributaries including the Holland River. The Holland River drains the Holland Marsh, a large agricultural area north of Toronto. Agricultural practices in the Holland Marsh can contribute significantly the contribution of phosphorus to Lake Simcoe, as well the Holland River watershed is urbanized with the large urban centers of Newmarket, Aurora and Bradford contributing to phosphorus loading. There are also four Water Pollution Controls Plants inputing into the Holland River or Cook's Bay directly as a point source of phosphorus contrinution. The combination of phosphorus contributors historically has significantly impacted on water quality in Cook's Bay.

Until the arrival of zebra mussels in 1995, water clarity in Cook's Bay was poor with average Secchi disc depths of 1 to 2 m: a result of excessive nutrient inputs and resultant algal growth (Eimers and Winter, 2005). The arrival of zebra mussels resulted in an increase in water clarity, and a proliferation of growth of rooted aquatic vegetation throughout the bay. Vegetation frequently breaks free of the lake bottom because of wave action and boating, and creates floating masses that accumulate on windward shores (typically the east shoreline). Rotting windrows of plants along shore smell, and detract from the naturally aesthetic appeal of the bay.

This study collected quantitative samples of rooted aquatic plants from over 100 locations within the photic zone of the bay. Plants were identified to species and weighed, and the data used to generate maps illustrating the distributions of dominant species. The data collected in this inventory set a baseline against which future inventories can be compared, and will be useful for predicting dissolved oxygen conditions throughout the bay, as well as into the larger bays of Lake Simcoe.

Macrophyte growth in Cook's Bay is anticipated to be a significant factor in controlling concentrations of dissolved oxygen (Baird and GLL, 2006). Photosynthetic activity of macrophytes during day produces dissolved oxygen, whereas these same plants consume oxygen at night. Excessive macrophyte growths can deplete oxygen at night, and also cause shifts in pH during the day because of the removal of CO_2. Studies of the macrophytes of Cook's Bay have been limited. The Lake Simcoe Environmental Management Strategy (LSEMS) initiated a survey of the Cook's Bay macrophyte community in 1987 to provide a comparison to their similar study completed in 1984. The purpose of the study was to determine if the reduction of nutrient input into Cooks Bay was having any significant changes on the macrophyte population (Neil et al., 1988). Bathymetric maps of Lake Simcoe roughly show the locations of emergent plants in the southern part of the bay in the vicinity of the input of the Holland River. The Ontario Ministry of Natural Resources, in association with the University of Waterloo digitally mapped the densities of rooted plants using penetrating sonar in the summer of 2006.

2.0 Materials and Methods

2.1 GENERAL STUDY DESIGN

The approach taken for the macrophyte survey of Cooks Bay involved sampling a large number of locations (121), and collecting quantitative samples of rooted macrophytes for estimates of biomass as well as taking water chemistry measurements at both the surface and approximately 1 meter off the bottom for each station.

Sampling points were generally pre-selected using a GIS, stratifying the study area by water depth based on available depth contours (Baird and GLL, 2006). Water depths targeted in the design were 0.5, 1, 2, 6 and 8 m. There was an emphasis placed on shallower water locations (2 m and less) as macrophyte diversity and density was anticipated to be at its highest (Figure 1).

Prior to conducting the full field program, initial sampling was conducted with a Standard Ponar grab to confirm that the maximum depth at which plants occurred in the bay was 8 m. Preliminary estimates on the depth to which plants extended was based on 2x Secchi disc depths for the bay, as well as anecdotal information provided by students from the University of Waterloo that had conducted side-scan inventories of plants in the Bay earlier in the season.

2.2 PONAR CALIBRATION

Synoptic samples of macrophytes were collected using a standard Ponar grab (0.1 m^2) and by hand (snorkeling) from within a 0.1 m^2 quadrate to compare the two methods (Appendix 1). These comparison samples were collected at 10 different locations representing different assemblages of plants and plant densities, all between 0.5 and 1.5 m of water. Sampling by hand produced higher estimates of plant biomass, and was considered to over estimate biomass because the operator was unable to limit sampling to within the 0.1 m^2 sampling area (Appendix 1). Subsequent samples of plants, for the purpose of characterizing plant biomass and diversity, were collected using the standard Ponar grab, as per Skubinna *et al.* (1995).

2.3 SUBMERGMENT VEGETATION SURVEY

Duplicate samples of macrophytes were collected at each of the 121 sampling locations using a Standard Ponar grab with 0.1 m^2 surface area. Samples were brought to surface, washed in laundry mesh bags, and stored on ice in plastic bags (Photographs 19 to 24, Appendix 4). Biomass samples were stored on ice until processing. All samples were sorted by species and weighed, using an Ohaus Portable Standard Balance, to the nearest 1 g of total wet weight. Following Carr *et al*. (2003), species sub-samples were dried at 90ºC to constant weight. Specimens of each species were also pressed and mounted to create a reference herbarium collection of macrophyte species of Cooks Bay (Photographs 1 to 5, Appendix 4). Dry weight biomass for each of the dominant plant species was estimated on the basis of observed ratios between wet weight and dry weight of subsamples.

Substrates were characterized, based on visual inspection, as either silt/muck, sand or clay (or mixtures). Water quality parameters (dissolved oxygen, temperature, pH, conductivity) were measured on site, at surface and 1 m off bottom, using a YSI water quality multi-meter. A single water quality record was made in shallow water (1 m or less). An observation of sediment type (i.e. clay, sand, silt, gravel) was noted at each station.

2.4 EMERGENT VEGETATION SURVEY

Emergent vegetation was mapping using a combination of satellite imagery interpretation with on-site confirmation. IKONOS-2 1-m resolution imagery from April 23, 2000 was used as a base map from which patches of emergent vegetation were mapped. This exercise was most relevant for the southern end of the bay which contained dense patches of emergent pencil weed (*Scirpus* sp.). Confirmation of the patches was carried out as part of the field program in August 2006.

2.5 MAPPING DISTRIBUTIONS

Sample-point locations (UTMs) and dry-weight biomass values were saved in an Excel spreadsheet that was converted to a dbase file that was imported into a Geographic Information System (GIS) and converted to a referenced geodatabase with a NAD83 Z17N projection. Rasterized Isophenes (contours showing values of biological events) were generated using a Nearest Neighbour Algorithm (computer subroutine to calculate densities between sampling points) show concentrations of the various species across the study area. These isophenes were mapped on geometrically corrected IKONOS-2 1m resolution satellite imagery from April 23, 2000 of Cooks Bay area.

2.6 CORRESPONDENCE ANALYSIS

Mapping of plant biomasses based on kriged surfaces was one method for illustrating distributions. We also used Canonical Correspondence Analysis (CCA) to explore the influences of water depth, substrate and location on plant assemblages. Correspondence Analysis is an ordination methodology, generally appropriate for summarizing assemblages of biota. Correspondence analysis is a common method used in ecology. It is also more convenient than most other ordination methods because it automatically ordinates both the samples and the taxa. The CA ordination procedure is designed to calculate a set of theoretical (synthetic) variables (axes) that best explain the variations in abundances of taxa across samples. Calculation of sample and taxa scores on the first ordination axis is done by iteratively estimating the weighted average sample scores and the weighted average taxa scores. For the first iteration, axis scores are arbitrarily assigned to each taxon. For each sample, the procedure determines the weighted average axis score, which is the average of the taxa scores weighted by the abundances of each taxon. The next iteration produces new weighted average axis scores for the taxa, calculated from the sample scores. The iterative procedure continues until there is little change in the sample and taxa scores. Estimation of second and third ordination axes follows a similar routine, except that the sample scores of additional axes are made orthogonal (uncorrelated) with the first and other axes. Sample scores in CA are usually scaled to have a mean of zero and standard deviation of 1 (ter Braak, 1992). The distribution of samples in a CA diagram (biplot) indicates the relative similarities and differences in composition based on taxa abundances. Samples with similar scores will have plant species similar proportions, while samples with different scores will have plant species in different proportions. The scatter diagram for taxa portrays the dispersion of plat taxa along the theoretical variables (axes). Thus, a sample with an axis-1 score of 2 would be dominated by those taxa that also had axis-1 scores close to 2.

Canonical Correspondence Analysis constrains the ordination of, in this case plants, by an imposed set of environmental descriptors (ter Braak, 1992). The six most dominant plants in the study area were used in this analysis (tapegrass, stonewort, flat-stem pondweed, coontail, Eurasian water milfoil, common waterweed, clasp-leaved pondweed). The data used in this analysis were the log-transformed (log of x+1) dry weight biomasses (g per 0.1 m^2) of each of the dominant plant species. Environmental data were depth (m), Easting and Northing. The influence of substrate (classified as silt, sand or clay) on the types of plants present was determined through inspection of the ordination biplot. Symbols for site scores were colour coded according to substrate class. An influence of substrate on the plant assemblage would show up as clusters of similarly coloured symbols in the ordination biplot.

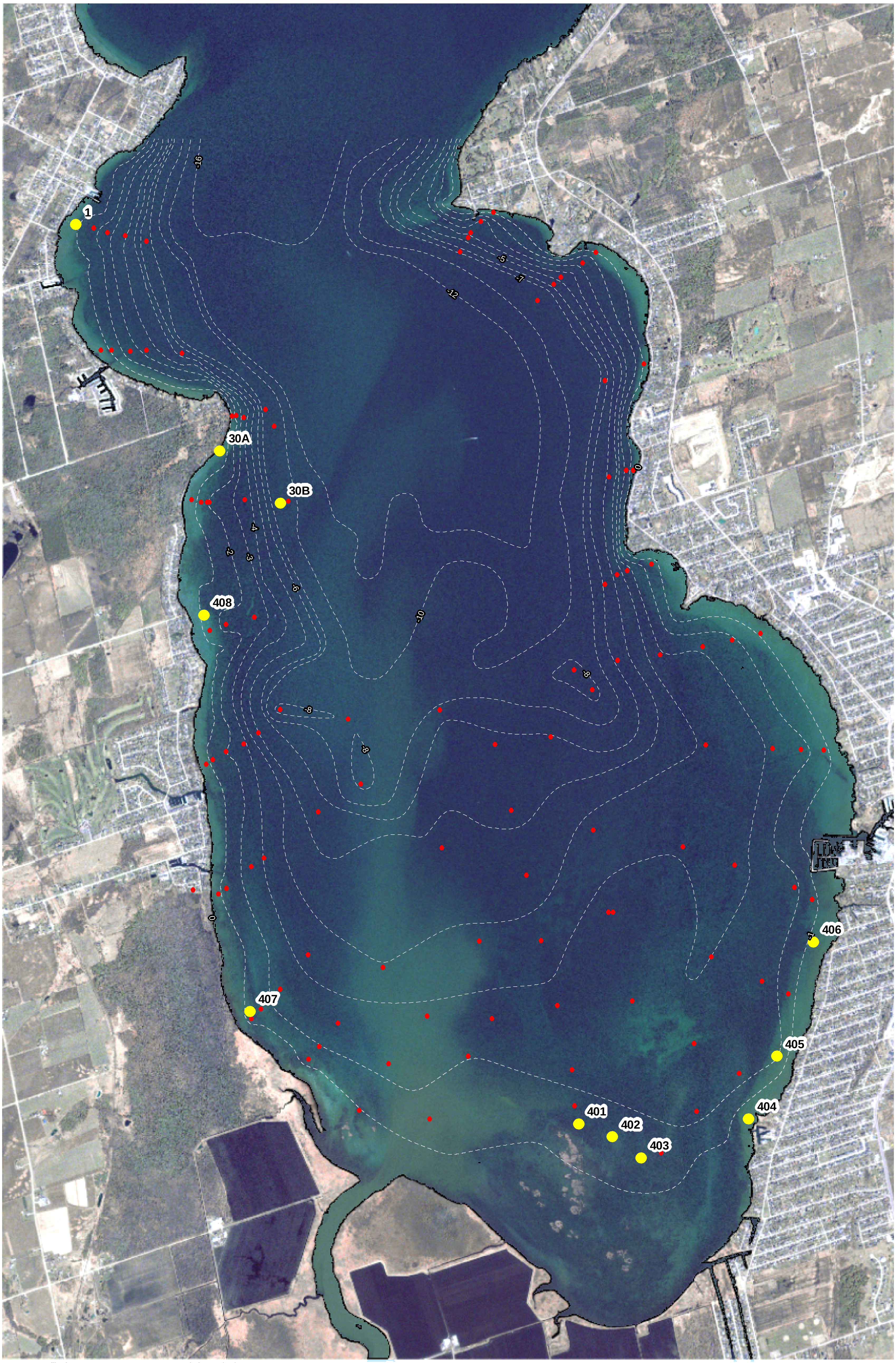

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FIGURE NO. 1

Sampling Locations

- Quantitative Survey Site
- Calibration Site

3.0 Results

3.1 WATER CHEMISTRY

Data from 1-m off bottom are described here because those data represent the most "limiting" or potentially influential conditions from a fisheries perspective. Temperatures throughout Cook's Bay ranged between a minimum of 21ºC and maximum of 24ºC, averaging 22ºC (Table 1). Water pH ranged between 7 and 9, with a mean of 8 (Table 1).

Dissolved oxygen levels ranged between 1.3 and 15.7 mg/L at 1 m off bottom. The low values were recorded in early morning samples from an area on the western side of the Bay offshore Gilford (Figure 2). High dissolved oxygen levels were recorded at surface and nearer shore (Figure 2). Low dissolved oxygen levels tended to co-occur with lower pH values of near 7, while high dissolved oxygen levels tended to co-occur with higher pH (Figure 3).

Table 1 Water Chemistry

Variable	Mean	Min	Max	Standard Deviation
Temperature	22	21	24	1
pH	8.0	7.0	9.0	0.3
Conductivity	353	308	381	19
Dissolved Oxygen	10.3	1.3	15.7	2.3

3.2 SUBSTRATE CHARACTERISTICS

The substrate throughout Cook's Bay was fine, consisting of clay, sand, and silt throughout the study area. The dominant combinations of sediment were clay/silt and clay/sand. The majority of the clay/sand combinations were clustered in the southern end of Cook's Bay, and along the south eastern shore (Figure 4).

3.3 MACROPHYTE DISTRIBUTIONS

Raw plant biomass data are presented in Appendix 2, while summaries are provided in Table 2 (below) and in maps. The average wet-weight to dry-weight ratio was 6:1 (Appendix 2). Based on that conversion ratio, the average dry weight biomass of total plants in the bay was 233 g/m^2, with a maximum observed biomass of 2.1 kg/m^2. Photographs of each species found in the lake are provided in Appendix 4. The most common species were tapegrass (*Vallisneria americana*), stonewort (*Chara*), flat-stemmed pondweed (*Potamogeton zosteriformis*), coontail (*Ceratophyllum demersum*), Eurasian water milfoil (*Myriophyllum spicatum*), American waterweed (*Elodea canadensis*), and Richardson's pondweed (*Potamogeton richardsoni*; Table

2). The canonical correspondence analysis of common taxa illustrated the influence of location and depth on plant assemblage data (Figure 5). Assemblages were generally more diverse in the south-east of the bay, and less diverse in the north-west of the bay. Stonewort and clasp-leaved pondweed more dominant in the north-west of the bay (Figures 5, 7, 8), while milfoil, tape grass and flat-stemmed pondweed were more dominant in the south-east (Figures 5, 9, 10, 11). American waterweed and coontail tended to be more dominant in assemblages in deeper water.

Less common species included five additional types of pondweed (sheathed pondweed, *Potamogeton vaginatus*; curley-leaved pondweed, *Potamogeton crispus*; water-thread pondweed, *P. diversifolius*; horned-pondweed, *Zannichellia palustris*; sago pondweed, *Potamogeton pectinatus*), in addition to the bushy pondweed, assumed to be *Najas flexilis* based on a single strand. Distributions of these less common species are illustrated in Figures 12 to 18, while the overall plant biomasses are illustrated in Figure 19.

Plant material was commonly found floating in the bay (Photographs 15, 16, Appendix 4), and drifting towards the eastern shore. Weed harvesters were observed on the eastern shore removing excess buildup of plant material (Photographs 26, 27, Appendix 4). Zebra mussels were also frequently found attached to stems of a variety of species including milfoil, stonewort and tapegrass (Photo 25, Appendix 4). Zebra mussel shells (dead specimens) were frequently found in relatively large numbers throughout the bay.

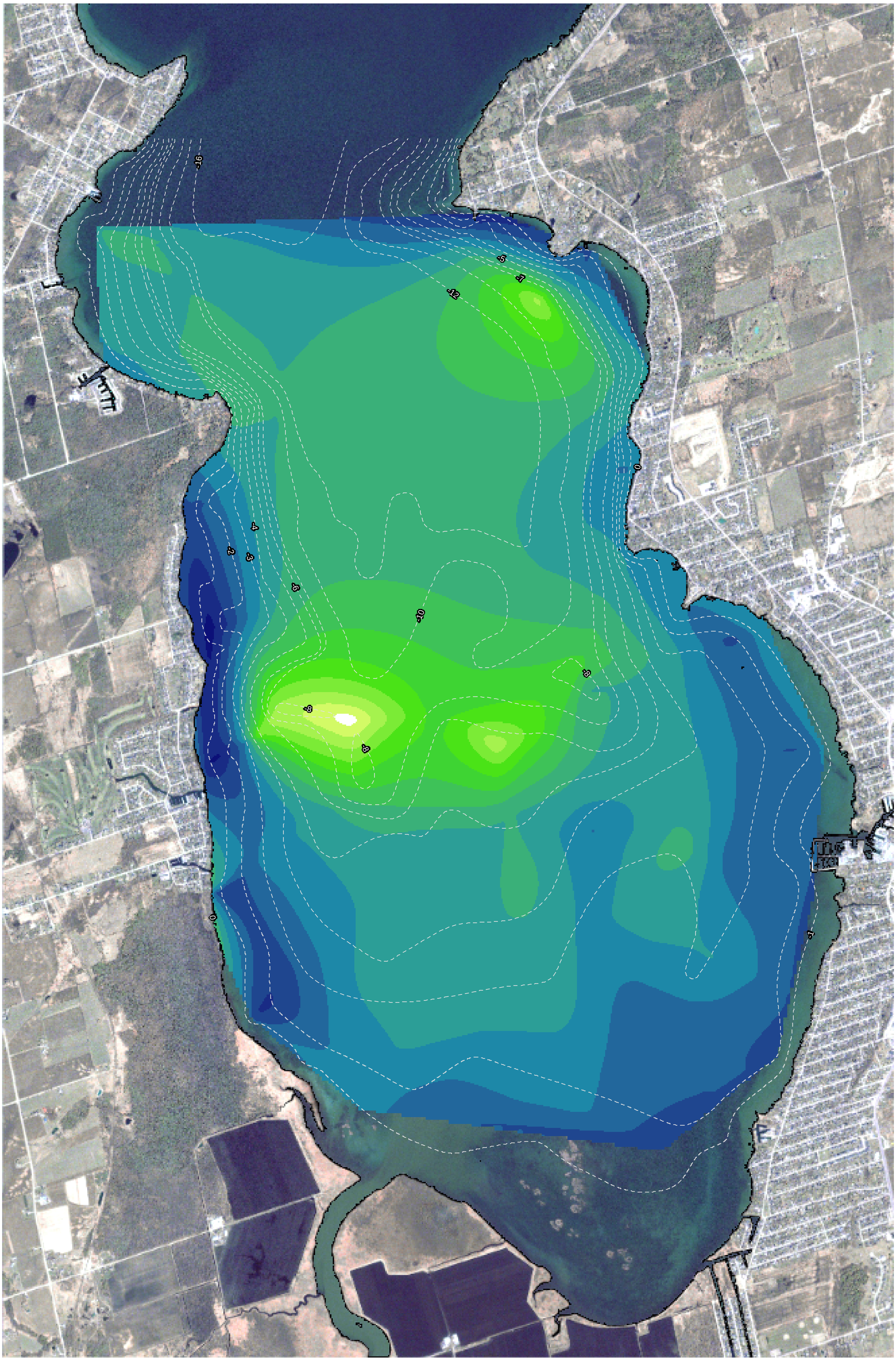
There were no distinct "communities", as would have been indicated by clusters of sites in the ordination biplot (Figure 5). Rather, there was a continuum in the assemblages from east to west, and shallow to deep. Inspection of the biplot (Figure 5a) illustrated that substrate class was unrelated to composition of the plant assemblages. The lack of influence of substrate class was confirmed by analysis of variance (not reported here). The influence of water depth was evident in the ordination biplot (Figure 5b), as well as in the biplots of individual species biomasses (grams dry mass per m^2) in relation to depth. Tapegrass, Chara, flat-stemmed pondweed and milfoil were limited to water < 4 m deep, while coontail and Elodea were found in water up to 8.5 m deep, but generally in water < 7 m deep. The maps illustrating the distributions of each of the species (Figures 7 to 19) were kriged, and in the cases of several of the species indicated that plants would likely be present at depths > 9 m, which was not the case, and was an artifact of the numerical methodology used.

Table 2 Average and maximum wet weight biomass (g) for each species in Cook's Bay, Aubust 2006.

Common Name	Species Name	Wet Weight		Dry Weight	
		Average	Maximum	Average	Maximum
Total Macrophytes		1396	12650	233	2108
Tape grass	*Vallisneria americana*	433	3665	72	611
Stonewort	*Chara spp.*	357	12475	60	2079
Flat-stem pondweed	*Potamogeton zosteriformis*	297	3260	50	543
Coontail	*Ceratophyllum demersum*	156	1635	26	273
Eurasian water milfoil	*Myriophyllum spicatum*	109	2010	18	335
Common waterweed	*Elodea canadensis*	32	905	5	151
Richardson's pondweed	*Potamogeton richardsonii*	5.5	170	1	28
Sheathed pondweed	*Potamogeton vaginatus*	1.9	105	<1	18
Bushy pondweed naiad	*Najas (flexilis?)*	1.1	55	<1	9
Curley-leaved pondweed	*Potamogeton crispus*	0.9	45	<1	8
Water-thread pondweed	*Potamogeton diversifolius*	0.8	25	<1	4
Horned pondweed	*Zannichellia palustris*	0.6	22	<1	4
Sago pondweed	*Potamogeton pectinatus*	0.2	15	<1	3

3.4 EMERGENT VEGETATION

The IKONOS image from April 2000 was generally consistent with what was observed in the field during this inventory in August 2006. Extensive patches of bulrush (*Scirpus* sp.) were observed in the south end of Cook's Bay (Photograph 6, 7, 8, 10, 11, 14, Appendix 4). Very small and fragmented patches of cattail (*Typha*) were present along the shoreline on both the east and west sides (Figure 20, Photograph 13-Appendix 4), but generally only in places where shorelines had not been hardened with concrete or steel shoreline protection. White water lily (*Nymphaea* sp.) were also present, but principally in the south west corner of the bay, just north of the dense bulrush beds, and along the shoreline.



Source: Satellite image GeoEye IKONOS 1m resolution 04/23/2000.

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FIGURE NO. 2

Dissolved Oxygen (mg/L)

1.5 - 2	8.0 - 9
2.0 - 3	9.0 - 10
3.0 - 4	10.0 - 11
4.0 - 5	11.0 - 12
5.0 - 6	12.0 - 13
6.0 - 7	13.0 - 14
7.0 - 8	14.0 - 15

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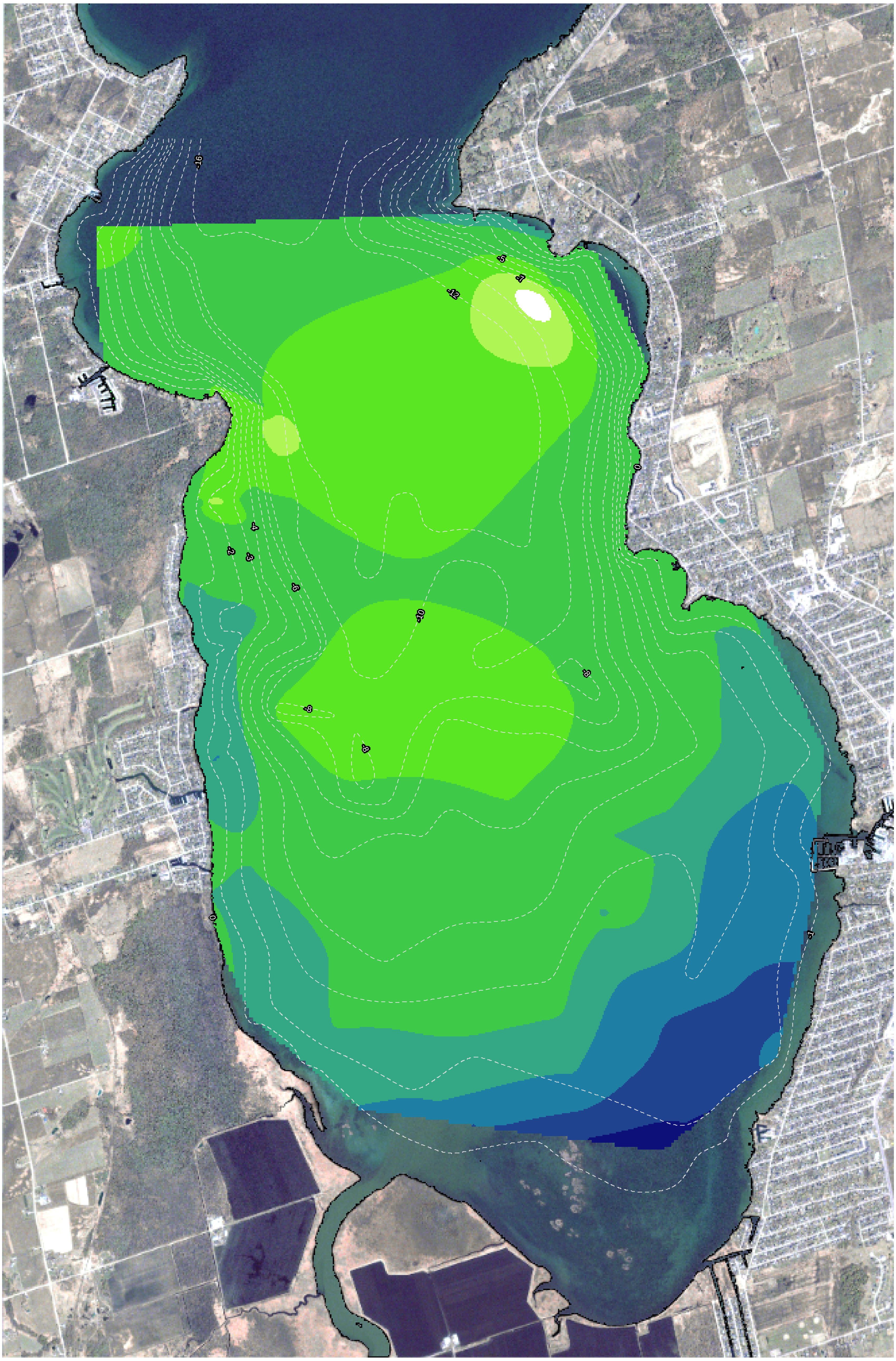

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FIGURE NO. 3

pH

	7.00- 7.25		8.00 - 8.25
	7.25 - 7.5		8.25 - 8.5
	7.50 - 7.75		8.50 - 8.75
	7.75 - 8		8.75 - 9

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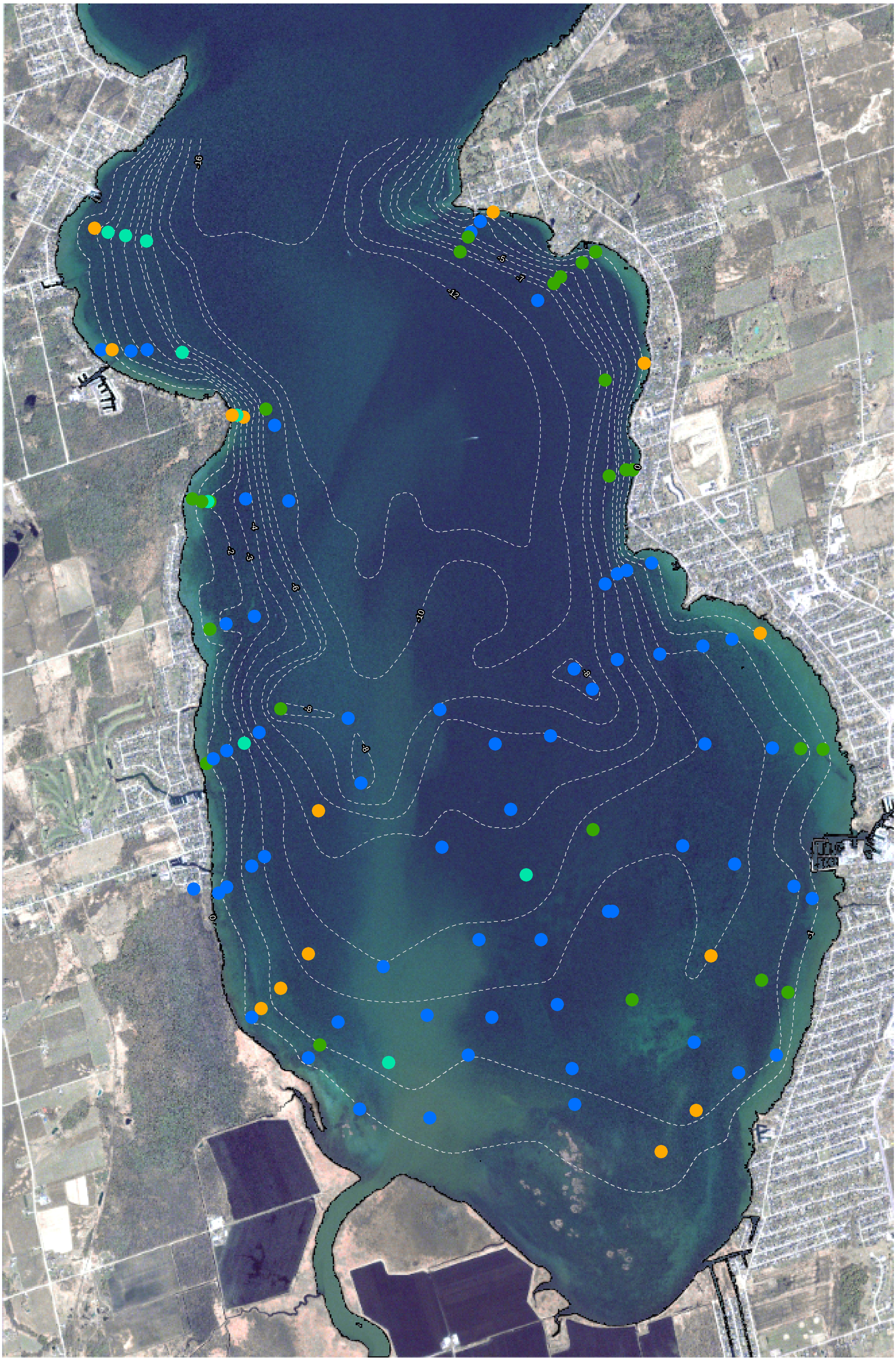

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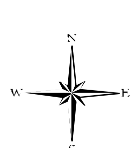

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FIGURE NO. 4

Macrophytes Biomass Dry Weight Average

Sediment Characteristics

Substrate

- Clay
- Sand
- Silt
- Other

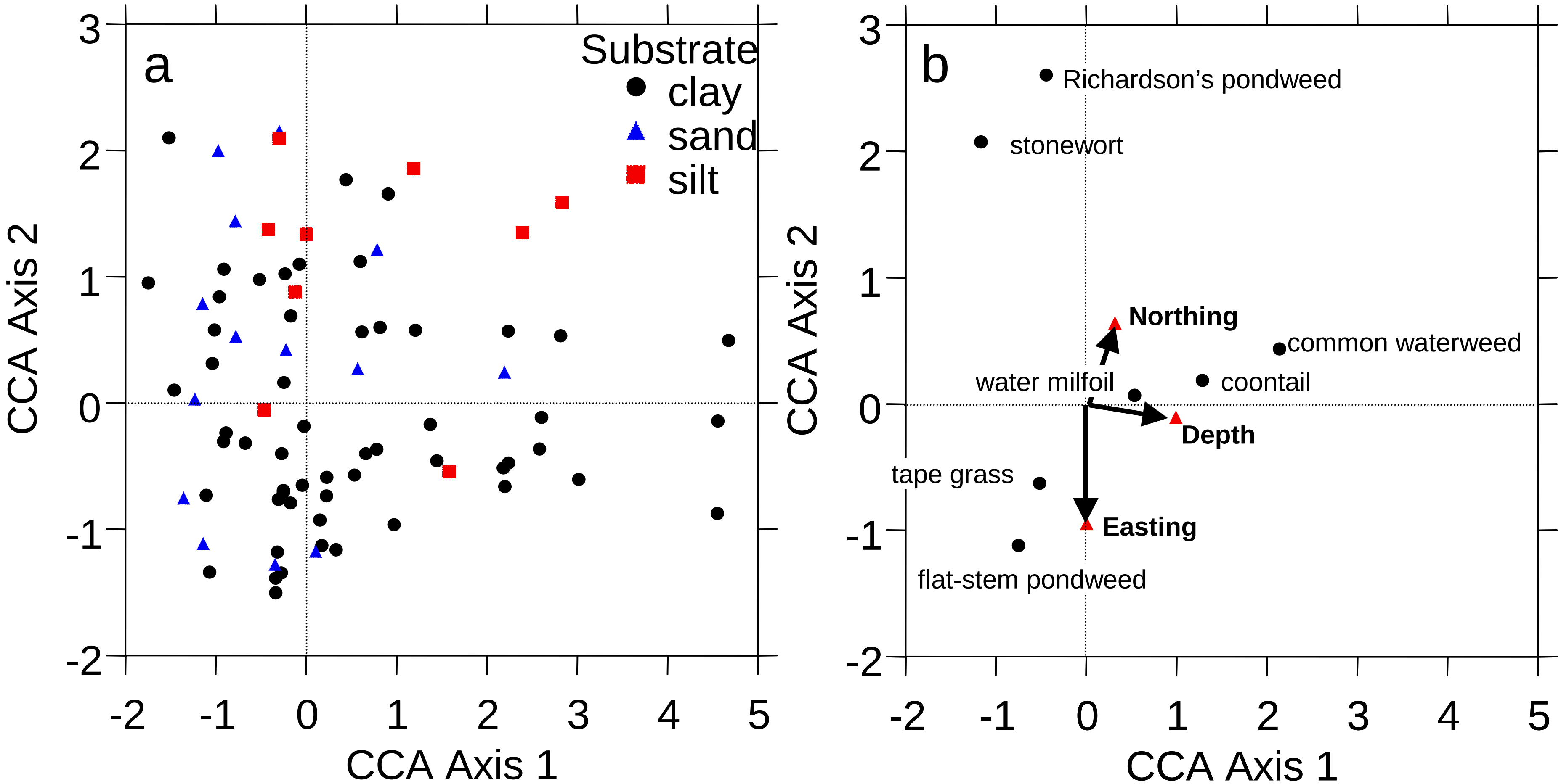
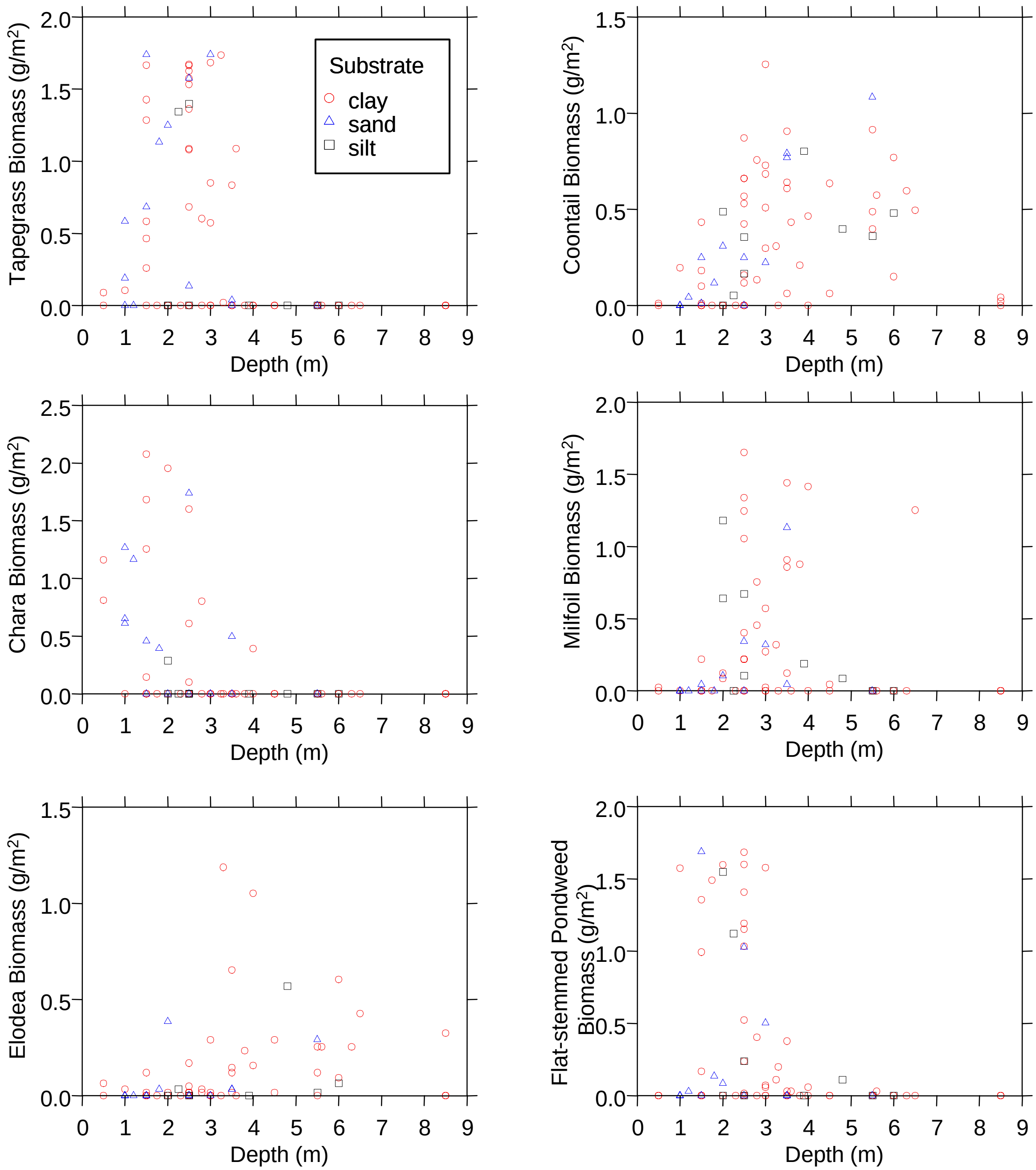


Figure 5 CCA biplots

Figure Note: Left panel (a) is the biplot for sample scores and illustrates the influence of substrate. Right panel (b) is the biplot for plant taxa, also showing the correlation (between –1 and +1) of environmental variables with the CCA axes.

Figure 6 Biplots of dry-weight biomass (g) of individual species in relation to water depth.



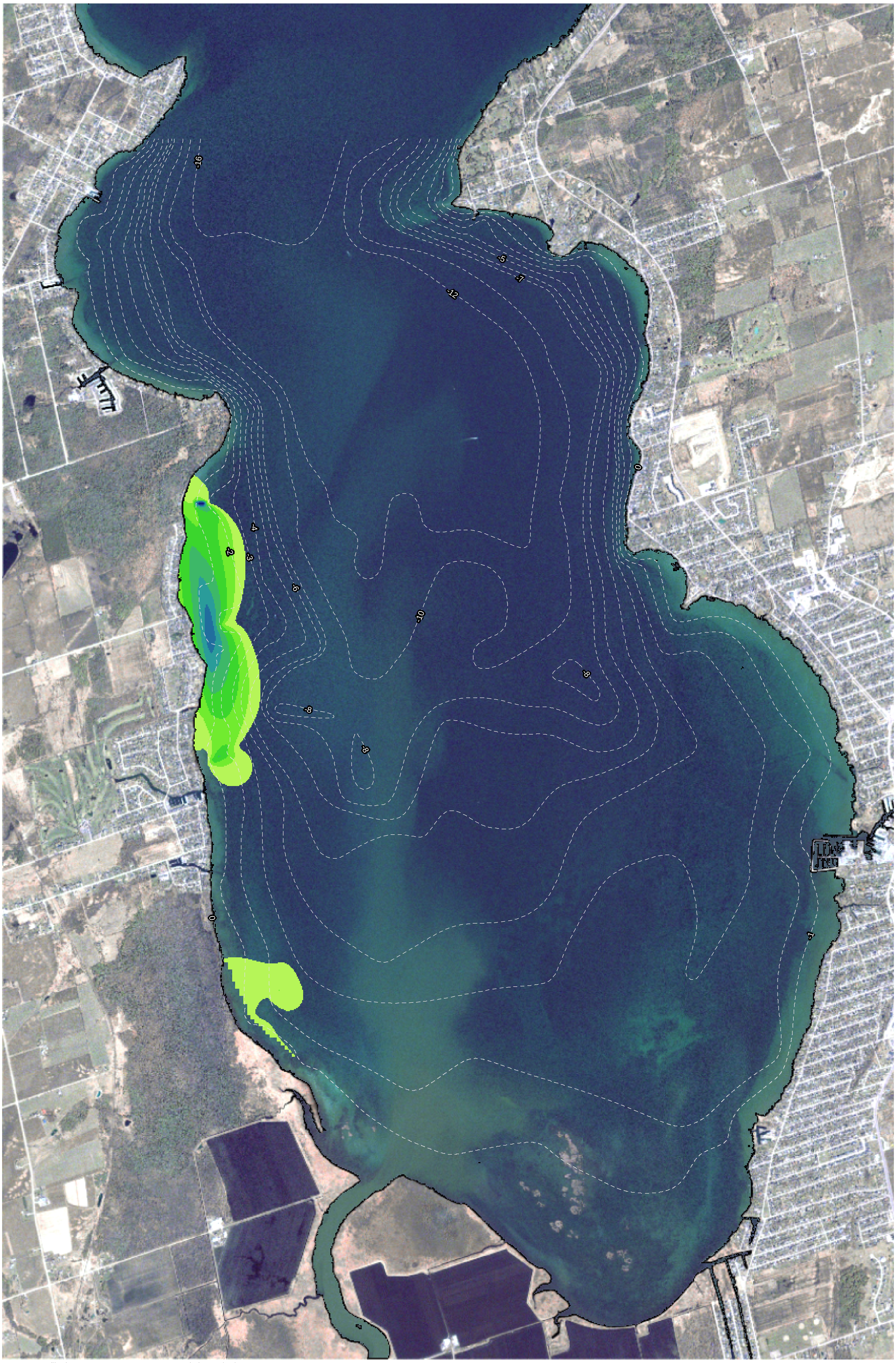


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FIGURE NO. 7

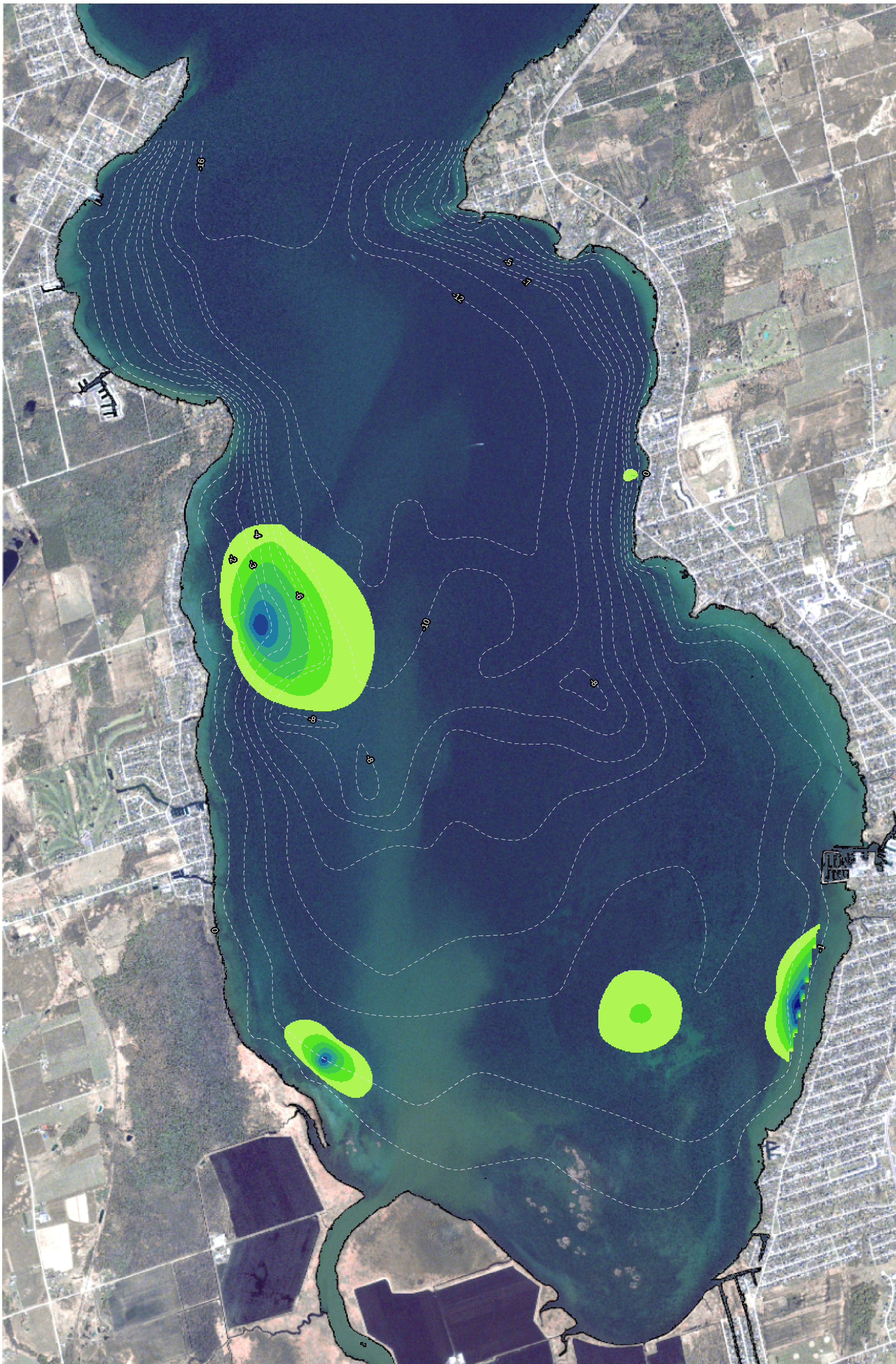
Macrophytes Biomass Dry Weight Average

Stonewort (*Chara sp.*)

Chara Dry Weight Average (mg)

0 - 25	125 - 150
25 - 50	150 - 175
50 - 75	175 - 200
75 - 100	200 - 225
100 - 125	

File: W:\active\60940049\graphics\GIS\MXD\december 2006\clasped-leaved pondweed (potamogeton richardsoni).mxd Revised: December 11, 2006



Source: Satellite image GeoEye IKONOS 1m resolution 04/23/2000.

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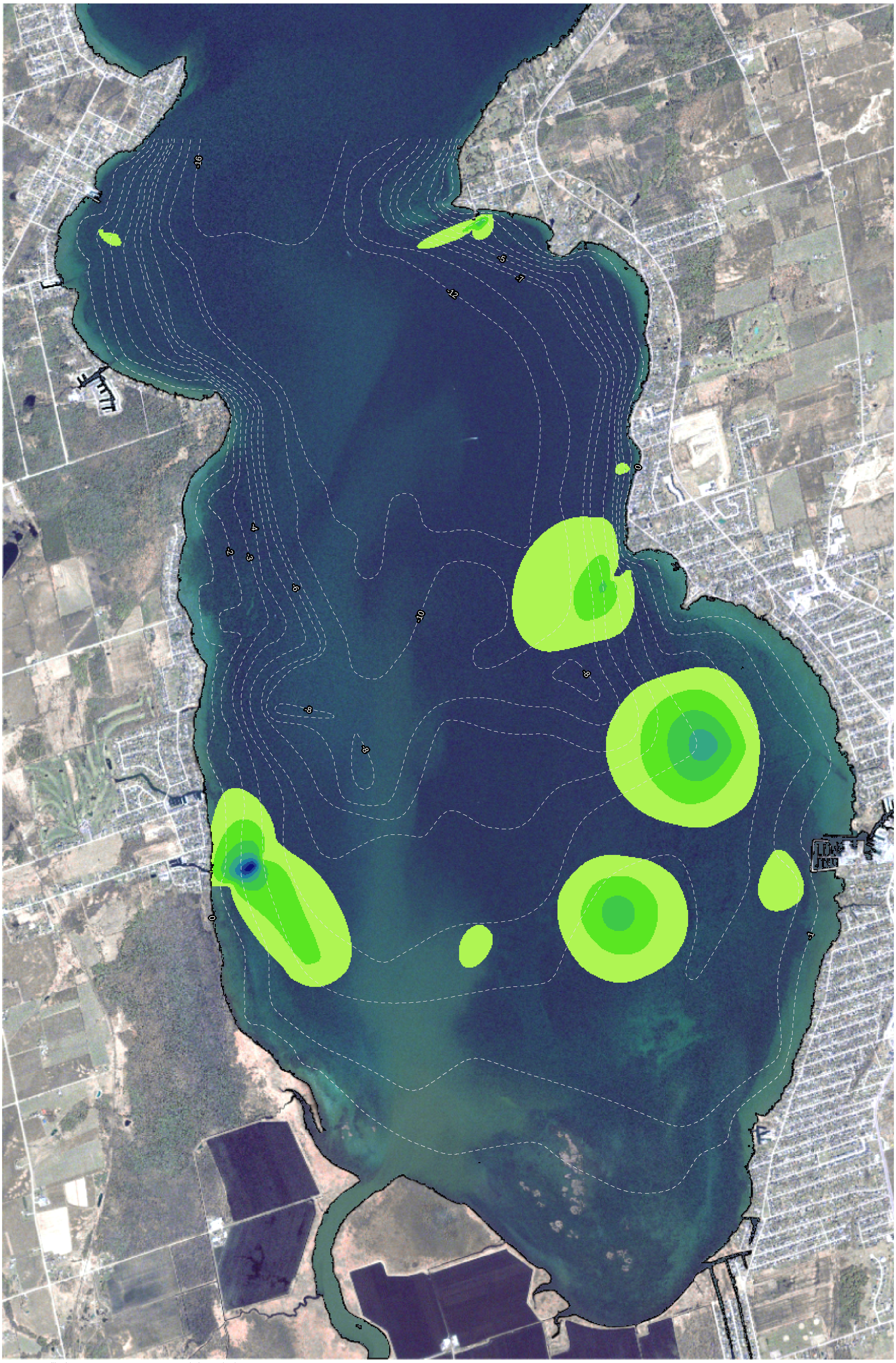
FIGURE NO. 8

Macrophytes Biomass Dry Weight Average

Clasped-leaved Pondweed (*Potamogeton richardsoni*)

Clasped-leave Pondweed Dry Weight Average (mg)

0.00 - 0.25	1.00 - 1.25
0.25 - 0.50	1.25- 1.50
0.50 - 0.75	1.50 - 1.75
0.75 - 1.00	1.75 - 2.00



Source: Satellite image GeoEye IKONOS 1m resolution 04/23/2000.

File: W:\active\60940049\graphics\GIS\MXD\december 2006\Eurasian Water Milfoil (Myriophyllum spicatum).mxd Revised: December 11, 2006

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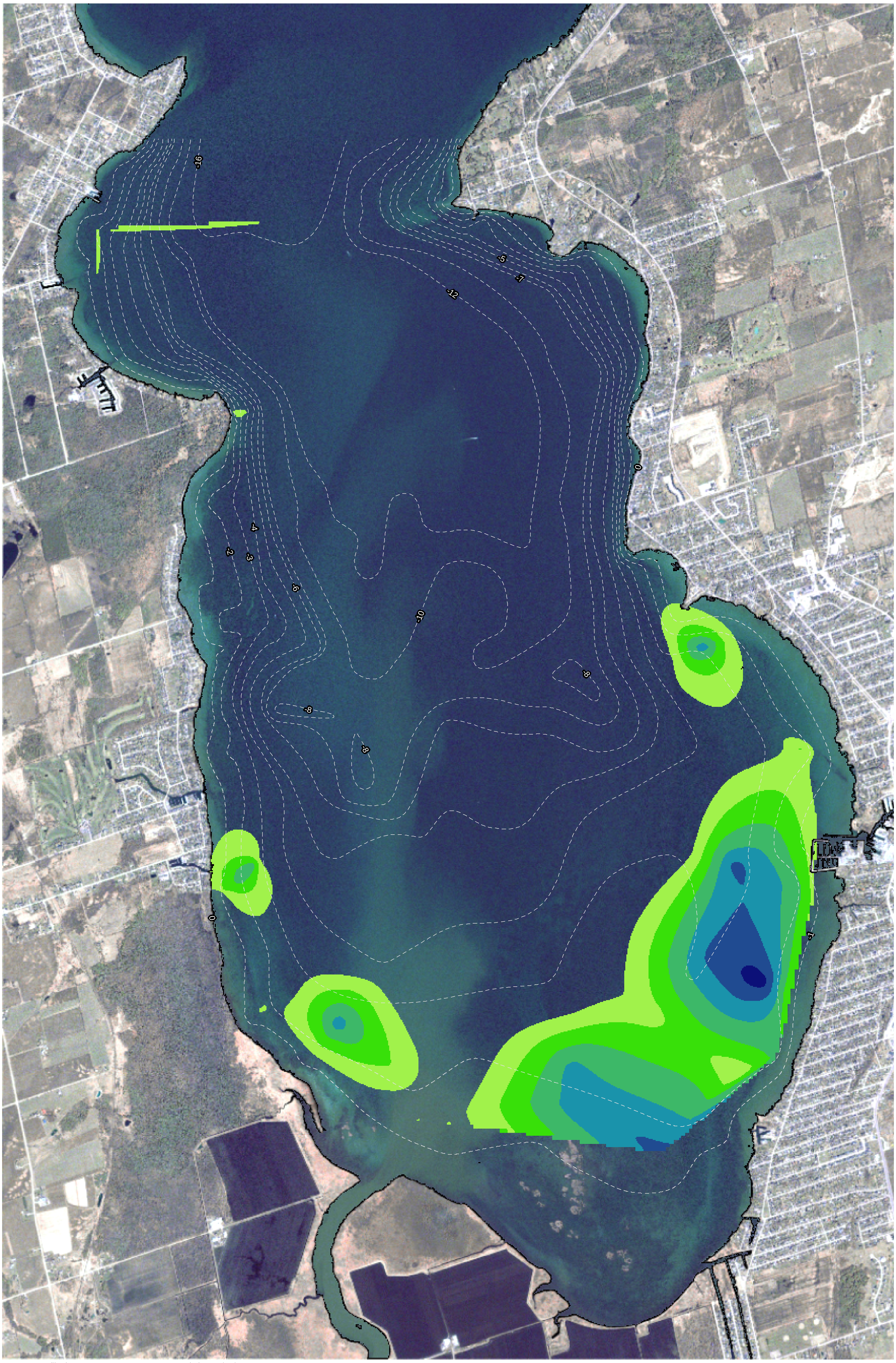
FIGURE NO. 9

Macrophytes Biomass Dry Weight Average

Eurasian Water Milfoil (*Myriophyllum spicatum*)

Water Milfoil Dry Weight Average (mg)

- 0 - 5
- 5.000000001 - 10
- 10.00000001 - 15
- 15.00000001 - 20
- 20.00000001 - 25
- 25.00000001 - 30
- 30.00000001 - 35
- 35.00000001 - 40



Source: Satellite image GeoEye IKONOS 1m resolution 04/23/2000.

File: W:\active\60940049\graphics\GIS\MXD\december 2006\tape grass (vallisneria americana).mxd Revised: December 11, 2006

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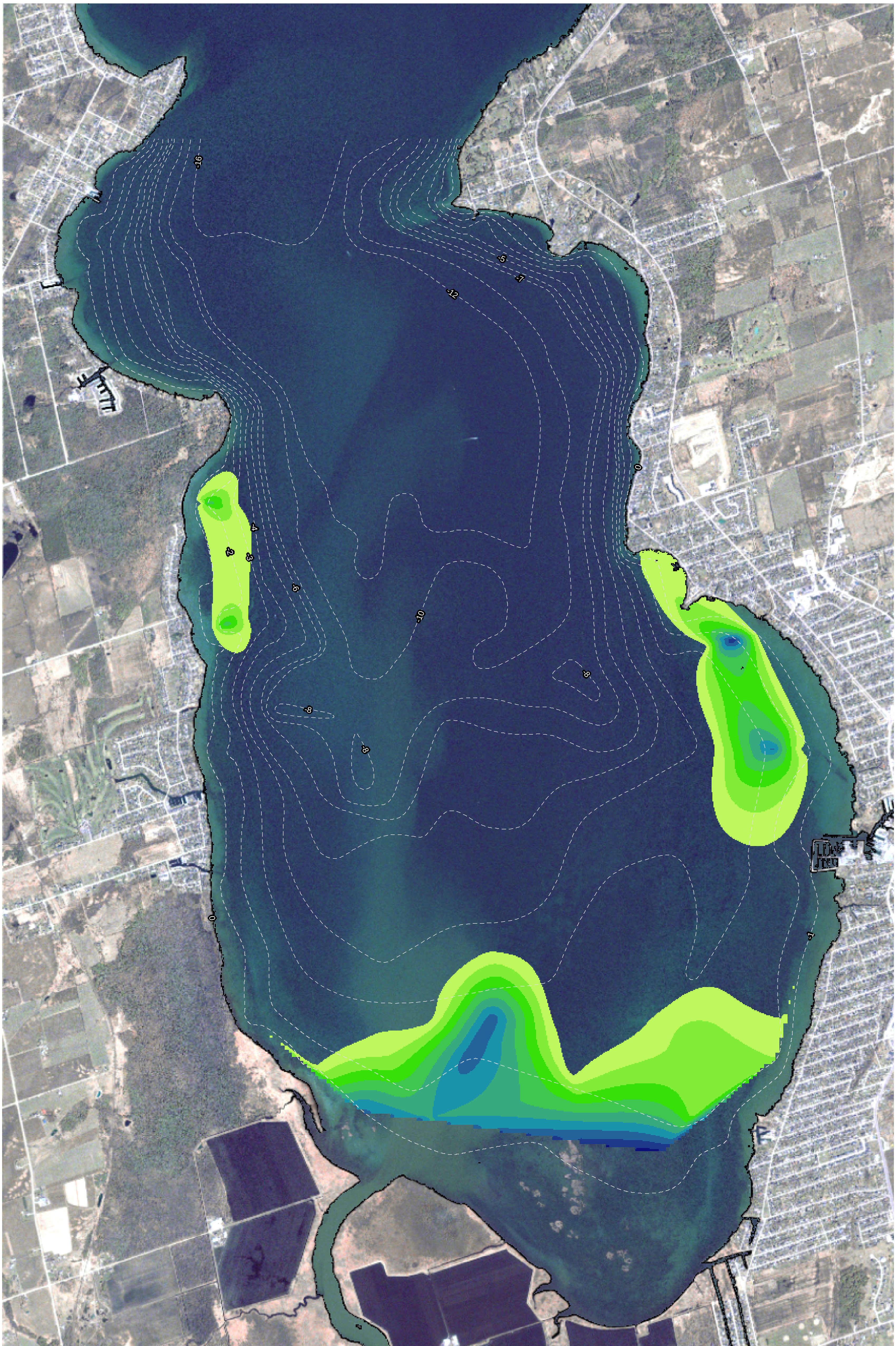
FIGURE NO. 10

Macrophytes Biomass Dry Weight Average

Tape Grass (*Vallisneria americana*)

Tape Grass Dry Weight Average (mg)

- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70



File: W:\active\60940049\graphics\GIS\MXD\december 2006\flat-stemmed pondweed (potamogeton zosteriformis).mxd Revised: December 11, 2006

Source: Satellite image GeoEye IKONOS 1m resolution 04/23/2000.

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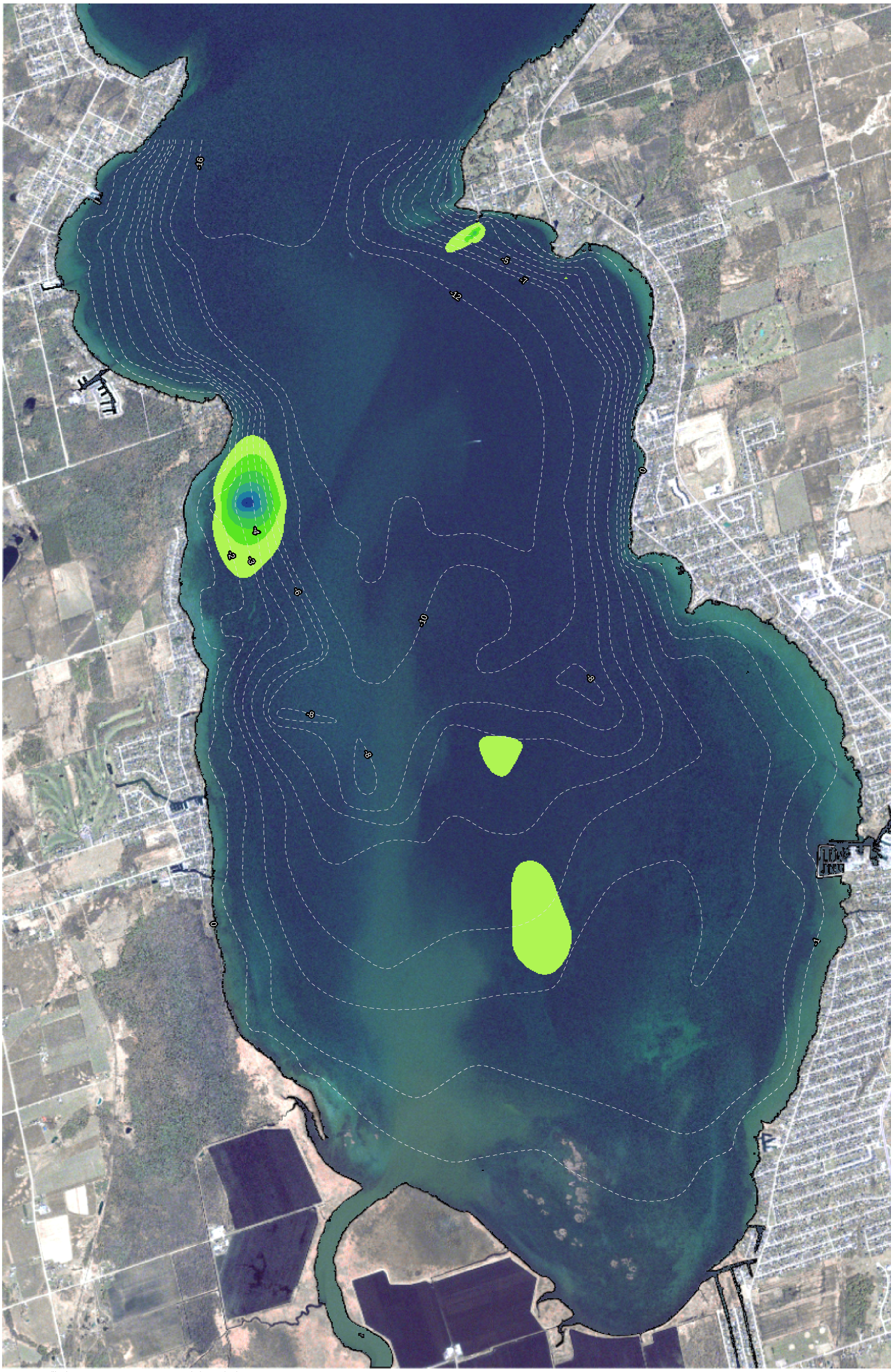
FIGURE NO. 11

Macrophytes Biomass Dry Weight Average

Flat-Stemmed Pondweed (*Potamogeton zosteriformis*)

Flat Stem Pondweed Dry Weight Average (mg)

0 - 5	25 - 30
5 - 10	30 - 35
10 - 15	35 - 40
15 - 20	40 - 45
20 - 25	45 - 50



File: W:\active\60940049\graphics\GIS\MXD\december 2006\american waterweed (elodea sp).mxd Revised: December 11, 2006

Source: Satellite image GeoEye IKONOS 1m resolution 04/23/2000.

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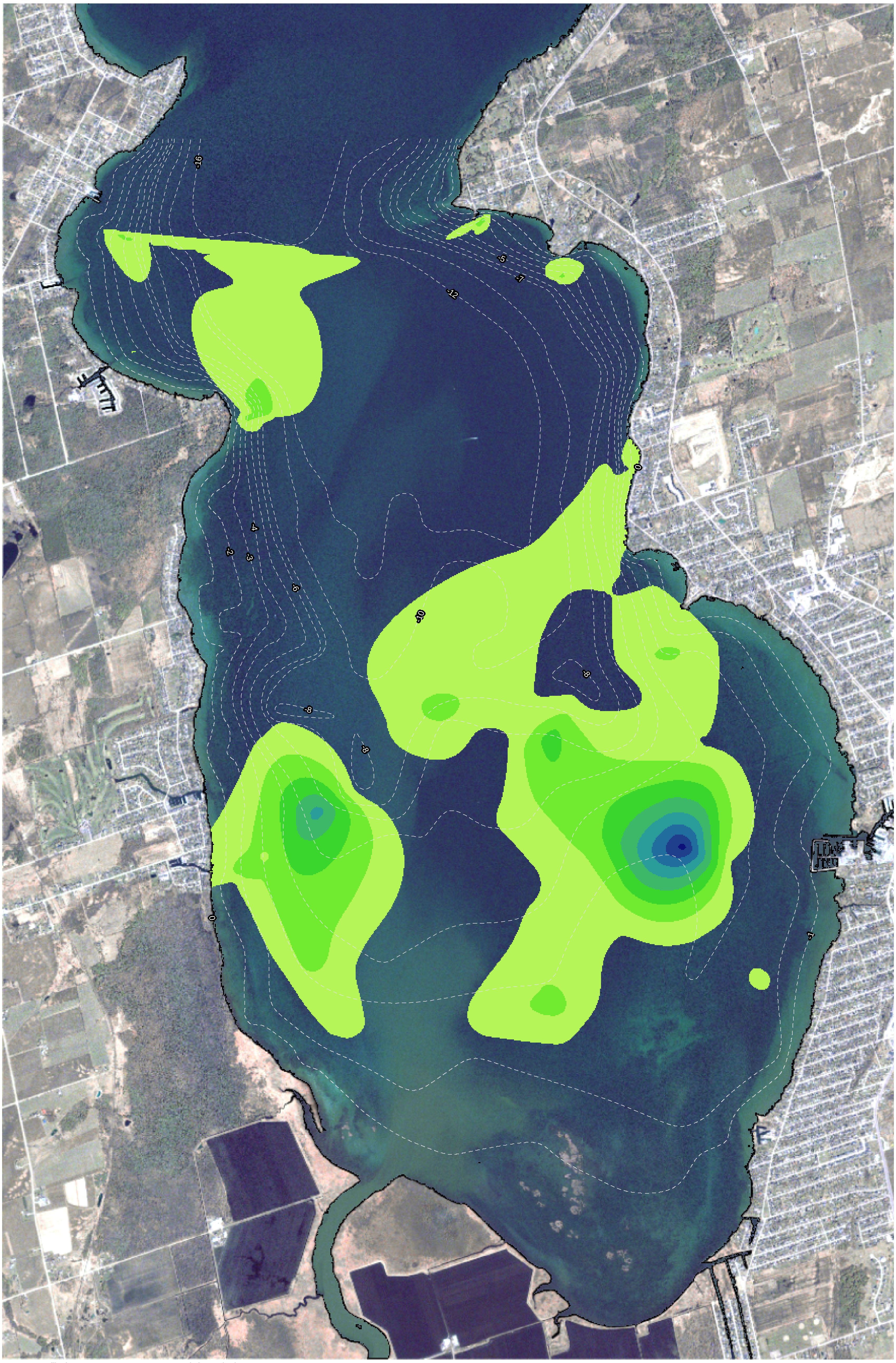
FIGURE NO. 12

Macrophytes Biomass Dry Weight Average

American Waterweed (*Elodea sp.*)

Elodea Dry Weight Average (mg)

0 - 2	8 - 10
2- 4	10 - 12
4 - 6	12 - 14
6 - 8	14 - 16



File: W:\active\60940049\graphics\GIS\MXD\december 2006\coontail (ceratophyllum dermersum).mxd Revised: December 11, 2006

Source: Satellite image GeoEye IKONOS 1m resolution 04/23/2000.

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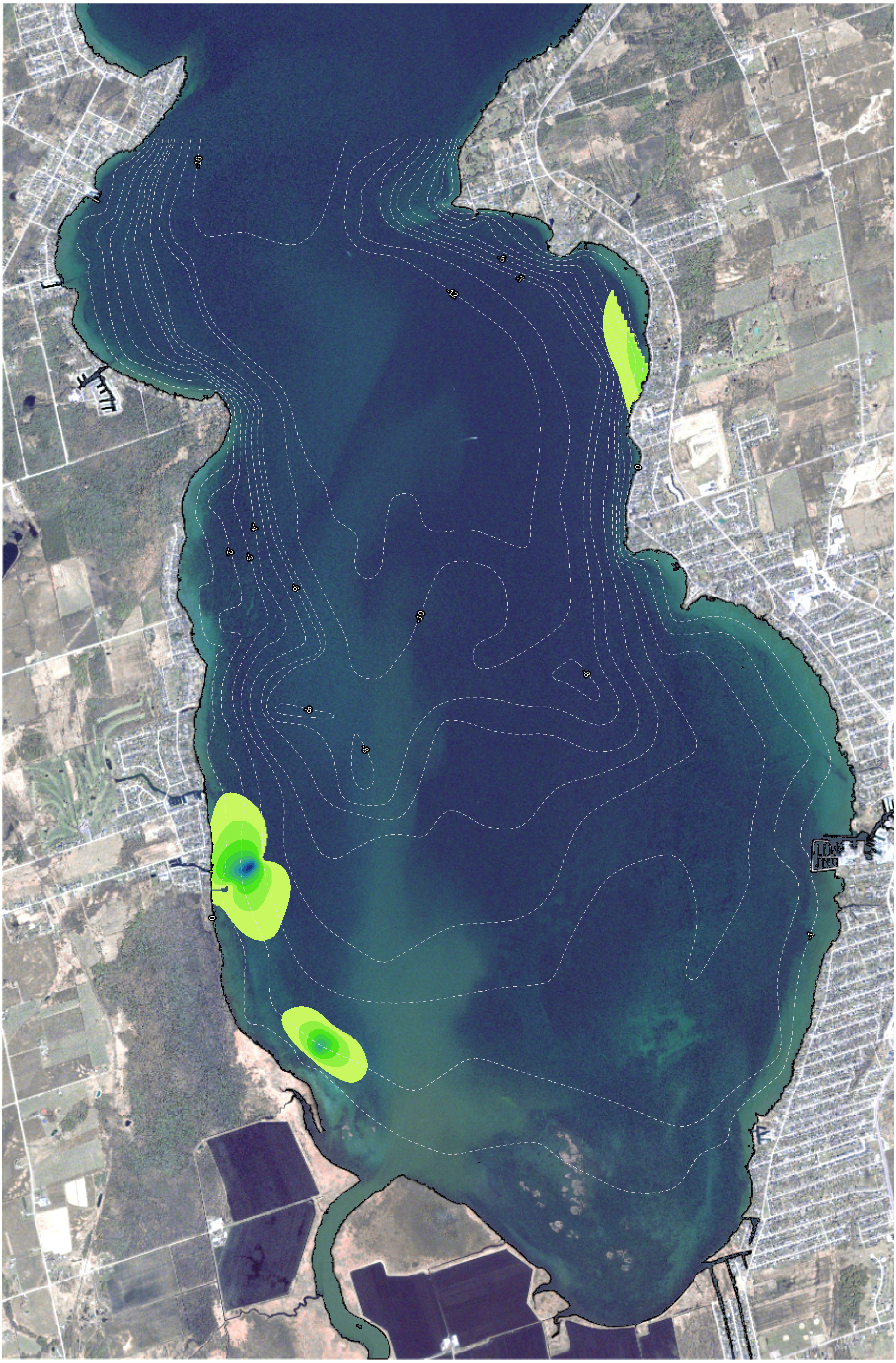
FIGURE NO. 13

Macrophytes Biomass Dry Weight Average

Coontail (*Ceratophyllum dermersum*)

Coontail Dry Weight Average (mg)

0 - 2	10 - 12
2 - 4	12. - 14
4 - 6	14 - 16
6 - 8	16 - 18
8 - 10	



File: W:\active\60940049\graphics\GIS\MXD\december 2006\coontail (ceratophyllum demersum).mxd Revised: December 11, 2006

Source: Satellite image GeoEye IKONOS 1m resolution 04/23/2000.

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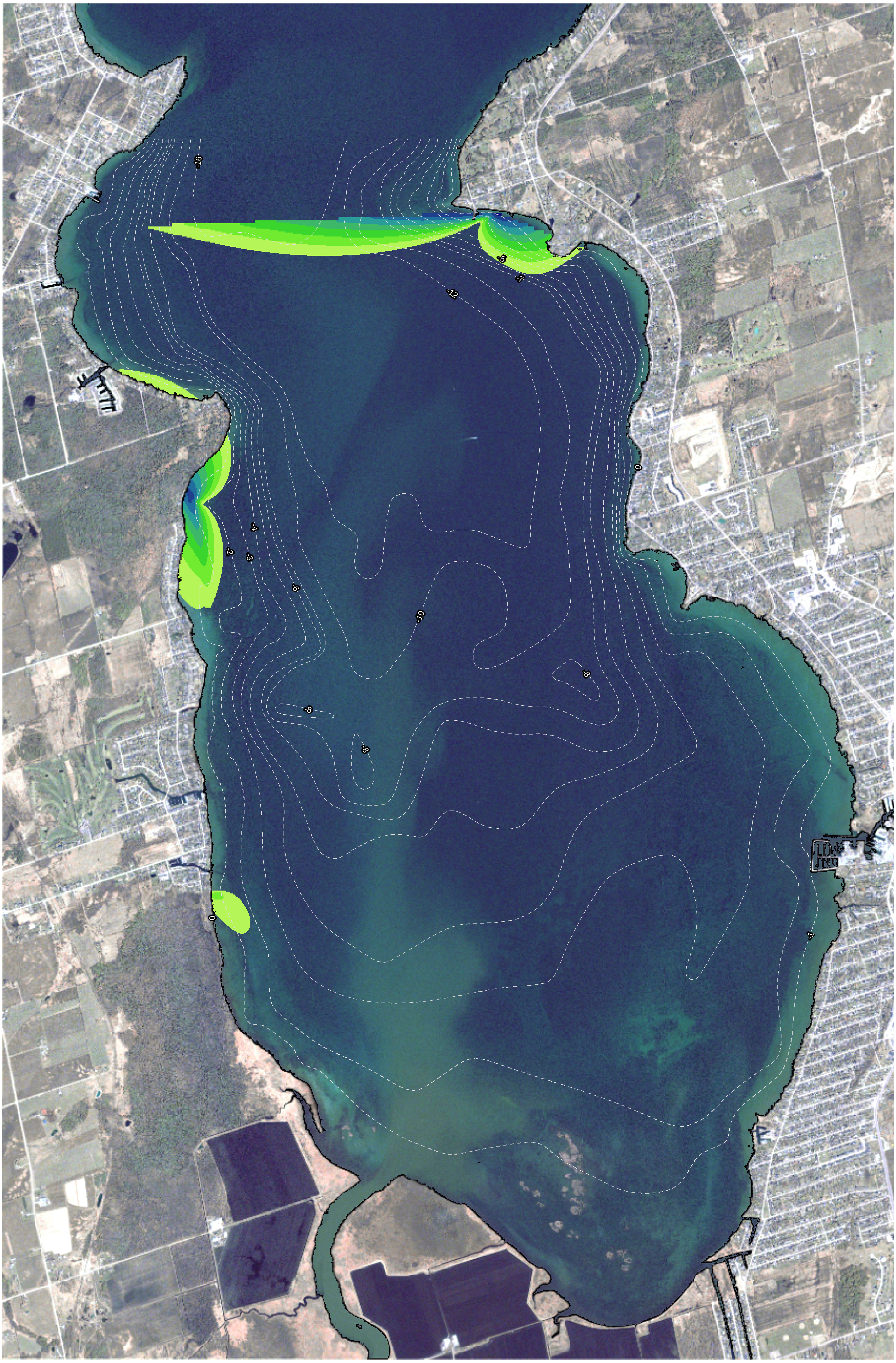
FIGURE NO. 14

Macrophytes Biomass Dry Weight Average

Slender Naiad (*Najas flexilis*)

Slender Naiad Dry Weight Average (mg)

0 - 0.5	3 - 3.5
0.5 - 1	3 - 4
1 - 1.5	4 - 4.5
1.5 - 2	4 - 5
2 - 2.5	5 - 5.5
2 - 3	



File: W:\active\60940049\graphics\GIS\MXD\december 2006\curly-leaved pondweed (potamogeton crispus).mxd Revised: December 11, 2006

Source: Satellite image GeoEye IKONOS 1m resolution 04/23/2000.

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FIGURE NO. 15

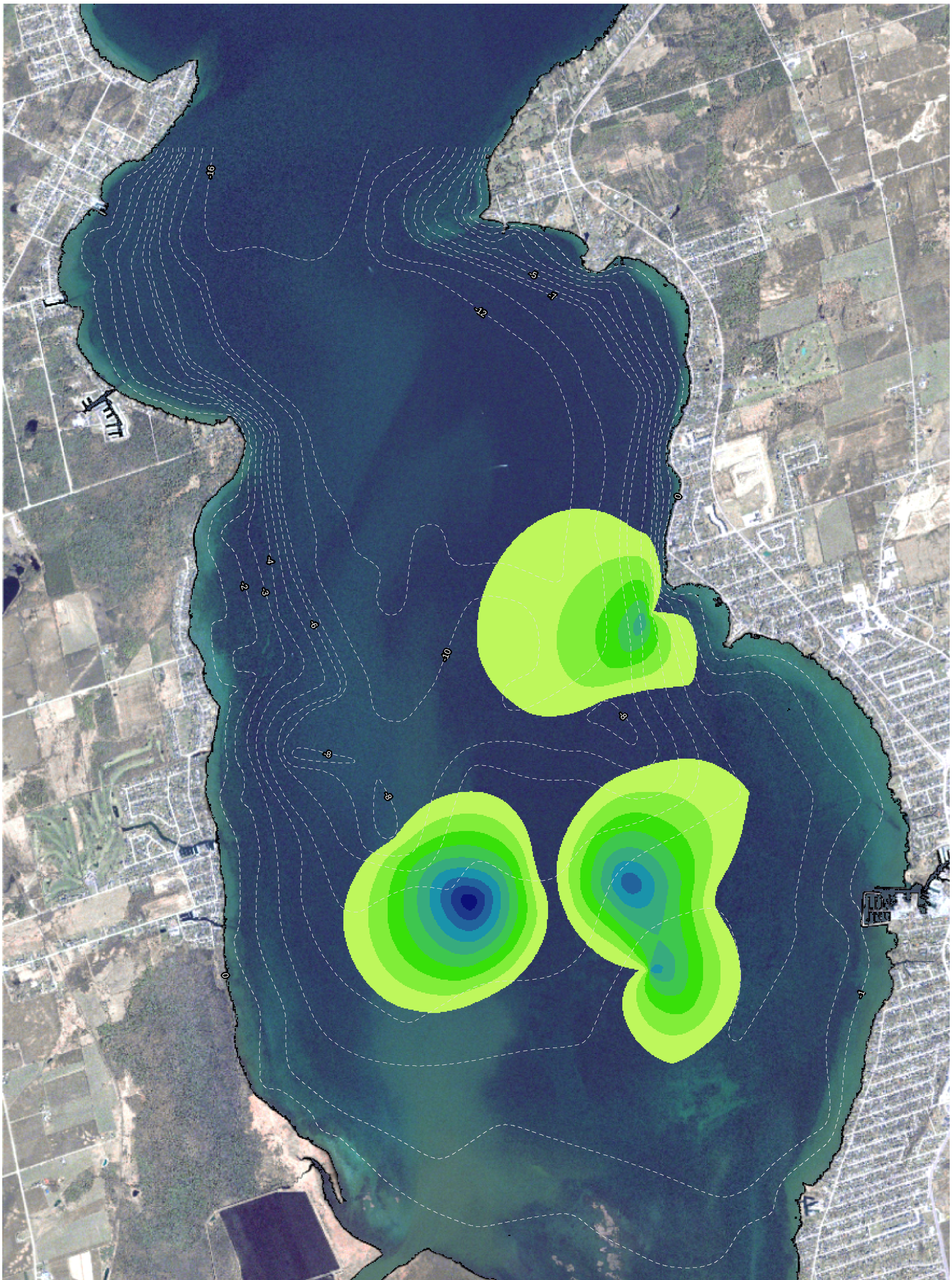
Macrophytes Biomass Dry Weight Average

Curly-Leaved Pondweed (*Potamogeton crispus*)

Curly-Leaved Pondweed Dry Weight Average (mg)

0 - 0.5	2 - 3
0.5 - 1	3 - 3.5
1 - 1.5	3 - 4
1 - 2	4 - 4.5
2 - 2.5	

File: W:\active\60940049\graphics\GIS\MXD\december 2006\water-thread pondweed (potamogeton diversifolius).mxd Revised: December 11, 2006



Source: Satellite image GeoEye IKONOS 1m resolution 04/23/2000.

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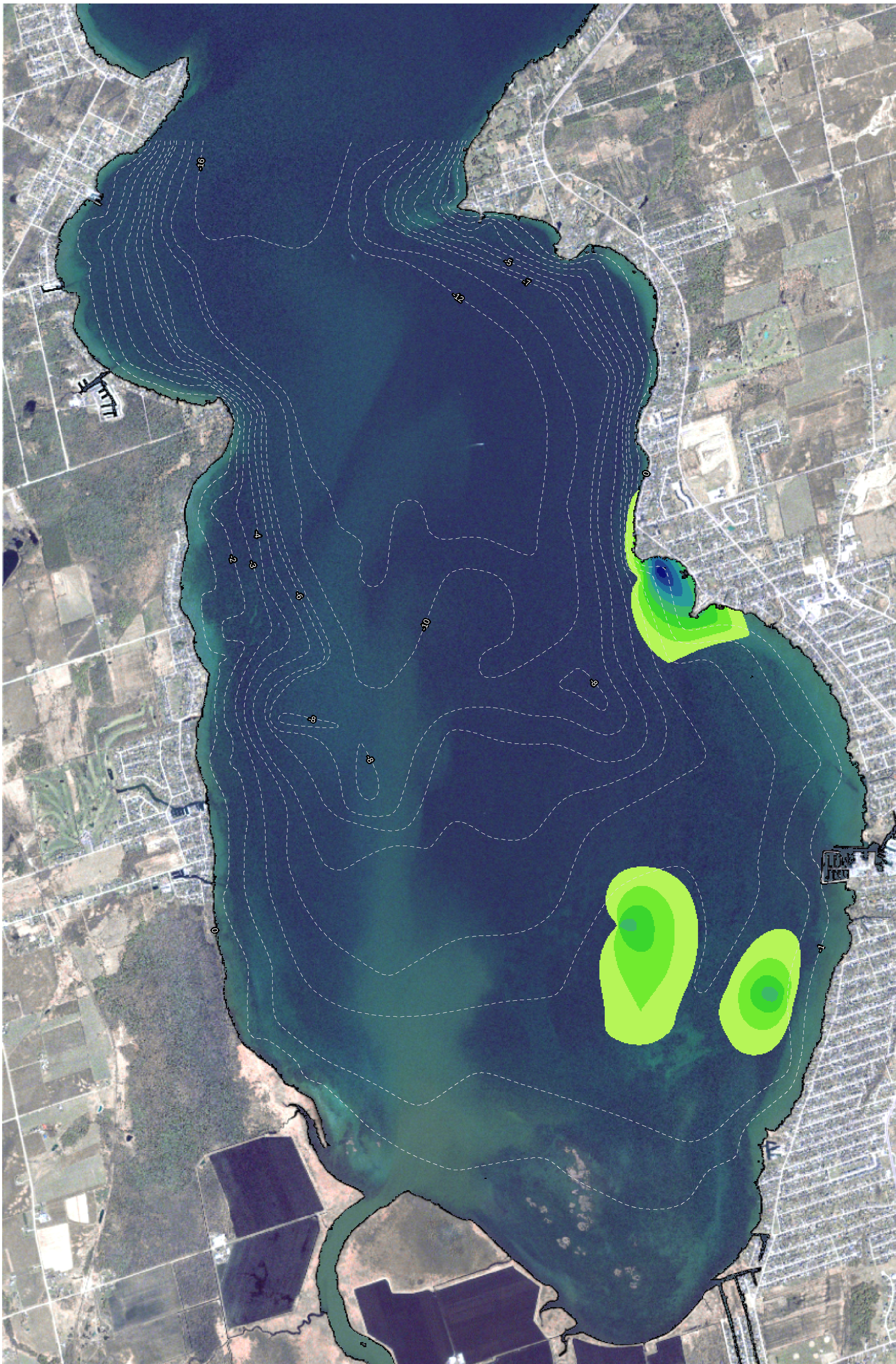
FIGURE NO. 16

Macrophytes Biomass Dry Weight Average

Water-Thread Pondweed (*Potamogeton diversifolius*)

Water-Thread Pondweed Dry Weight Average (mg)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- 1.25 - 1.5
- 1.50 - 1.75
- 1.75 - 2
- 2 - 2.25
- 2.25 - 2.5



File: W:\active\60940049\graphics\GIS\MXD\december 2006\horned pondweed (zannichellia palustris).mxd Revised: December 11, 2006

Source: Satellite image GeoEye IKONOS 1m resolution 04/23/2000.

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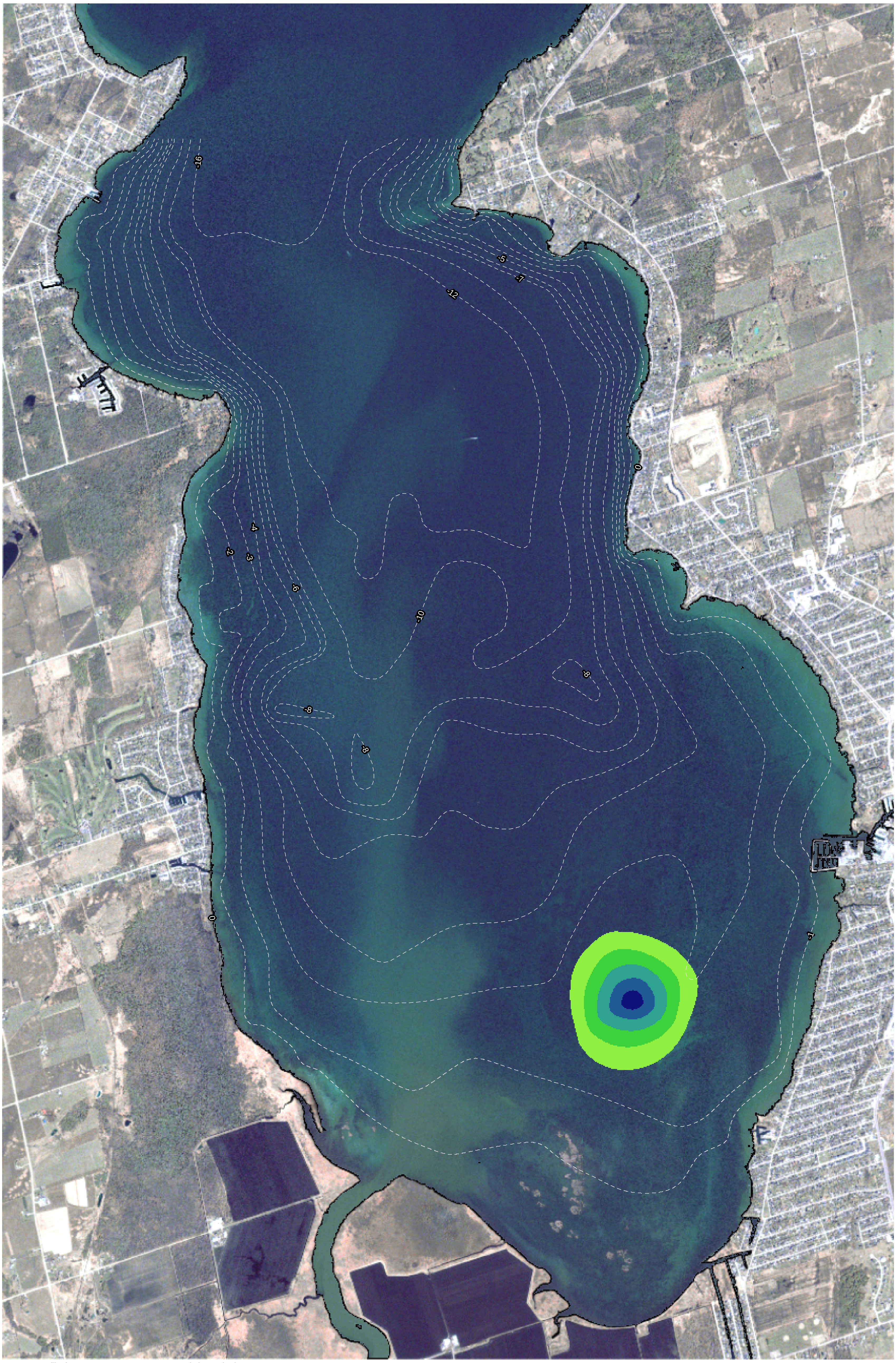
FIGURE NO. 17

Macrophytes Biomass Dry Weight Average

Horned Pondweed (*Zannichellia palustris*)

Horned Pondweed Dry Weight Average (mg)

0 - 0.25	1.25 - 1.5
0.25 - 0.5	1.50 - 1.75
0.5 - 0.75	1.75 - 2
0.75 - 1	2 - 2.25
1 - 1.25	



File: W:\active\60940049\graphics\GIS\MXD\december 2006\sago pondweed (potamogeton pectinata).mxd Revised: December 11, 2006

Source: Satellite image GeoEye IKONOS 1m resolution 04/23/2000.

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Meters

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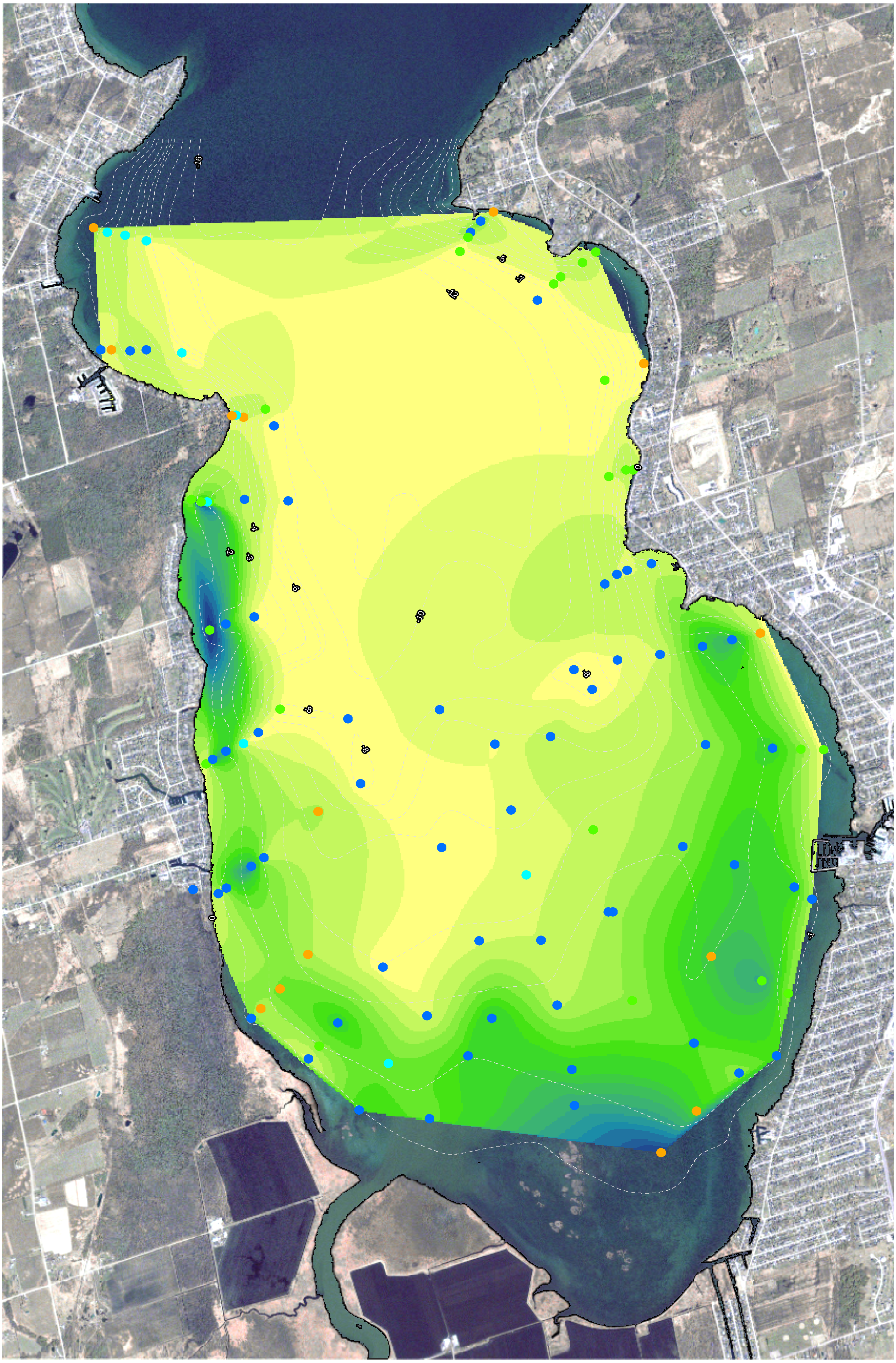
FIGURE NO. 18

Macrophytes Biomass Dry Weight Average

Sago Pondweed (*Potamogeton pectinata*)

Sago Pondweed Dry Weight Average (mg)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- 1.25 - 1.5



Source: Satellite image GeoEye IKONOS 1m resolution 04/23/2000.

File: W:\active\60940049\graphics\GIS\MXD\december 2006\total composite biomass distribution and sed charac.mxd Revised: April 4, 2007

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Total Biomass Distribution (mg)

0 - 25	360 - 400
25 - 50	400 - 435
50 - 100	435 - 470
100 - 140	470 - 500
140 - 180	500 - 550
180 - 220	550 - 580
220 - 250	580 - 630
250 - 300	630 - 700
300 - 325	700 - 840
325 - 360	840 - 1,200

(Ranges defined by natural breaks [Jenks])

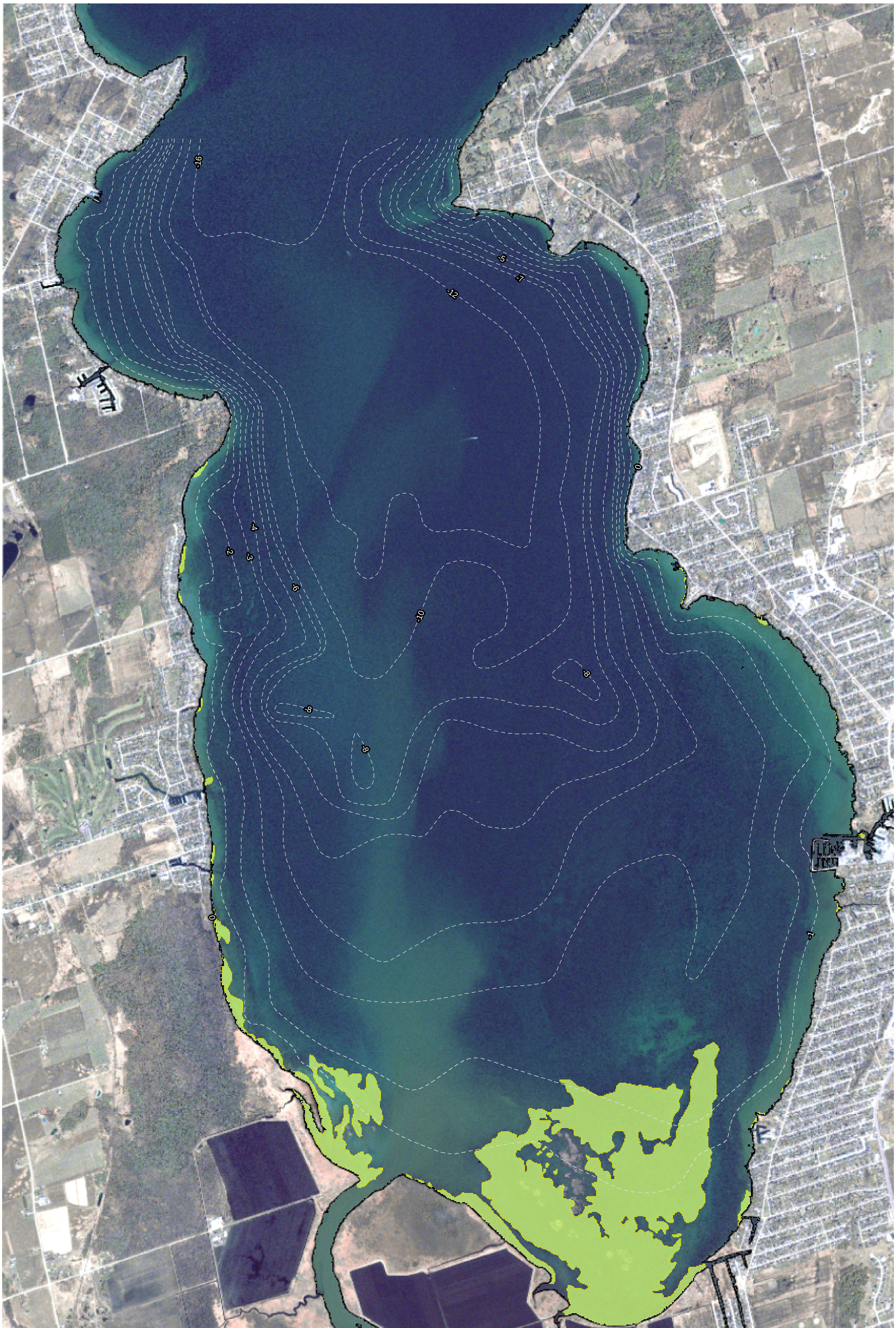
Substrate Characteristics

- clay
- sand
- silt
- unknown

FIGURE NO. 19

Macrophytes Biomass Dry Weight Average

Total Composite Biomass & Sediment Characteristics



File: W:\active\60940049\graphics\GIS\MXD\december 2006\emergent vegetation.mxd Revised: December 11, 2006

Source: Satellite image GeoEye IKONOS 1m resolution 04/23/2000.

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FIGURE NO. 20

Emergent Vegetation

Emergent Vegetation

4.0 Discussion

The aquatic macrophyte flora in Cook's Bay was comprised of a relatively common assemblage of species, at densities typical for eutrophic lakes. Macrophyte growths were probably responsible for localized variations in water quality, specifically dissolved oxygen levels and pH. The data produced by this survey represent a baseline against which future inventories of the lake can be compared. These observations are discussed below.

Average and maximum plant biomass in Cooks Bay was 233 g/m^2 and 1.2 kg/m^2 respectively. In lakes where submergent macrophytes dominate the plant community, plant biomass typically ranges between 20 to 500 g/m^2 (Wetzel, 1973). Macrophyte growths in Lake Opinicon, part of the Rideau Canal system, were reported to be upwards of 500 g/m^2 (Crowder *et al*., 1977). Biomass of plants in Lake St. Clair increased to between 100 g/m^2 and 3.5 kg/m^2 after the introduction of zebra mussels in about 1988 (Griffiths, 1993; Hunter and Simons, 2004). In Lake Luknajno (Poland), biomass of Charophytes exceeded 1 kg/m^2.

Dominant macrophytes in Cooks Bay included tape grass (*Vallisneria americana*), stonewort (C*hara spp.*), flat-stem pondweed (*Potomogeton zosteriformis*), coontail (*Ceratophyllum demersum*), Eurasian water milfoil (*Myriophyllum spicatum*), common waterweed (*Elodea canadensis*), and Richardson's pondweed (*Potamogeton richardsonii*). All of these are common to lakes in the area (e.g., Crowder *et al*., 1977; Knapton and Petrie, 1999; Kilgour *et al*., 2000), and to Cooks Bay historically (Neil *et al*., 1988). In a plant survey in Lake Couchiching (1997), the macrophyte community was likewise dominated by the stonewort *Chara*, as well as tape grass, and Richardson's pondweed (Kilgour *et al*., 2000). The bushy pondweed (*Najas flexilis*), which was rare in Cooks Bay in this survey, was a relatively dominant form in Lake Couchiching in 1997 (Kilgour *et al*., 2000). Common waterweed and milfoil were found, but in low densities in Lake Couchiching. Less common macrophytes in Cooks Bay were sheathed pondweed, bushy pondweed, curley-leaved pondweed, water-thread pondweed, horned pondweed and sago pondweed. All of these are relatively broadly distributed in Canada (Appendix 5).

The dominant macrophytes in Cooks Bay have changed somewhat since surveys conducted in 1984 and 1987. Neil *et al*. (1988) found Chara to be dominant in both 1984 and 1987, with water star grass (*Zosterella dubia*) and sago pondweed being subdominant. *Myriophyllum*, coontail, *Elodea* and bushy pondweed were also present in those earlier surveys, but in low abundance. Here, tape grass, *Chara*, flat-stemmed pondweed, coontail and milfoil were all highly abundant in the bay (Table 2).

Macrophyte growths in Cooks Bay are dense enough to have had significant effects on water quality. Dissolved oxygen levels were observed to be significantly depressed in localized areas such as offshore from Gilford (west side of the bay) during early morning. Associated with the low dissolved oxygen levels was lower pH. This decline in dissolved oxygen and pH is consistent with what occurs during plant respiration: consumption of oxygen and production of carbon dioxide causes a local pH depression (Petr, 2000). Such low levels of dissolved oxygen are normally compensated for during the day when plants consume carbon dioxide and release dissolved oxygen. Super-saturation of dissolved oxygen levels were also observed in Cooks Bay in mid- to late-afternoon sampling periods. High dissolved oxygen levels co-occurred in this survey with high pH levels reflecting the removal of CO_2 from the water column. In extreme cases, increases in pH resulting from plant consumption of CO_2 can result in ammonia becoming toxic to fish.

Changes water quality occurred after the introduction of zebra mussels to the lake in 1995, and that has led to an increase in the apparent growth of plants. Secchi disc depths prior to zebra mussels, for example, averaged between 3 and 4 m in Cooks Bay, and have increased to 5 to 6 m in recent years (Eimers *et al*., 2005). Total macrophyte biomass of Cooks Bay has increased somewhat since the arrival of zebra mussels in 1995. Neil *et al*. (1988) reported an average standing crop wet weight biomass of 1.2 kg/m^2 for the survey in 1987, with plants limited to water depths of < 6 to 8 m. In this 2006 survey, average biomass (across all stations) was 1.4 kg/m^2, while plants were not found in water deeper than 8.5 m, while the greatest densities were in < 4 m, consistent with the 1997 survey. This 2006 survey included parts of the whole bay, whereas the 1987 survey focused on the southern part of Cooks Bay. The northern part of the bay had lower plant biomass (average of 1.1 kg/m^2) than the southern part of the bay (1.5 kg/m^2; Figure 19). A value of 1.5 kg/m^2 represents an increase of some 25% over the average plant biomass reported from the 1987 survey (Neil *et al*., 1988). That estimated increase may be an underestimate if we consider that considerable plant biomass detaches from the bottom and drifts to the eastern shore of Cooks Bay. The principal species involved in the accumulations on the eastern shore have been tapegrass, milfoil and coontail, i.e., the three species that are among the most dominant in terms of average biomass in the bay at the present time.

Zebra mussels have, similarly, been attributed with changes in water clarity and plant growth in other lakes. Secchi disc depths in Lake Onieda (New York, USA) increased from, 2.6 ± 0.1 m before the zebra mussel invasion to 3.5 ± 0.2 m after their establishment in the lake, while the depth of light penetration prior to zebra mussel invasion was 6.7 ± 0.13 m, and increased to 7.8 ± 0.17 m after the increased occupation of zebra mussels (Zhu *et al*., 2006). Macrophyte habitat was considered to have increased by 33% from 90 km^2 to 111 km^2, post zebra mussel settlement (Zhu *et al*., 2006). Idrisi *et al*. (2001) also noted a 46% reduction in phytoplankton chlorophyll *a* concentrations in Lake Oneida after the zebra mussel invasion. Increased water clarity has also been noted in Longton fishing lake in Preston, Lancashire (Aldridge *et al*., 2004), and in Saginaw Bay, Michigan (Skubinna *et al*., 1995). Skubinna *et al* (1995) documented an increase in the depth of macrophyte colonization over a two-year period Caraco *et al*. (2000) determined that the invasion of zebra mussels into the Hudson River was responsible for an increase in macrophyte photosynthesis, and thus moderation of dissolved oxygen concentrations. Griffiths (1993) observed that increased water clarity coincided with higher densities of macrophytes in Lake St. Clair, and that the resulting changes (both zebra mussels and plants) produced significant shifts in the benthic community.

An interesting phenomenon observed in Cooks Bay was the attachment to plants by zebra mussels (see also Stantec, 2006 for previous observations in Cooks Bay). The same phenomenon was observed in Lake St. Clair (Hunter and Simons, 2004), and Lake Couchiching

(Kilgour *et al*., 2000). The senescence of plants in Lake St. Clair in the fall of each year results in the attached mussels being deposited on the soft lake substrata, with subsequent death of juvenile mussels (Hunter and Simons, 2004). Attachment to plants, with later deposition to the bottom of the lake is considered a significant "check" on numbers of zebra mussels (Hunter and Simons, 2004). Samples collected in Cooks Bay typically contained numerous empty shells of zebra mussels, likely mussels from the previous year. Unlike some locations (e.g., Lake Erie), the dead shells on the bottom of Cooks Bay were not colonized by juvenile zebra mussels, likely demonstrating the inadequacy of the benthic environment for young classes of mussels.

Macrophyte biomass was unrelated to substrate composition in this study, a finding that is not surprising given the generally sandy/silty nature of the bottom in most locations (Figure 4). Substrate was generally firmer closer to shore and in shallower water, though not always, so substrate preferences, if they occurred, co-occurred with depth preferences of the various plant species. The substrate classes were also subjectively determined, so there was likely some variability in substrate nomenclature. The increased growth of macrophytes in Cooks Bay, however, is probably influencing the nature of the sediments. Higher macrophyte growth will reduce water circulation, and thus enhance the settling of suspended particles and nutrients (Chambers *et al*., 1999). There is presently not enough data to determine the degree to which sediment quality has changed in Cooks Bay.

In contrast to substrate, the distributions of the various plant species varied with depth in a typical fashion. The stonewort *Chara*, flat-stemmed pondweed and tapegrass were limited to shallower waters of about < 4 m, whereas coontail and *Elodea canadensis* were less restricted, and abundant at up to 7 m. Coontail is a non-rooted plant, and is often found in several metres of water, while *Elodea canadensis* is also commonly found in deep water (Borman, 1997). Macrophytes normally distribute in lakes according to water depth, as it relates to water clarity and light penetration.

A recent survey of benthic macroinvertebrates (Stantec, 2006) indicated a somewhat diverse community in Cooks Bay in 7 m of water, dominated by zebra mussels (>45%) but one lacking sensitive groups like mayflies. The lack of mayflies was suggestive of somewhat degraded habitat quality, probably depressions in dissolved oxygen concentrations. Low concentrations of dissolved oxygen were recorded in a few locations (Figure 2) during early-morning sampling, in this study. Subsequent visits were not made to those locations with low dissolved oxygen, but the expectation is that those locations would have had very high dissolved oxygen concentrations during the day. Plants, because they respire, consume dissolved oxygen at night. Super-saturation of dissolved oxygen concentrations can also occur during the day where excessive plant growths occur. Dissolved oxygen concentrations in excess of about 13 mg/L were above 100% saturation levels in Cooks Bay during this inventory (Figure 2).

Excessive macrophyte growths in Cooks Bay have presented largely an aesthetic issue because of the large accumulations of plant material on shorelines, principally the eastern shore. Chambers *et al* (1999) review management triggers and possible actions. Macrophyte biomasses of 0.5 kg/m^2 have been enough in some instances to trigger management. The average mid-summer biomass is 2 to 3 times that trigger in Cooks Bay, well above that trigger. Management options are limited, however, limited in freshwaters to manual harvesting, nutrient reduction, biological control, and chemical treatment. Manual harvesting is ongoing in Cooks Bay along the eastern shoreline (see photos in Appendix 4). The bay, however, is simply too large to implement a large-scale harvesting operation, though local control will provide temporary relief of unaesthetic buildups. Harvesting provides a short-term benefit, and often leads to fragmentation of stems that can ultimately increase the density of plant growth (Getsinger *et al*., 2005). Nutrient inputs to the bay are high because of the agricultural land uses in Holland Marsh and inputs to the Holland River. The requirement for nutrient reduction to Lake Simcoe has been argued on the basis that it would prevent oxygen depletion in the hypolimnion (deep cold water) of the main lake basin (Snodgrass and Holubeshen, 1992; Baird and GLL, 2006), but it would also likely limit growth of macrophytes. Biological control involves the introduction of a herbivore to consume plants. Creed and Sheldon (1995) advocate the use of the North American aquatic weevil, *Euhrychiopsis lecontei*, as a control agent for milfoil. The larva of the moth *Acentria nivea* was considered by Painter and McCabe (1987) to be responsible for control of milfoil in some Kawartha Lakes. That species was not found during the 1984 and 1987 inventories of Cooks Bay (Neil *et al*., 1988). In the case of the Kawartha Lakes, the introduction of *A. nivea* was natural. Carp and other fish species are also variously used as control agents for plants, but introductions of new fish species into Lake Simcoe would be unacceptable. Chemical treatment involves the use of a herbicide such as complexed copper, 2,4-D, diquat or glyphosate at concentrations that are lethal to plants but protective of fish and other aquatic animals. Like physical treatment, chemical treatment provides a temporary benefit.

5.0 Management Implications and Recommendations

The data produced by this survey represent a baseline against which future inventories can be compared. These data also partially fulfills one of the recommendations made by Baird and GLL (2006) to carry out a lake-wide inventory of aquatic macrophytes in support of a lake-wide hydrodynamic and water quality model. A number of initiatives related to macrophyte inventories of Cooks Bay have recently been carried out, which these data will compliment. The University of Waterloo, for example, used side-scanning technologies to map the three-dimensional structure of the plant community (Dave Barton, personal communication).

Additional information is needed to more fully understand the linkages and potentially negative interactions between macrophyte growths and the quality of habitat for benthic macroinvertebrates and fish in Cooks Bay. First, the initial benthic community monitoring program included a single sample of littoral benthos from Cooks Bay (Stantec, 2006). The linkage between macrophytes and benthic macroinvertebrates and sediment quality would be more easily made if there were additional locations at which there were synoptic samples of benthic macroinvertebrates, plants and sediments. Diurnal measurements of dissolved oxygen should also be made to determine the degree of oxygen sag that occurs in the bay at night during mid-summer. Autumn, and under-ice measurements of dissolved oxygen would also be beneficial because the die-off and decay of plant material would be expected to deplete dissolved oxygen concentrations.

Additional information is needed to understand the factors limiting the growth of macrophytes, and the potential to reduce macrophyte growths through reduction in nutrient loads. A variety of models exist to model macrophyte productivity, with the models generally integrating information on light availability, nutrient concentrations in water, and water temperature (Carr *et al*., 1997). Plant growth models could be used with a mass-balance model to determine the sources and sinks for nutrients would demonstrate whether mitigation of plant growth is feasible.

Continued monitoring of the macrophyte beds in Cooks Bay at two- to three-year intervals, in the long term would provide data that could be used to demonstrate changes in standing stock biomass, and the influence of mitigation actions (if any are taken).

6.0 Literature Cited

Aldridge, D.C., P. Elliott and G.D. Moggridge. 2004. The recent and rapid spread of the zebra mussel (*Dreissena polymorpha*) in Great Britain. Biological Conservation. 119: 253-261.

Baird and Associates, and Gartner Lee Limited. 2006. Lake Simcoe hydrodynamic and water quality model. Prepared for Lake Simcoe Region Conservation Authority. Baird Project No. 10940.

Borman, S., Korth, R. and Temte, J. Through the Looking Glass: A field guide to aquatic plants. Reindl Printing. 1997.

Caraco, N.F., J.J. Cole, S.E.G. Findlay, D.T. Fischer, M.L. Pace and D.L. Strayer. 2000. Dissolved oxygen declines in the Hudson River associated with the invation of zebra mussel (*Dreissena polylorpha*). Environmental Science & Technology. 34(7) 12.04-1210.

Carr, G., S.A.E. Bod, H.C. Duthie and W.D. Taylor. 2003. Macrophyte biomass and water quality in Ontario rivers. Journal of the North American Benthological Society, 22:182-193.

Carr, G.M., H.C. Duthie and W.D. Taylor. 1997. Models of aquatic plant productivity: a review of the factors that influence growth. Aquatic Botany, 59:195-215.

Chambers, P.A., R.E. DeWreede, E.A. Irlandi and H. Vandermeulen. 1999. Management issues in aquatic macrophyte ecology: a Canadian perspective. Canadian Journal of Botany, 77:471-487.

Creed, R.P. Jr. and S.P. Sheldon. 1995. Weevils and watermilfoil: did a North American herbivore cause the decline of an exotic plant. Ecological Applications, 5:1113-1121.

Crowder, A.A., J.M. Bristow, M.R. King and S. Vanderkloet. 1977. Distribution, seasonality and biomass of aquatic macrophytes in Lake Opinicon (Eastern Ontario). Canadian Naturalist, 104:441-456.

Eimers, M.C. and J.G. Winter. 2005. Lake Simcoe Water Quality Update 2000-2003. Lake Simcoe Environmental Management Strategy, Technical Report Imp.B.20. Prepared by the Ontario Ministry of the Environment, Toronto.

Eimers, M.C., J.G. Winters, W.A. Scheider, S.A., Watmough, and K.H. Nicholls. 2005. Recent changes and patterns in the water chemistry of lake Simcoe. Journal of Great Lakes Research. 31(3): 322-332.

Evans, D.O., Nicholls, K.H., Allen, Y.C., and McMurtry, M.J. 1996. Historical land use, phosphorus loading, and loss of fish habitat in Lake Simcoe, Canada. Canadian Journal of Fisheries and Aquatic Science. 53: 194-218.

Getsinger, F., M.D. Moore, C.P. Layne and others. 2005. Best management practices in support of fish and wildlife habitat. Aquatic Ecosystem Restoration Foundation.

Griffiths, R.W. 1993. Effects of zebra mussels (*Dreissena polymorpha*) on the benthic fauna of Lake St. Clair. In, T.F. Nalepa and D.W. Schloesser (eds), Zebra Mussels, Biology, Impacts, and Control. Lewis Publishers, Boca Raton.

Hunter R.D., and Simons, K.A. 2004. Dreissenids in Lake St. Clair in 2001: Evidence for population regulation. Journal of Great Lakes Research, 30(4): 528-537.

Idrisi, N., E.L. Mills, L.G. Rudstam, and D.J. Stewart. 2001. Impact of zebra mussels (*Dreissena polymorpha*) on the pelagic lower tropic levels of Oneida Lake, New York. Canadian Journal of Fisheries and Aquatic Science. 58: 1430-1441.

Kilgour, B.W., B. Hawkins, J. Westwood, P. Kauss and A. Gemza. 2000. Lake Couchiching Environmental Quality – 1997. Volume I – Main Findings. Report to the Ontario Ministry of the Environment.

Knapton, R.W., and Petrie, S.A. 1999. Changes in distribution and abundance of submerged macrophytes in Long Point's Inner Bay, Lake Erie: implications for foraging waterfowl. Journal of Great Lakes Research. 25: 783–798.

Neil, J., J. Graham and J. Warren. 1988. Aquatic Plants of Cooks Bay, Lake Simcoe, 1987. Prepared for Lake Simcoe Environmental Management Strategy Technical Committee. LSEMS Technical Report Number B.4.

Painter, D.S. and K.J. McCabe. 1987. Investigation into the disappearance of Eurasian water milfoil in the Kawartha Lakes. National Water Research Institute, Environment Canada, Burlington.

Petr, T. 2000. Interactions between fish and aquatic macrophytes in inland waters. A review. FAO Fisheries Technical Paper. No. 396. Rome, FAO. 2000. 185 p.

Skubinna, J.P., Coon, T.G. and Batterson, T.R. 1995. Increased abundance and depth of submersed macrophytes in response to decreased turbidity in Saginaw Bay, Lake Huron. Journal of Great Lakes Research (21(4): 476-488.

Snodgrass, W.J. and J. Holubeshen. 1992. Hypolimnetic oxygen dynamics in Lake Simcoe Part 3: model confirmation and prediction of the effects of management. Lake Simcoe Environmental Management Strategy Technical Committee, LSEMS Implementation Tech. Rep. No. Imp.B.16.

Stantec Consulting Ltd. 2006. Benthic macro-invertebrate sampling and analysis of Lake Simcoe. Report to the Lake Simcoe Region Conservation Authority.

ter Braak, C.J.F. 1992. *CANOCO - a FORTRAN Program for Canonical Community Ordination*. Microcomputer Power, Ithaca, NY

Wetzel, R.G. Limnology: Second Edition. Saunders College Publishing. 1983.

Zhu, B., D.G. Fitzgerald, C.M. Mayer, L.G. Rudstam, and E.L. Mills. 2006. Alteration of ecosystem function by zebra mussels on Oneida Lake: impacts on submerged macrophytes. Ecosystems. 9: 1017-1028.

Appendix 1

Ponar Calibration

Appendix 1 –Comparison of Standard Ponar vs Quadrate Sampling

The traditional approach for sampling macrophyte biomass is by laying a quadrate on the bottom of the lake or river, and clipping and collecting stems from within the quadrate. Sampling within quadrates in deep water requires the use of snorkeling or SCUBA. Plants within Cook's Bay extent to about 8 m, and so would require SCUBA to carry out a conventional study of plant biomass. The objective of the macrophyte study was to characterize both species diversity and plant biomass throughout Cook's Bay. The use of SCUBA slows the sampling process, is costly, and limits the number of samples that can be collected. The use of Ponar grabs to collect plants was anticipated to potentially over or underestimate the biomass of plants, but was considered advantageous because more sampling could be conducted.

The purpose of this aspect of the study was to determine the bias imposed on the data by using Ponar grabs to collect aquatic plants. On August 22, 2006, ten sample sites were selected in various locations throughout Cook's Bay (see map below). The sample locations were located in shallower waters, with depths ranging from 0.5 m to 1.5 m, and with an attempt to have locations that were representative of both high and low plant biomass . Both the quadrate and the standard Ponar were used to collect samples at each of the 10 locations, producing 10 paired observations of plant biomass.

Samples were placed in large laundry bags and rinsed to remove any remaining sediment. Any root structures which remained on plant samples were removed, as root mass was not to be included in the overall biomass calculation. Once rinsed the total wet weight of both the quadrate sample and the ponar sample were recorded.

Plant wet weights varied between a low of about 50 g per 0.1 m^2, to a high of about 2500 g per 0.1 m^2 (quadrate). There was no apparent under or overestimate of plant biomass, with wet weights below about 1 kg per 0.1 m^2. However, the standard Ponar grab underestimated plant wet weights, when wet weights in the quadrate were > 1 kg per 0.1 m^2.

Samples collected within the 0.1 m^2 quadrate were considered by the operators to potentially be overestimates of the plant biomass, when there were large growths of plants. The two samples that produced plant biomass estimates > 1 kg per 0.1 m2 were collected within littoral areas dominated by the plant *Chara*. With tangled masses, it was difficult for the person sampling to limit the collection to within the quadrate, and there was some expectation that the samples contained plant material from outside the quadrate. In contrast, samples collected with the standard Ponar were considered to be potentially more representative of the plant biomass: the wave produced by the Ponar forced plants outside the intended sampling area (as defined by the jaws of the grab away from the sampling area. The jaws, thus, only sampled plants within the jaws. The jaws, by cutting through the root systems, provided a very discrete sample.

Based on these observations, the use of the Ponar grab was considered to provide an adequate estimate of plant biomass.

Figure – Giant ponar and quadrate sample locations.

Figure 1. Relationship between plant biomass (wet weight, g/0.1 m2) obtained using a Standard Ponar and a Quadrate sampling.

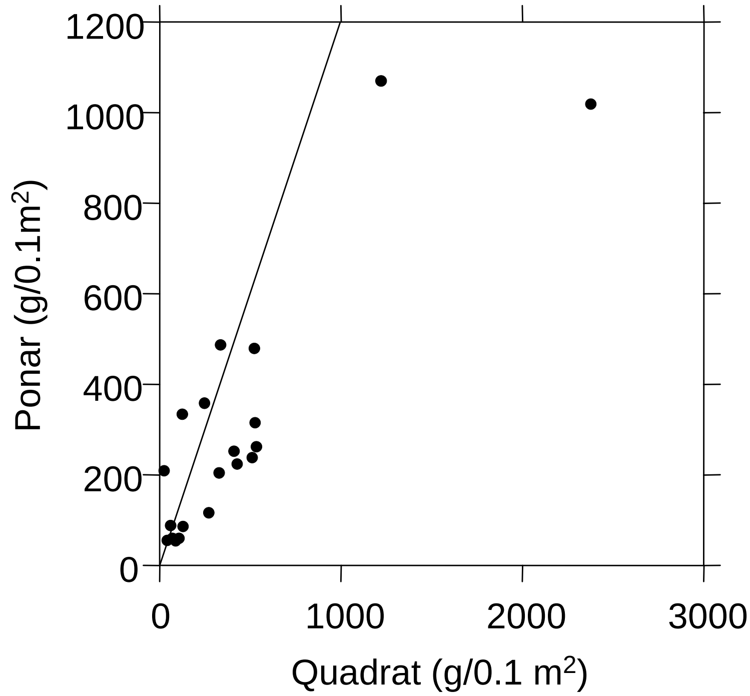

Table 1-1. Biomass results of giant ponar vs. quadrate method.

Station #	Replicate	Wet Weight (g/0.1 m^2)	
		Standard Ponar	Quadrate
1	1	262	533
1	2	252	410
30	1	60	106
30	2	86	128
401	1	487	336
401	2	479	522
402	1	315	525
402	2	224	427
403	1	238	510
403	2	358	247
404	1	88	60
404	2	54	88
405	1	55	41
405	2	60	69
406	1	116	270
406	2	334	125
407	1	209	24
407	2	204	327
408	1	1070	1220
408	2	1019	2377

Appendix 2

Macrophyte Biomass Data

Station #	X	Y	Reps	Notes	Wet Weight							
					Clasped-leaved Pondweed	Tape-Grass	Chara	Elodea	Coontail	Water Milfoil	Common Waterweed	Flat Stem Pondweed
2	616547	4902649	1		0	128	0	0	9	2	0	0
2	616547	4902649	2		0	56	0	18	11	0.5	0	3
2	616547	4902649			0	92	0	9	10	1.25	0	1.5
3	616647	4902617	-	No Sample	0	0	0	0	0	0	0	0
4	616647	4902617	1		0	0	0	0	26	26	0	0
4	616647	4902617	2		0	0	0	0	14	104	0	0
4	616647	4902617			0	0	0	0	20	65	0	0
5	616782	4902592	1		0	0	0	0	61	0	0	0
5	616782	4902592	2		0	0	0	0	42	5	0	0
5	616782	4902592			0	0	0	0	51.5	2.5	0	0
11	616600	4901731	1		0	0	34	0	0	0	0	0
11	616600	4901731	2		0	0	7	2	0.5	0	0	0
11	616600	4901731			0	0	20.5	1	0.25	0	0	0
12	616679	4901734	1		0	0	45	0	2	0	0	0.5
12	616679	4901734	2		0	0	57	0	0	0	0	0.5
12	616679	4901734			0	0	51	0	1	0	0	0.5
13	616821	4901724	1		0	66	0	0	30	25	0	0.5
13	616821	4901724	2		2	0.5	0	0	13	0	0	2
13	616821	4901724			1	33.25	0	0	21.5	12.5	0	1.25
14	616942	4901732	1		0	10	0	0	14	0	0	1
14	616942	4901732	2		0	113	0	0	19	0	0	0
14	616942	4901732			0	61.5	0	0	16.5	0	0	0.5
15	617208	4901711	1		0	0	0	0.5	25	0	0	0
15	617208	4901711	2	No Plants	0	0	0	0	0	0	0	0
15	617208	4901711			0	0	0	0.25	12.5	0	0	0
21	617672	4901224	1		0	0	16	0.5	47	0.5	0	0
21	617672	4901224	2		0	1	0	0.5	47	0.5	0	0
21	617672	4901224			0	0.5	8	0.5	47	0.5	0	0
22	617618	4901242	1		0	94	0	0	3	0.5	0	0
22	617618	4901242	2		0	169	0	0	6	2	0	10
22	617618	4901242			0	131.5	0	0	4.5	1.25	0	5
23	617586	4901238	1		0	36	14	0	0	0.5	0	0
23	617586	4901238	2		0	6	0	0	0.5	0.5	0	0
23	617586	4901238			0	21	7	0	0.25	0.5	0	0

Station #	X	Y	Reps	Notes	Wet Weight							
					Clasped-leaved Pondweed	Tape-Grass	Chara	Elodea	Coontail	Water Milfoil	Common Waterweed	Flat Stem Pondweed
31	617683	4900608	1		0	0	0	124	0	0	0	0
31	617683	4900608	2		0	0.5	0	57	0	0	0	8
31	617683	4900608			0	0.25	0	90.5	0	0	0	4
32	617414	4900588	1		0	2	0	0	1	1	0	223
32	617414	4900588	2		0	3	0	0.5	24	18	0	94
32	617414	4900588			0	2.5	0	0.25	12.5	9.5	0	158.5
33	617399	4900588	1		0	0	7	0	0	26	0	158
33	617399	4900588	2		0	0	0	0	0	5	0	310
33	617399	4900588			0	0	3.5	0	0	15.5	0	234
34	617353	4900589	1		0	0	1435	0	0	0	0	0
34	617353	4900589	2		0	35	1060	0	0	0	0	0
34	617353	4900589			0	17.5	1247.5	0	0	0	0	0
35	617282	4900608	1		0	0	226	0	0	0	0	0
35	617282	4900608	2		0	0	21	0	0	0	0	0
35	617282	4900608			0	0	123.5	0	0	0	0	0
41	617753	4899726	1	No Plants	0	0	0	0	0	0	0	0
41	617753	4899726	2		29	0	0	0	0	0	0	0
41	617753	4899726			14.5	0	0	0	0	0	0	0
43	617540	4899672	1		0	29	286	0	0	0	0	1
43	617540	4899672	2		0	13	5	0	0	0	0	335
43	617540	4899672			0	21	145.5	0	0	0	0	168
44	617418	4899627	1		0	0	768	5	0	0	0	18
44	617418	4899627	2		0	0	620	0	0	0	0	0
44	617418	4899627			0	0	694	2.5	0	0	0	9
51	617391	4898621	1		0	1	31	0	0	0	0	0
51	617391	4898621	2		2	23	5	1	0	0	0	0
51	617391	4898621			1	12	18	0.5	0	0	0	0
52	617443	4898652	1		0	0	617	0	0	0	0	6
52	617443	4898652	2		0	21	269	0	0	0	0	0.5
52	617443	4898652			0	10.5	443	0	0	0	0	3.25
53	617541	4898713	1		0	0	387	0	0	3	0	0
53	617541	4898713	2		0	0	277	0	0	0	0	0
53	617541	4898713			0	0	332	0	0	1.5	0	0
54	617674	4898773	1		0	0	0	0	0.5	21	0	0

Station #	X	Y	Reps	Notes	Wet Weight							
					Clasped-leaved Pondweed	Tape-Grass	Chara	Elodea	Coontail	Water Milfoil	Common Waterweed	Flat Stem Pondweed
54	617674	4898773	2		0	0	0	0	24	13	0	0
54	617674	4898773			0	0	0	0	12.25	17	0	0
55	617785	4898854	1		0	0	0	0	13	0	0	0
55	617785	4898854	2		0	0	0	0	16	0	0	0
55	617785	4898854			0	0	0	0	14.5	0	0	0
61	618235	4898262	1		0	0	0	12	200	0	0	0
61	618235	4898262			0	0	0	6	107.25	0	0	0
62	617827	4897916	1		0	0	0	0	20	60	0	0
62	617827	4897916	2		0	0	0	5	45	5	0	0
62	617827	4897916			0	0	0	2.5	32.5	32.5	0	0
63	617729	4897848	1		0	452	2	0	96	2	0	0
63	617729	4897848	2		0	0	0	0.5	28	400	0	0
63	617729	4897848			0	226	1	0.25	62	201	0	0
64	617545	4897687	1		0	63	90	0	0	0	0	0
64	617545	4897687	2		0	219	37	0	0	0	0	0
64	617545	4897687			0	141	63.5	0	0	0	0	0
65	617484	4897645	1		0	2	78	0	0	0	0	0
65	617484	4897645	2		0	0.5	23	0	0	0.5	0	0
65	617484	4897645			0	1.25	50.5	0	0	0.25	0	0
71	617294	4897675	1		0	0	0	7	12	0	0	0
71	617294	4897675	2		0	0	0	3	45	0	0	0
71	617294	4897675			0	0	0	5	28.5	0	0	0
72	618159	4897187	1		0	0	0	1	76	51	0	0
72	618159	4897187	2		0	0	0	0	24	64	0	0
72	618159	4897187			0	0	0	0.5	50	57.5	0	0
73	617947	4896928	1		0	0	203	0	3	11	0	0
73	617947	4896928	2		0	4	199	0	12	0	0	0
73	617947	4896928			0	2	201	0	7.5	5.5	0	0
74	617802	4896777	1		0	43	11	0	3	0	0	2
74	617802	4896777	2		0	95	0	1	3	0	0	3
74	617802	4896777			0	69	5.5	0.5	3	0	0	2.5
75	617729	4896707	1		0	4	119	0	0	0	0	0
75	617729	4896707	2		0	5	234	0	0	0	0	0
75	617729	4896707			0	4.5	176.5	0	0	0	0	0

Station #	X	Y	Reps	Notes	Wet Weight							
					Clasped-leaved Pondweed	Tape-Grass	Chara	Elodea	Coontail	Water Milfoil	Common Waterweed	Flat Stem Pondweed
80	618722	4897090	1	No Plants	0	0	0	0	0	0	0	0
80	618722	4897090	2	No Plants	0	0	0	0	0	0	0	0
80	618722	4897090			0	0	0	0	0	0	0	0
81	618383	4896674	1		0	160	0	0	26	0	0	0
81	618383	4896674	2		0	343	0	0	43	0	0	0
81	618383	4896674			0	251.5	0	0	34.5	0	0	0
82	618242	4896498	1		0	130	49	0	1	0	0	0
82	618242	4896498	2		29	82	13	0	0	0.5	0	0
82	618242	4896498			14.5	106	31	0	0.5	0.25	0	0
83	618160	4896403	1		0	13	0	0	4	6	0	0
83	618160	4896403	2		0	18	3	0	6	0	0	0
83	618160	4896403			0	15.5	1.5	0	5	3	0	0
90	619563	4898766	1		0	0	0	38	8	0	0	0
90	619563	4898766	2	No Plants	0	0	0	0	0	0	0	0
90	619563	4898766			0	0	0	19	4	0	0	0
94	619684	4898272	1		0	0	0	10	37	0	0	0
94	619684	4898272	2		0	0	0	0	16	0	0	1
94	619684	4898272			0	0	0	5	26.5	0	0	0.5
96	619800	4897783	1		0	0	0	6	22	2	0	0
96	619800	4897783	2		0	0	0	28	7	0	0	4
96	619800	4897783			0	0	0	17	14.5	1	0	2
97	619445	4897291	1		0	0	0	3	2	16	0	0
97	619445	4897291	2		0	0	0	6	10	44	0	0
97	619445	4897291			0	0	0	4.5	6	30	0	0
99	619912	4897293	1		0	0	0	3	28	1	0	0
99	619912	4897293	2		0	0	0	41	31	2	0	0
99	619912	4897293			0	0	0	22	29.5	1.5	0	0
100	619541	4896708	1		0	0	0	3	52	9	0	394
100	619541	4896708	2		0	0	0	3	17	5	0	135
100	619541	4896708			0	0	0	3	34.5	7	0	264.5
102	619053	4896726	1		0	0	0	0	3	0	0	0
102	619053	4896726	2		0	0	0	0.5	4	43	0	21
102	619053	4896726			0	0	0	0.25	3.5	21.5	0	10.5
104	619363	4896426	1		0	0	0	0.5	0	0	0	231

Station #	X	Y	Reps	Notes	Wet Weight							
					Clasped-leaved Pondweed	Tape-Grass	Chara	Elodea	Coontail	Water Milfoil	Common Waterweed	Flat Stem Pondweed
104	619363	4896426	2		0	0	0	0	0	2	0	296
104	619363	4896426			0	0	0	0.25	0	1	0	263.5
107	620032	4896804	1		0	0	40	0.5	81	3	0	0
107	620032	4896804	2		0	33	0	0.5	10	14	0	0
107	620032	4896804			0	16.5	20	0.5	45.5	8.5	0	0
110	618543	4896016	1		0	0	0	1	0	0	0	318
110	618543	4896016	2		0	3	0	0	11	0	0	180
110	618543	4896016			0	1.5	0	0.5	5.5	0	0	249
112	619072	4895951	1		0	0	0	0	0	0	0	243
112	619072	4895951	2		0	0	0	0	0	0	0	166
112	619072	4895951			0	0	0	0	0	0	0	204.5
119	620144	4896322	1		0	197	23	0.5	3	1	0	0
119	620144	4896322	2		0	297	0	0	3	5	0	32
119	620144	4896322			0	247	11.5	0.25	3	3	0	16
128	620815	4895698	1		0	496	0	0	2	0	0	463
128	620815	4895698	2		0	95	0	0	13	0	0	189
128	620815	4895698			0	295.5	0	0	7.5	0	0	326
130	621081	4896008	1		0	166	0	0	0	0	0	108
130	621081	4896008	2		0	236	0	0	0	0	0	24
130	621081	4896008			0	201	0	0	0	0	0	66
132	621401	4896293	1		0	25	0	0	0	0	0	130
132	621401	4896293	2		0	96	0	0	0	0	0	50
132	621401	4896293			0	60.5	0	0	0	0	0	90
135	621062	4896520	1		0	163	0	0	0	6	0	142
135	621062	4896520	2		0	79	0	0	0	0	0	57
135	621062	4896520			0	121	0	0	0	3	0	99.5
141	620595	4896841	1		0	79	31	0.5	0.5	16	0	0.5
141	620595	4896841	2		9	49	106	0	0.5	0	0	0
141	620595	4896841			4.5	64	68.5	0.25	0.5	8	0	0.25
144	620416	4897505	1		0	0	0	0.5	13	59	0	0.5
144	620416	4897505	2		0	0	0	1	33	94	0	0
144	620416	4897505			0	0	0	0.75	23	76.5	0	0.25
148	621189	4897172	1		0	316	0	0	0	0	0	17
148	621189	4897172	2		0	277	0	0	13	10	0	13

Station #	X	Y	Reps	P. Crispus	Najas Flexis	Wet Weight				Total
						Sheathed Pondweed	Sago Pondweed	Horned Pondweed	Water Thread pondweed	
148	621189	4897172		0	0	0	0	0	0	323
149	621572	4896990	1	0	0	0	0	0.5	0	453.5
149	621572	4896990	2	0	0	16	0.5	2	0	380.5
149	621572	4896990		0	0	8	0.25	1.25	0	417
150	621770	4896895	1	0	0	0	0	0	0	261
150	621770	4896895	2	0	0	0	0	0	0	55
150	621770	4896895		0	0	0	0	0	0	158
154	621366	4897861	1	0	0	0	0	0	0	404
154	621366	4897861	2	0	0	0	0	0	0	216
154	621366	4897861		0	0	0	0	0	0	310
155	620979	4897999	1	0	0	0	0	0	0	244
155	620979	4897999	2	0	0	0	0	0	0	83
155	620979	4897999		0	0	0	0	0	0	163.5
160	622035	4898726	1	0	0	0	0	0	0	0
160	622035	4898726	2	0	0	0	0	0	0	0
160	622035	4898726		0	0	0	0	0	0	0
161	621866	4898731	1	0	0	21	0	0	0	149.5
161	621866	4898731	2	0	0	0	0.5	0	0	177.5
161	621866	4898731		0	0	10.5	0.25	0	0	163.5
162	621652	4898737	1	0	0	0	0	0	0	354
162	621652	4898737	2	0	0	0	0	0.5	0	206.5
162	621652	4898737		0	0	0	0	0.25	0	280.25
163	621147	4898764	2	0	0	0	0	0	0	157.5
163	621147	4898764	1	0	0	0	0	0.5	0.5	118
163	621147	4898764		0	0	0	0	0.25	0.25	137.75
171	620805	4899444	1	0	0	0	0	0	0	64
171	620805	4899444	2	0	0	0	0	0.5	0.5	35
171	620805	4899444		0	0	0	0	0.25	0.25	49.5
179	619983	4898826	1	0	0	0	0	0	0	110
179	619983	4898826	2	0	0	0	0	0	0	39
179	619983	4898826		0	0	0	0	0	0	74.5
182	620483	4900046	2	0	0	0	0	0	0	17
182	620483	4900046	2	0	0	0	0	0	0	60
182	620483	4900046		0	0	0	0	0	0	38.5

Station #	X	Y	Reps	Notes	Wet Weight							
					Clasped-leaved Pondweed	Tape-Grass	Chara	Elodea	Coontail	Water Milfoil	Common Waterweed	Flat Stem Pondweed
183	620557	4900073	2		0	0	0	0.5	3	0	0	1
183	620557	4900073	1		0	0	0	0	0	57	0	0
183	620557	4900073			0	0	0	0.25	1.5	28.5	0	0.5
184	620742	4900125	1		0	0	0	2	25	0	0	25
184	620742	4900125	2		0	0	0	2	8	0	0	96
184	620742	4900125			0	0	0	2	16.5	0	0	60.5
191	620422	4900781	1		0	0	0	5	26	0	0	0
191	620422	4900781	2		0	0	0	4	20	0	0	0
191	620422	4900781			0	0	0	4.5	23	0	0	0
203	620392	4901504	1	No Plants	0	0	0	0	0	0	0	0
203	620392	4901504	2	No Plants	0	0	0	0	0	0	0	0
203	620392	4901504			0	0	0	0	0	0	0	0
212	620059	4902281	1		0	0	0	12	65	0	0	0
212	620059	4902281	2		0	0	0	18	29	0	0	0
212	620059	4902281			0	0	0	15	47	0	0	0
213	620007	4902229	1	No Plants	0	0	0	0	0	0	0	0
213	620007	4902229	2		0	0	5	0	6	0	0	0
213	620007	4902229			0	0	2.5	0	3	0	0	0
214	619885	4902104	1	No Plants	0	0	0	0	0	0	0	0
214	619885	4902104	2	No Plants	0	0	0	0	0	0	0	0
214	619885	4902104			0	0	0	0	0	0	0	0
222	619381	4902617	1		0	0	0	100	0	0	0	0
222	619381	4902617	2		0	0	11	29	0	0	0	0
222	619381	4902617			0	0	5.5	64.5	0	0	0	0
223	619360	4902580	1		0	0	4	3	5	0	0	2
223	619360	4902580	2		0	0	17	21	0	0	0	16
223	619360	4902580			0	0	10.5	12	2.5	0	0	9
224	619299	4902470	1	No Plants	0	0	0	0	0	0	0	0
224	619299	4902470	2	No Plants	0	0	0	0	0	0	0	0
224	619299	4902470			0	0	0	0	0	0	0	0
501	616941	4902550	1		0	0	0	0	39	0	0	0
501	616941	4902550	2		0	0	0	2	0	0	0	0
501	616941	4902550			0	0	0	1	19.5	0	0	0
504	617838	4901285	1		0	0	0	0	102	0	0	0

Station #	X	Y	Reps	Notes	Wet Weight							
					Clasped-leaved Pondweed	Tape-Grass	Chara	Elodea	Coontail	Water Milfoil	Common Waterweed	Flat Stem Pondweed
504	617838	4901285	2		0	0	0	0	10	0	0	0
504	617838	4901285			0	0	0	0	56	0	0	0
505	617904	4901162	1	No Plants	0	0	0	0	0	0	0	0
505	617904	4901162	2	No Plants	0	0	0	0	0	0	0	0
505	617904	4901162			0	0	0	0	0	0	0	0
506			1		0	0	0	5	18	0	0	0
506			2		0	0	0	0	17	0	0	0
506					0	0	0	2.5	17.5	0	0	0
507	618010	4900597	1	No Plants	0	0	0	0	0	0	0	0
507	618010	4900597	2		0	0	0	14	0	0	0	0
507	618010	4900597			0	0	0	7	0	0	0	0
509	617948	4899031	1		0	0	0	0	30	0	0	0
509	617948	4899031	2		0	0	0	0	9	0	0	0
509	617948	4899031			0	0	0	0	19.5	0	0	0
510	618553	4898470	1		0	0	0	0	1	0	0	0
510	618553	4898470	2	No Plants	0	0	0	0	0	0	0	0
510	618553	4898470			0	0	0	0	0.5	0	0	0
601	620163	4896051	1		0	217	0	0	5	0	0	223
601	620163	4896051	2		0	280	0	0	0	0	0	73
601	620163	4896051			0	248.5	0	0	2.5	0	0	148
602	618763	4896368	1		0	0	0	1	2	0	0	105
602	618763	4896368	2		0	230	0	0	0.5	0	0	62
602	618763	4896368			0	115	0	0.5	1.25	0	0	83.5
603	621950	4897603	1		0	128	0	0	0	0	0	0
603	621950	4897603	2		0	72	0	0.5	0.5	0	0	0
603	621950	4897603			0	100	0	0.25	0.25	0	0	0
604	621815	4897693	1		0	304	0	0	25	63	0	8
604	621815	4897693	2		0	97	0	0	7	32	0	2
604	621815	4897693			0	200.5	0	0	16	47.5	0	5
610	621684	4896424	1		0	180	0	0	0	0	0	75
610	621684	4896424	2		0	183	0	0	0	0	0	59
610	621684	4896424			0	181.5	0	0	0	0	0	67
611	620301	4898122	1		0	0	0.5	6	79	0	0	0
611	620301	4898122	2		0	0	0	0	22	0	0	0

Station #	X	Y	Reps	Notes	Wet Weight							
					Clasped-leaved Pondweed	Tape-Grass	Chara	Elodea	Coontail	Water Milfoil	Common Waterweed	Flat Stem Pondweed
611	620301	4898122			0	0	0.25	3	50.5	0	0	0
612	619164	4897990	4	No Plants	0	0	0	0	0	0	0	0
612	619164	4897990	2		0	0	0	0.5	3	0	0	0
612	619164	4897990			0	0	0	0.25	1.5	0	0	0
613	619455	4902699	1		0	47	0	0	91	68	0	10
613	619455	4902699	2		0	17	0	4	45	176	0	9
613	619455	4902699			0	32	0	2	68	122	0	9.5
614	619552	4902770	1		0	19	0	0	0	0	0	0
614	619552	4902770	2		0	12	23	0	0	0	0	0
614	619552	4902770			0	15.5	11.5	0	0	0	0	0
615	620222	4902387	1		0	3	0	0.5	10	28	0	27
615	620222	4902387	2		0	3	0	0	28	0	0	52
615	620222	4902387			0	3	0	0.25	19	14	0	39.5
616	620321	4902469	1		0	0.5	39	0	0	0	0	0
616	620321	4902469	2		0	0	64	0	0	0	0	0
616	620321	4902469			0	0.25	51.5	0	0	0	0	0
617	620602	4900830	1		0	0	0	0	3	0	0	0
617	620602	4900830	2		0	7	27	0	67	0	0	0
617	620602	4900830			0	3.5	13.5	0	35	0	0	0
618	620685	4901631	1	No Plants	0	0	0	0	0	0	0	0
618	620685	4901631	2		0	0	26	0	0	0	0	0
618	620685	4901631			0	0	13	0	0	0	0	0
619	620551	4900829	1		12	0	0	10	0	9	0	17
619	620551	4900829	2		0	114	0	0	18	117	0	0
619	620551	4900829			6	57	0	5	9	63	0	8.5
620	620450	4897505	1		0	0	0	0	3	103	0	0
620	620450	4897505	2		0	0	0	0.5	49	88	0	0
620	620450	4897505			0	0	0	0.25	26	95.5	0	0
621	619149	4899025	1		0	0	0	0	80	0	0	0
621	619149	4899025	2		0	0	0	3	14	0	0	0
621	619149	4899025			0	0	0	1.5	47	0	0	0
622	618458	4898959	1	No Plants	0	0	0	0	0	0	0	0
622	618458	4898959	2	No Plants	0	0	0	0	0	0	0	0
622	618458	4898959			0	0	0	0	0	0	0	0

Station #	X	Y	Reps	Notes	Wet Weight							
					Clasped-leaved Pondweed	Tape-Grass	Chara	Elodea	Coontail	Water Milfoil	Common Waterweed	Flat Stem Pondweed
623	620157	4899329	1	No Plants	0	0	0	0	0	0	0	0
623	620157	4899329	2	No Plants	0	0	0	0	0	0	0	0
623	620157	4899329			0	0	0	0	0	0	0	0
624	620485	4899401	1	No Plants	0	0	0	0	0	0	0	0
624	620485	4899401	2		0	0	0	4	40	0	0	0
624	620485	4899401			0	0	0	2	20	0	0	0
625	621127	4899502	1		0	212	0	0.5	64	0.5	0	0
625	621127	4899502	2		0	305	0	0	10	0	0	0
625	621127	4899502			0	258.5	0	0.25	37	0.25	0	0
626	621347	4899551	1		0	66	0	0.5	0.5	0	0	563
626	621347	4899551	2		0	57	0	0	8	6	0	82
626	621347	4899551			0	61.5	0	0.25	4.25	3	0	322.5
627	621561	4899601	2		0	1	57	0	0	0	0	0
627	621561	4899601	1		2	5	74	0	0	0	0	0
627	621561	4899601			1	3	65.5	0	0	0	0	0
628	620391	4899972	1		0	0	0	14	19	1	0	0
628	620391	4899972	2		0	0	0	7	22	154	0	0
628	620391	4899972			0	0	0	10.5	20.5	77.5	0	0
629	620294	4899179	2		0	0	0	0	2	0	0	0
629	620294	4899179	1	No Plants	0	0	0	0	0	0	0	0
629	620294	4899179			0	0	0	0	1	0	0	0

biomass averages

Station #	X	Y	Reps	Wet Weight						Total
				P. Crispus	Najas Flexis	Sheathed Pondweed	Sago Pondweed	Horned Pondweed	Water Thread pondweed	
2	616547	4902649	1	0	0	0	0	0	0	139
2	616547	4902649	2	0	0	0	0	0	0	88.5
2	616547	4902649		0	0	0	0	0	0	113.75
3	616647	4902617	-	0	0	0	0	0	0	0
4	616647	4902617	1	0	0	0	0	0	0	52
4	616647	4902617	2	0	0	0	0	0	0	118
4	616647	4902617		0	0	0	0	0	0	85
5	616782	4902592	1	0	0	0	0	0	0	61
5	616782	4902592	2	0	0	0	0	0	0	47
5	616782	4902592		0	0	0	0	0	0	54
11	616600	4901731	1	0	0	0	0	0	0	34
11	616600	4901731	2	0	0	0	0	0	0	9.5
11	616600	4901731		0	0	0	0	0	0	21.75
12	616679	4901734	1	0	0	0	0	0	0	47.5
12	616679	4901734	2	0	0	0	0	0	0	57.5
12	616679	4901734		0	0	0	0	0	0	52.5
13	616821	4901724	1	0	0	0	0	0	0	121.5
13	616821	4901724	2	0	0	0	0	0	0	17.5
13	616821	4901724		0	0	0	0	0	0	69.5
14	616942	4901732	1	0	0	0	0	0	0	25
14	616942	4901732	2	0	0	0	0	0	0	132
14	616942	4901732		0	0	0	0	0	0	78.5
15	617208	4901711	1	0	0	0	0	0	0	25.5
15	617208	4901711	2	0	0	0	0	0	0	0
15	617208	4901711		0	0	0	0	0	0	12.75
21	617672	4901224	1	0	0	0	0	0	0	64
21	617672	4901224	2	0	0	0	0	0	0	49
21	617672	4901224		0	0	0	0	0	0	56.5
22	617618	4901242	1	0	0	0	0	0	0	97.5
22	617618	4901242	2	0	0	0	0	0	0	187
22	617618	4901242		0	0	0	0	0	0	142.25
23	617586	4901238	1	0	0	0	0	0	0	50.5
23	617586	4901238	2	0	0	0	0	0	0	7
23	617586	4901238		0	0	0	0	0	0	28.75

Station #	X	Y	Reps	Wet Weight						Total
				P. Crispus	Najas Flexis	Sheathed Pondweed	Sago Pondweed	Horned Pondweed	Water Thread pondweed	
31	617683	4900608	1	0	0	0	0	0	0	124
31	617683	4900608	2	0	0	0	0	0	0	65.5
31	617683	4900608		0	0	0	0	0	0	94.75
32	617414	4900588	1	0	0	0	0	0	0	227
32	617414	4900588	2	0	0	0	0	0	0	139.5
32	617414	4900588		0	0	0	0	0	0	183.25
33	617399	4900588	1	0	0	0	0	0	0	191
33	617399	4900588	2	0	0	0	0	0	0	315
33	617399	4900588		0	0	0	0	0	0	253
34	617353	4900589	1	0	0	0	0	0	0	1435
34	617353	4900589	2	0	0	0	0	0	0	1095
34	617353	4900589		0	0	0	0	0	0	1265
35	617282	4900608	1	0	0	0	0	0	0	226
35	617282	4900608	2	8	0	0	0	0	0	29
35	617282	4900608		4	0	0	0	0	0	127.5
41	617753	4899726	1	0	0	0	0	0	0	0
41	617753	4899726	2	0	0	0	0	0	0	29
41	617753	4899726		0	0	0	0	0	0	14.5
43	617540	4899672	1	0	0	0	0	0	0	316
43	617540	4899672	2	0	0	0	0	0	0	353
43	617540	4899672		0	0	0	0	0	0	334.5
44	617418	4899627	1	0	0	0	0	0	0	791
44	617418	4899627	2	0	0	0	0	0	0	620
44	617418	4899627		0	0	0	0	0	0	705.5
51	617391	4898621	1	0	0	0	0	0	0	32
51	617391	4898621	2	0	0	0	0	0	0	31
51	617391	4898621		0	0	0	0	0	0	31.5
52	617443	4898652	1	0	0	0	0	0	0	623
52	617443	4898652	2	0	0	0	0	0	0	290.5
52	617443	4898652		0	0	0	0	0	0	456.75
53	617541	4898713	1	0	0	0	0	0	0	390
53	617541	4898713	2	0	0	0	0	0	0	277
53	617541	4898713		0	0	0	0	0	0	333.5
54	617674	4898773	1	0	0	0	0	0	0	21.5

Station #	X	Y	Reps	Wet Weight						Total
				P. Crispus	Najas Flexis	Sheathed Pondweed	Sago Pondweed	Horned Pondweed	Water Thread pondweed	
54	617674	4898773	2	0	0	0	0	0	0	37
54	617674	4898773		0	0	0	0	0	0	29.25
55	617785	4898854	1	0	0	0	0	0	0	13
55	617785	4898854	2	0	0	0	0	0	0	16
55	617785	4898854		0	0	0	0	0	0	14.5
61	618235	4898262	1	0	0	0	0	0	0	212
61	618235	4898262		0	0	0	0	0	0	113.25
62	617827	4897916	1	0	0	0	0	0	0	80
62	617827	4897916	2	0	0	0	0	0	0	55
62	617827	4897916		0	0	0	0	0	0	67.5
63	617729	4897848	1	0	11	2	0	0	0	565
63	617729	4897848	2	0	0	0	0	0	0	428.5
63	617729	4897848		0	5.5	1	0	0	0	496.75
64	617545	4897687	1	0	0	0	0	0	0	153
64	617545	4897687	2	0	0	0	0	0	0	256
64	617545	4897687		0	0	0	0	0	0	204.5
65	617484	4897645	1	3	0	0	0	0	0	83
65	617484	4897645	2	0	2	0	0	0	0	26
65	617484	4897645		1.5	1	0	0	0	0	54.5
71	617294	4897675	1	0	0	0	0	0	0	19
71	617294	4897675	2	0	0	0	0	0	0	48
71	617294	4897675		0	0	0	0	0	0	33.5
72	618159	4897187	1	0	0	0	0	0	0	128
72	618159	4897187	2	0	0	0	0	0	0	88
72	618159	4897187		0	0	0	0	0	0	108
73	617947	4896928	1	0	0	0	0	0	0	217
73	617947	4896928	2	0	0	0	0	0	0	215
73	617947	4896928		0	0	0	0	0	0	216
74	617802	4896777	1	0	0	0	0	0	0	59
74	617802	4896777	2	0	0	0	0	0	0	102
74	617802	4896777		0	0	0	0	0	0	80.5
75	617729	4896707	1	0	0	0	0	0	0	123
75	617729	4896707	2	0.5	0	0	0	0	0	239.5
75	617729	4896707		0.25	0	0	0	0	0	181.25

Station #	X	Y	Reps	Wet Weight						Total
				P. Crispus	Najas Flexis	Sheathed Pondweed	Sago Pondweed	Horned Pondweed	Water Thread pondweed	
80	618722	4897090	1	0	0	0	0	0	0	0
80	618722	4897090	2	0	0	0	0	0	0	0
80	618722	4897090		0	0	0	0	0	0	0
81	618383	4896674	1	0	0	0	0	0	0	186
81	618383	4896674	2	0	0	0	0.5	0	0	386.5
81	618383	4896674		0	0	0	0.25	0	0	286.25
82	618242	4896498	1	0	7	0	0	0	0	187
82	618242	4896498	2	0	0	0	0	0	0	124.5
82	618242	4896498		0	3.5	0	0	0	0	155.75
83	618160	4896403	1	0	0	0	0	0	0	23
83	618160	4896403	2	0	0	0	0	0	0	27
83	618160	4896403		0	0	0	0	0	0	25
90	619563	4898766	1	0	0	0	0	0	0	46
90	619563	4898766	2	0	0	0	0	0	0	0
90	619563	4898766		0	0	0	0	0	0	23
94	619684	4898272	1	0	0	0	0	0	0	47
94	619684	4898272	2	0	0	0	0	0	0	17
94	619684	4898272		0	0	0	0	0	0	32
96	619800	4897783	1	0	0	0	0	0	0	30
96	619800	4897783	2	0	0	0	0	0	0	39
96	619800	4897783		0	0	0	0	0	0	34.5
97	619445	4897291	1	0	0	0	0	0	0	21
97	619445	4897291	2	0	0	0	0	0	0	60
97	619445	4897291		0	0	0	0	0	0	40.5
99	619912	4897293	1	0	0	0	0	0	0	32
99	619912	4897293	2	0	0	0	0	0	0	74
99	619912	4897293		0	0	0	0	0	0	53
100	619541	4896708	1	0	0	0	0	0	0	458
100	619541	4896708	2	0	0	0	0	0	0	160
100	619541	4896708		0	0	0	0	0	0	309
102	619053	4896726	1	0	0	0	0	0	0	3
102	619053	4896726	2	0	0	0	0	0	0	68.5
102	619053	4896726		0	0	0	0	0	0	35.75
104	619363	4896426	1	0	0	0	0	0	0	231.5

Station #	X	Y	Reps	Wet Weight						Total
				P. Crispus	Najas Flexis	Sheathed Pondweed	Sago Pondweed	Horned Pondweed	Water Thread pondweed	
104	619363	4896426	2	0	0	0	0	0	0	298
104	619363	4896426		0	0	0	0	0	0	264.75
107	620032	4896804	1	0	0	0	0	0	0	124.5
107	620032	4896804	2	0	0	0	0	0	0	57.5
107	620032	4896804		0	0	0	0	0	0	91
110	618543	4896016	1	0	0	0	0	0	0	319
110	618543	4896016	2	0	0	0	0	0	0	194
110	618543	4896016		0	0	0	0	0	0	256.5
112	619072	4895951	1	0	0	0	0	0	0	243
112	619072	4895951	2	0	0	0	0	0	0	166
112	619072	4895951		0	0	0	0	0	0	204.5
119	620144	4896322	1	0	0	0	0	0	0	224.5
119	620144	4896322	2	0	0	0	0	0	0	337
119	620144	4896322		0	0	0	0	0	0	280.75
128	620815	4895698	1	0	0	0	0	0	0	961
128	620815	4895698	2	0	0	0	0	0	0	297
128	620815	4895698		0	0	0	0	0	0	629
130	621081	4896008	1	0	0	0	0	0	0	274
130	621081	4896008	2	0	0	0	0	0	0	260
130	621081	4896008		0	0	0	0	0	0	267
132	621401	4896293	1	0	0	0	0	0	0	155
132	621401	4896293	2	0	0	0	0	0	0	146
132	621401	4896293		0	0	0	0	0	0	150.5
135	621062	4896520	1	0	0	0	0	0	0	311
135	621062	4896520	2	0	0	0	0	0	0	136
135	621062	4896520		0	0	0	0	0	0	223.5
141	620595	4896841	1	0	0	0	3	1	0.5	132
141	620595	4896841	2	0	0	0	0	0	0	164.5
141	620595	4896841		0	0	0	1.5	0.5	0.25	148.25
144	620416	4897505	1	0	0	0	0	0	0.5	73.5
144	620416	4897505	2	0	0	0	0	0	0	128
144	620416	4897505		0	0	0	0	0	0.25	100.75
148	621189	4897172	1	0	0	0	0	0	0	333
148	621189	4897172	2	0	0	0	0	0	0	313

Station #	X	Y	Reps	Wet Weight						Total
				P. Crispus	Najas Flexis	Sheathed Pondweed	Sago Pondweed	Horned Pondweed	Water Thread pondweed	
148	621189	4897172		0	0	0	0	0	0	323
149	621572	4896990	1	0	0	0	0	0.5	0	453.5
149	621572	4896990	2	0	0	16	0.5	2	0	380.5
149	621572	4896990		0	0	8	0.25	1.25	0	417
150	621770	4896895	1	0	0	0	0	0	0	261
150	621770	4896895	2	0	0	0	0	0	0	55
150	621770	4896895		0	0	0	0	0	0	158
154	621366	4897861	1	0	0	0	0	0	0	404
154	621366	4897861	2	0	0	0	0	0	0	216
154	621366	4897861		0	0	0	0	0	0	310
155	620979	4897999	1	0	0	0	0	0	0	244
155	620979	4897999	2	0	0	0	0	0	0	83
155	620979	4897999		0	0	0	0	0	0	163.5
160	622035	4898726	1	0	0	0	0	0	0	0
160	622035	4898726	2	0	0	0	0	0	0	0
160	622035	4898726		0	0	0	0	0	0	0
161	621866	4898731	1	0	0	21	0	0	0	149.5
161	621866	4898731	2	0	0	0	0.5	0	0	177.5
161	621866	4898731		0	0	10.5	0.25	0	0	163.5
162	621652	4898737	1	0	0	0	0	0	0	354
162	621652	4898737	2	0	0	0	0	0.5	0	206.5
162	621652	4898737		0	0	0	0	0.25	0	280.25
163	621147	4898764	2	0	0	0	0	0	0	157.5
163	621147	4898764	1	0	0	0	0	0.5	0.5	118
163	621147	4898764		0	0	0	0	0.25	0.25	137.75
171	620805	4899444	1	0	0	0	0	0	0	64
171	620805	4899444	2	0	0	0	0	0.5	0.5	35
171	620805	4899444		0	0	0	0	0.25	0.25	49.5
179	619983	4898826	1	0	0	0	0	0	0	110
179	619983	4898826	2	0	0	0	0	0	0	39
179	619983	4898826		0	0	0	0	0	0	74.5
182	620483	4900046	2	0	0	0	0	0	0	17
182	620483	4900046	2	0	0	0	0	0	0	60
182	620483	4900046		0	0	0	0	0	0	38.5

Station #	X	Y	Reps	Wet Weight						Total
				P. Crispus	Najas Flexis	Sheathed Pondweed	Sago Pondweed	Horned Pondweed	Water Thread pondweed	
183	620557	4900073	2	0	0	0	0	0	0	4.5
183	620557	4900073	1	0	0	0	0	0	0	57
183	620557	4900073		0	0	0	0	0	0	30.75
184	620742	4900125	1	0	0	0	0	0.5	0.5	53
184	620742	4900125	2	0	0	0	0	4	0	110
184	620742	4900125		0	0	0	0	2.25	0.25	81.5
191	620422	4900781	1	0	0	0	0	0	0	31
191	620422	4900781	2	0	0	0	0	0	0	24
191	620422	4900781		0	0	0	0	0	0	27.5
203	620392	4901504	1	0	0	0	0	0	0	0
203	620392	4901504	2	0	0	0	0	0	0	0
203	620392	4901504		0	0	0	0	0	0	0
212	620059	4902281	1	0	0	0	0	0	0	77
212	620059	4902281	2	0	0	0	0	0	0	47
212	620059	4902281		0	0	0	0	0	0	62
213	620007	4902229	1	0	0	0	0	0	0	0
213	620007	4902229	2	0	0	0	0	0	0	11
213	620007	4902229		0	0	0	0	0	0	5.5
214	619885	4902104	1	0	0	0	0	0	0	0
214	619885	4902104	2	0	0	0	0	0	0	0
214	619885	4902104		0	0	0	0	0	0	0
222	619381	4902617	1	0	0	0	0	0	0	100
222	619381	4902617	2	0	0	0	0	0	0	40
222	619381	4902617		0	0	0	0	0	0	70
223	619360	4902580	1	0	0	0	0	0	0	14
223	619360	4902580	2	0	0	0	0	0	0	54
223	619360	4902580		0	0	0	0	0	0	34
224	619299	4902470	1	0	0	0	0	0	0	0
224	619299	4902470	2	0	0	0	0	0	0	0
224	619299	4902470		0	0	0	0	0	0	0
501	616941	4902550	1	0	0	0	0	0	0	39
501	616941	4902550	2	0	0	0	0	0	0	2
501	616941	4902550		0	0	0	0	0	0	20.5
504	617838	4901285	1	0	0	0	0	0	0	102

Station #	X	Y	Reps	Wet Weight						Total
				P. Crispus	Najas Flexis	Sheathed Pondweed	Sago Pondweed	Horned Pondweed	Water Thread pondweed	
504	617838	4901285	2	0	0	0	0	0	0	10
504	617838	4901285		0	0	0	0	0	0	56
505	617904	4901162	1	0	0	0	0	0	0	0
505	617904	4901162	2	0	0	0	0	0	0	0
505	617904	4901162		0	0	0	0	0	0	0
506			1	0	0	0	0	0	0	23
506			2	0	0	0	0	0	0	17
506				0	0	0	0	0	0	20
507	618010	4900597	1	0	0	0	0	0	0	0
507	618010	4900597	2	0	0	0	0	0	0	14
507	618010	4900597		0	0	0	0	0	0	7
509	617948	4899031	1	0	0	0	0	0	0	30
509	617948	4899031	2	0	0	0	0	0	0	9
509	617948	4899031		0	0	0	0	0	0	19.5
510	618553	4898470	1	0	0	0	0	0	0	1
510	618553	4898470	2	0	0	0	0	0	0	0
510	618553	4898470		0	0	0	0	0	0	0.5
601	620163	4896051	1	0	0	0	0	0	0	445
601	620163	4896051	2	0	0	0	0	0	0	353
601	620163	4896051		0	0	0	0	0	0	399
602	618763	4896368	1	0	0	0	0	0	0	108
602	618763	4896368	2	0	0	0	0	0	0	292.5
602	618763	4896368		0	0	0	0	0	0	200.25
603	621950	4897603	1	0	0	0	0	0	0	128
603	621950	4897603	2	0	0	0	0.5	0	0	73.5
603	621950	4897603		0	0	0	0.25	0	0	100.75
604	621815	4897693	1	0	0	0	0	0	0	400
604	621815	4897693	2	0	0	0	0	0	0	138
604	621815	4897693		0	0	0	0	0	0	269
610	621684	4896424	1	0	0	0	0	0	0	255
610	621684	4896424	2	0	0	0	0	0	0	242
610	621684	4896424		0	0	0	0	0	0	248.5
611	620301	4898122	1	0	0	0	0	0	4	89.5
611	620301	4898122	2	0	0	0	0	0	0	22

Station #	X	Y	Reps	Wet Weight						Total
				P. Crispus	Najas Flexis	Sheathed Pondweed	Sago Pondweed	Horned Pondweed	Water Thread pondweed	
611	620301	4898122		0	0	0	0	0	2	55.75
612	619164	4897990	4	0	0	0	0	0	0	0
612	619164	4897990	2	0	0	0	0	0	5	8.5
612	619164	4897990		0	0	0	0	0	2.5	4.25
613	619455	4902699	1	0	0	0	0	0	0	216
613	619455	4902699	2	0	0	0	0	0	0	251
613	619455	4902699		0	0	0	0	0	0	233.5
614	619552	4902770	1	0	0	0	0	0	0	19
614	619552	4902770	2	9	0	0	0	0	0	44
614	619552	4902770		4.5	0	0	0	0	0	31.5
615	620222	4902387	1	0	0	0	0	0	0	68.5
615	620222	4902387	2	0	0	0	0	0	0	83
615	620222	4902387		0	0	0	0	0	0	75.75
616	620321	4902469	1	0	0	0	0	0	0	39.5
616	620321	4902469	2	0	0	0	0	0	0	64
616	620321	4902469		0	0	0	0	0	0	51.75
617	620602	4900830	1	0	0	0	0	0	0	3
617	620602	4900830	2	0	0	0	0	0	0	101
617	620602	4900830		0	0	0	0	0	0	52
618	620685	4901631	1	0	0	0	0	0	0	0
618	620685	4901631	2	0	3	0	0	0	0	29
618	620685	4901631		0	1.5	0	0	0	0	14.5
619	620551	4900829	1	0	0	0	0	0	0	48
619	620551	4900829	2	0	0	0	0	0	0	249
619	620551	4900829		0	0	0	0	0	0	148.5
620	620450	4897505	1	0	0	0	0	2	0.5	108.5
620	620450	4897505	2	0	0	0	0	0.5	3	141
620	620450	4897505		0	0	0	0	1.25	1.75	124.75
621	619149	4899025	1	0	0	0	0	0	0	80
621	619149	4899025	2	0	0	0	0	0	0	17
621	619149	4899025		0	0	0	0	0	0	48.5
622	618458	4898959	1	0	0	0	0	0	0	0
622	618458	4898959	2	0	0	0	0	0	0	0
622	618458	4898959		0	0	0	0	0	0	0

Station #	X	Y	Reps	Wet Weight						Total
				P. Crispus	Najas Flexis	Sheathed Pondweed	Sago Pondweed	Horned Pondweed	Water Thread pondweed	
623	620157	4899329	1	0	0	0	0	0	0	0
623	620157	4899329	2	0	0	0	0	0	0	0
623	620157	4899329		0	0	0	0	0	0	0
624	620485	4899401	1	0	0	0	0	0	0	0
624	620485	4899401	2	0	0	0	0	0	0	44
624	620485	4899401		0	0	0	0	0	0	22
625	621127	4899502	1	0	0	0	0	0	0	277
625	621127	4899502	2	0	0	0	0	0	0	315
625	621127	4899502		0	0	0	0	0	0	296
626	621347	4899551	1	0	0	0	0	0	0	630
626	621347	4899551	2	0	0	0	0	0	0	153
626	621347	4899551		0	0	0	0	0	0	391.5
627	621561	4899601	2	0	0	0	0	0	0	58
627	621561	4899601	1	0	0	2	0	0	0	83
627	621561	4899601		0	0	1	0	0	0	70.5
628	620391	4899972	1	0	0	0	0	0	3	37
628	620391	4899972	2	0	0	0	0	0	0	183
628	620391	4899972		0	0	0	0	0	1.5	110
629	620294	4899179	2	0	0	0	0	0	0	2
629	620294	4899179	1	0	0	0	0	0	0	0
629	620294	4899179		0	0	0	0	0	0	1

(shaded) biomass averages

Appendix 3

Supporting Environmental Data

Station #	Depth 1	Notes	Depth 2	D.O.	Conductivity (1)	Conductivity (2)	pH	Temp
401	Surface		0.5	11.37	364	340	8.05	21.35
402	Surface		0.5	14.20	374	351	8.62	21.86
403	Surface		0.5	13.04	362	340	8.9	21.92
404	Surface		0.5	10.74	330	317	8.7	22.88
405	Surface		0.5	11.25	327	316	8.52	23.13
406	Surface		0.5	11.87	319	307	8.42	23.12
407	Surface		0.5	13.30	335	327	8.17	23.79
408	Surface		0.5	15.68	333	322	8.19	23.33
505	Surface		0.5	9.19	372	351	7.8	22.09
505	1m Off Bottom		8	9.09	372	350	7.3	21.98
504	Surface		0.5	9.14	372	351	7.78	22.08
504	1m Off Bottom		5.3	8.86	372	350	7.75	21.94
25	Surface	No Sample						
23	Surface		0.5	8.67	372	351	7.72	22.13
15	Surface		0.5	9.07	373	352	7.79	22.06
15	1m Off Bottom		4.5	8.94	371	348	7.77	21.74
502	Surface		0.5	9.20	372	351	7.81	22.06
502	1m Off Bottom		7	8.17	372	350	7.79	21.97
14	Surface		0.5	9.16	372	349	7.77	21.78
14	Bottom		2.6	9.92	369	344	7.82	21.38
13	Surface		0.5	9.41	369	345	7.8	21.63
13	1m Off Bottom		2	9.83	365	341	7.85	21.45
12	Surface		0.5	10.02	365	340	7.82	21.37
11	Surface		0.5	10.10	364	338	7.83	21.31
5	Surface		0.5	8.87	373	348	7.67	21.51
5	1m Off Bottom		3	8.16	373	348	7.68	21.57
4	Surface		0.5	8.76	371	346	7.72	21.52
4	1m Off Bottom		2	8.70	371	347	7.71	21.51
1	Surface		0.5	8.05	353	344	8.05	23.6
30	Surface		0.5	10.73	369	361	7.92	23.94
3	Surface	No Sample						
2	Surface		0.5	9.15	367	341	7.71	21.24
2	1m Off Bottom		2	9.27	366	339	7.71	21.13
22	Surface		0.5	8.86	371	350	7.71	22.09
22	1m Off Bottom		1.5	8.82	371	350	7.72	22.09
21	Surface		0.5	8.86	372	351	7.72	22.08
21	1m Off Bottom		2.5	8.90	372	351	7.74	22.06
501	Surface		0.5	9.06	372	350	7.78	21.87
501	1m Off Bottom		5	8.95	372	350	7.79	21.81
502	Surface		0.5	9.05	372	350	7.8	21.92
502	1m Off Bottom		7	9.00	372	350	7.8	21.82
603	Surface		0.5	11.71	325	307	8.2	22.38
603	1m Off Bottom		1	12.40	325	307	8.3	22.17
604	Surface		0.5	11.50	315	295	8.3	22.02
604	1m Off Bottom		2	11.29	315	295	8.37	21.67
203	Surface		0.5	10.07	370	355	7.9	22.72
203	1m Off Bottom		6	8.73	369	348	7.86	21.96
617	Surface		0.5	9.82	369	353	7.88	22.73
617	1m Off Bottom		4	10.51	366	347	7.9	22.23

Station #	Depth 1	Notes	Depth 2	D.O.	Conductivity (1)	Conductivity (2)	pH	Temp
616	Surface		0.5	11.93	361	346	7.97	22.91
619	Surface		0.5	9.92	364	352	7.9	23.24
619	1m Off Bottom		3	11.58	356	337	7.99	22.17
191	Surface		0.5	9.78	369	354	7.88	22.93
191	1m Off Bottom		4	10.73	369	354	7.95	22.13
615	Surface		0.5	10.82	365	349	7.92	22.61
615	1m Off Bottom		2	12.06	361	342	7.98	22.38
212	Surface		0.5	10.17	370	351	7.9	22.46
212	1m Off Bottom		4	10.05	364	343	7.91	21.97
222	Surface		0.5	10.31	368	349	7.9	22.39
222	1m Off Bottom		3.5	11.27	363	341	7.94	21.94
613	Surface		0.5	10.63	367	349	7.92	22.45
613	1m Off Bottom		3	13.43	356	336	8.05	21.94
614	Surface		0.5	13.74	359	345	8.08	22.94
130	Surface		0.5	11.73	331	314	8.46	22.15
130	1m Off Bottom		2	12.12	330	310	8.65	21.59
610	Surface		0.5	10.92	335	316	8.33	22.21
610	1m Off Bottom		2	12.56	333	312	8.44	21.7
612	Surface		0.5	9.74	370	357	7.95	23.14
612	1m Off Bottom		4	9.87	366	347	7.91	22.23
611	Surface		0.5	10.12	362	349	7.97	23.03
611	1m Off Bottom		3	11.07	360	339	8	22.06
214	Surface		0.5	10.29	370	353	7.95	22.64
214	1m Off Bottom		8	3.51	381	357	7.02	21.73
213	Surface		0.5	10.65	368	351	7.89	22.75
213	1m Off Bottom		5	9.15	368	346	7.84	21.92
223	Surface		0.5	10.30	369	349	7.92	22.19
223	1m Off Bottom		3.5	10.95	366	344	7.93	21.85
224	Surface		0.5	9.87	370	351	7.91	22.34
224	1m Off Bottom		5	9.47	369	347	7.86	21.87
618	Surface		0.5	9.72	366	352	7.89	22.87
71	Surface		0.5	8.70	361	355	7.7	22.71
71	1m Off Bottom		5.3	5.34	374	355	7.7	22.22
72	Surface		0.5	11.40	365	348	8.03	22.55
72	1m Off Bottom		2.5	11.28	361	344	8.07	22.52
73	Surface		0.5	12.88	341	325	8.14	22.64
73	1m Off Bottom		1.5	12.75	341	325	8.13	22.61
74	Surface		0.5	13.60	331	318	8.22	22.92
74	1m Off Bottom		0.8	13.42	331	318	8.18	22.93
75	Surface		0.5	11.99	334	322	8.13	23.09
64	Surface		0.5	12.81	328	316	8.15	23
65	Surface		0.5	12.84	328	320	8.17	23.54
63	Surface		0.5	11.20	358	342	8.01	22.6
63	1m Off Bottom		1.5	11.54	358	342	8	22.58
62	Surface		0.5	10.51	366	349	7.9	22.54
62	1m Off Bottom		2.5	10.50	366	348	7.92	22.53
44	Surface		0.5	14.39	329	314	8.07	22.61
43	Surface		0.5	13.05	347	330	8.11	22.35
43	1m Off Bottom		1.5	13.13	347	329	8.13	22.36

Station #	Depth 1	Notes	Depth 2	D.O.	Conductivity (1)	Conductivity (2)	pH	Temp
508	Surface		0.5	9.62	371	353	7.88	22.35
508	1m Off Bottom		5.5	9.63	366	346	7.91	22.04
41	Surface		0.5	10.41	369	351	7.97	22.38
41	1m Off Bottom		1.3	10.31	366	348	8.01	22.33
35	Surface		0.5	11.91	357	341	7.82	22.58
34	Surface		0.5	12.23	358	341	7.88	22.45
32	Surface		0.5	11.52	362	344	7.89	22.33
32	1m Off Bottom		1.3	11.41	362	344	7.3	22.32
33	Surface		0.5	12.12	360	342	7.91	22.3
33	1m Off Bottom		1	12.21	360	342	7.9	22.4
31	Surface		0.5	9.57	369	349	7.87	22.19
31	1m Off Bottom		2.3	10.02	370	350	7.83	22.19
30	Surface		0.5	9.21	370	349	7.81	22.17
30	1m Off Bottom		5.5	9.15	371	352	7.82	22
507	Surface		0.5	8.49	370	349	7.72	21.99
507	1m Off Bottom		7.5	8.53	370	349	7.77	22.25
45	Surface	No Sample						
51	Surface		0.5	13.69	308	299	8.19	23.45
52	Surface		0.5	14.56	315	303	8.29	23.04
53	Surface		0.5	13.71	342	327	8.17	22.68
53	1m Off Bottom		1	13.49	341	326	8.21	22.71
54	Surface		0.5	10.46	368	351	7.96	22.51
54	1m Off Bottom		1.5	11.14	366	348	8.02	22.41
509	Surface		0.5	8.47	371	354	7.81	22.47
509	1m Off Bottom		7.5	3.43	371	351	7.72	22.18
55	Surface		0.5	9.32	371	353	7.86	22.46
55	1m Off Bottom		4.5	4.29	366	346	7.84	22.26
510	Surface		0.5	9.23	371	354	7.81	22.57
510	1m Off Bottom		7.5	6.57	372	352	7.76	22.22
61	Surface		0.5	9.40	371	354	7.84	22.52
61	1m Off Bottom		4.5	9.54	371	352	7.84	22.3
128	Surface		0.5	14.10	342	328	8.99	23.27
128	1m Off Bottom		1	12.90	342	318	8.99	21.21
135	Surface		0.5	10.65	323	306	8.44	22.37
135	1m Off Bottom		2	11.68	322	303	8.62	21.94
141	Surface		0.5	9.87	335	320	8.2	22.64
141	1m Off Bottom		2	11.46	331	311	8.39	21.92
163	Surface		0.5	9.42	362	345	7.9	22.48
163	1m Off Bottom		3	10.07	360	339	7.95	21.97
179	Surface		0.5	9.48	363	347	7.9	22.51
179	1m Off Bottom		5	6.67	366	346	7.69	22.1
155	Surface		0.5	9.37	333	316	8.16	22.29
155	1m Off Bottom		2.5	8.32	338	316	8.04	21.74
154	Surface		0.5	10.70	311	397	8.29	22.69
154	1m Off Bottom		2.5	11.90	309	290	8.5	21.74
150	Surface		0.5	10.76	315	300	8.27	22.44
150	1m Off Bottom		1	11.92	316	298	8.6	21.95
160	Surface		0.5	10.43	324	308	8.16	22.27
160	1m Off Bottom		1	10.82	325	308	8.19	22.31

Station #	Depth 1	Notes	Depth 2	D.O.	Conductivity (1)	Conductivity (2)	pH	Temp
161	Surface		0.5	11.03	312	295	8.18	22.16
161	1m Off Bottom		2	12.03	311	291	8.23	21.87
162	Surface		0.5	11.52	331	313	8.05	22.08
162	1m Off Bottom		2	11.99	329	309	8.16	21.85
149	Surface		0.5	10.58	323	304	8.42	22.03
149	1m Off Bottom		2	11.14	323	301	8.55	21.48
148	Surface		0.5	9.78	325	309	8.29	22.55
148	1m Off Bottom		2.5	9.95	323	302	8.33	21.66
144	Surface		0.5	9.83	356	342	8.01	22.91
144	1m Off Bottom		3	10.80	357	336	8.03	22.02
132	Surface		0.5	10.33	324	310	8.24	22.58
132	1m Off Bottom		2	11.87	324	303	8.57	21.6
622	Surface		0.5	7.34	372	351	7.71	22.04
622	1m Off Bottom		7	1.34	373	352	7.54	21.89
621	Surface		0.5	8.93	372	350	7.76	21.69
621	1m Off Bottom		5	6.63	371	351	7.64	22.01
94	Surface		0.5	9.17	368	346	7.76	21.86
94	1m Off Bottom		5	8.92	368	346	7.77	21.95
90	Surface		0.5	9.23	372	349	7.78	21.77
90	1m Off Bottom		5.5	3.15	381	354	7.62	21.69
90	Bottom		6	1.64	382	356	7.52	21.68
99	Surface		0.5	9.38	360	337	7.77	21.69
99	1m Off Bottom		3	9.22	359	337	7.8	21.77
96	Surface		0.5	9.21	364	341	7.76	21.7
96	1m Off Bottom		4.5	8.64	363	341	7.75	21.84
107	Surface		0.5	9.48	339	316	7.9	21.45
107	1m Off Bottom		2	9.48	339	316	7.95	21.51
119	Surface		0.5	10.71	328	302	8.16	21.28
119	1m Off Bottom		2	10.69	325	302	8.22	21.29
601	Surface		0.5	10.46	324	298	8.36	20.76
601	1m Off Bottom		1	10.61	325	299	8.44	20.85
104	Surface		0.5	10.69	341	316	8.1	21.12
104	1m Off Bottom		1.5	10.52	341	316	8.07	21.17
100	Surface		0.5	9.92	357	333	7.95	21.5
100	1m Off Bottom		2	9.76	355	332	7.95	21.57
112	Surface		0.5	12.02	327	300	8.22	20.68
112	1m Off Bottom		1	11.88	327	301	8.31	20.73
102	Surface		0.5	9.36	360	337	7.97	21.58
102	1m Off Bottom		2	9.32	360	337	7.91	21.61
97	Surface		0.5	9.24	363	341	7.84	21.84
97	1m Off Bottom		3.2	9.16	363	342	7.84	21.86
82	Surface		0.5	10.88	333	312	8.02	21.69
82	1m Off Bottom		1.5	11.24	332	311	8.11	21.68
83	Surface		0.5	10.12	335	313	8.01	21.57
83	1m Off Bottom		1	10.32	335	313	8.07	21.53
80	Surface		0.5	9.30	365	343	7.82	21.84
80	1m Off Bottom		3.5	9.13	365	343	7.81	21.86
81	Surface		0.5	10.29	350	327	7.91	21.68
81	1m Off Bottom		2	10.70	349	327	7.97	21.68

Station #	Depth 1	Notes	Depth 2	D.O.	Conductivity (1)	Conductivity (2)	pH	Temp
110	Surface		0.5	10.49	328	302	8.26	20.9
602	Surface		0.5	10.59	346	321	8.13	21.24
602	1m Off Bottom		1.75	10.20	346	321	8.16	21.25
623	Surface		0.5	9.61	371	348	7.85	21.88
623	1m Off Bottom		7.5	6.38	369	348	7.77	21.95
620	Surface		0.5	10.14	355	332	7.84	21.55
620	1m Off Bottom		1.5	9.54	355	332	7.87	21.7
628	Surface		0.5	10.07	368	346	7.85	21.87
628	1m Off Bottom		5.5	9.37	368	346	7.82	21.94
629	Surface		0.5	10.23	369	347	7.88	21.86
629	1m Off Bottom		7.5	9.10	369	348	7.79	21.92
184	Surface		0.5	10.95	356	333	7.89	21.67
627	Surface		0.5	10.46	349	326	7.99	21.6
182	Surface		0.5	9.77	368	346	7.84	21.97
182	1m Off Bottom		3.5	9.38	367	346	7.84	22.03
183	Surface		0.5	10.14	365	342	7.87	21.8
183	1m Off Bottom		2.5	10.03	363	341	7.88	21.84
626	Surface		0.5	12.52	344	321	7.99	21.64
626	1m Off Bottom		1.5	12.45	341	320	8.08	21.68
625	Surface		0.5	10.98	356	333	7.9	21.68
625	1m Off Bottom		2	10.97	355	333	7.93	21.74
171	Surface		0.5	9.48	364	341	7.85	21.74
171	1m Off Bottom		2	9.25	362	340	7.88	21.94
624	Surface		0.5	9.42	368	346	7.83	21.77
624	1m Off Bottom		4.5	8.12	369	347	7.81	21.95

Mean	10.19	354	335	7.98	22.10
Max	15.68	382	397	8.99	23.94
Min	1.34	308	290	7.02	20.68
Standard Deviation	2.01	19	18	0.27	0.56

Appendix 3 - Sediment Characteristics

Station #	Sediment
408	-
407	-
406	-
405	-
404	-
403	-
402	-
401	-
1	-
30A	-
30B	clay / silt / sand
502A	silt / clay (soft)
501	silt / clay
502B	clay (soft) / silt
504	
505	clay / silt
25	-
23	sand / clay
15	silt / clay
14	clay / silt / sand
13	clay / silt / sand
12	sand / silt
11	clay / silt / sand
5	silt / clay
4	silt / clay
3	-
2	sand / silt
22	silt / clay
21	sand / silt
604	clay
153	-
152	-
603	clay / sand
204	-
201	-
202	-
203	
617	-
616	-
191	
619	-
212	
615	-
211	-
222	clay / silt
613	clay / sand

Station #	Sediment
221	-
614	sand
137	-
610	clay
130	sand / clay
611	-
612	clay / silt / sand
214	clay
213	
224	
223	
144	clay / sand
132	clay / sand
148	sand / silt
149	
161	
162	clay / sand
150	
160	
155	clay / sand
154	clay / sand
163	clay / sand
179	clay / silt
135	clay / sand
141	
128	sand / clay
510	clay
61	sand / silt / clay
509	-
55	clay / silt
53	clay / silt
54	silt / clay
52	clay / silt
51	-
507	clay / silt
45	-
31	clay (soft)
32	-
33	silt / clay
34	-
35	-
41	clay / silt
508	clay
44	-
43	clay / silt
62	sand / silt / clay

Station #	Sediment
63	clay / silt / sand
64	caly / silt
65	clay / silt
71	clay (soft)
72	sand / clay
73	sand / clay
74	sand / clay
75	clay / silt
618	sand
624	clay / silt
171	clay
626	clay / silt / sand
625	clay / silt
182	clay / silt
183	clay (soft)
184	clay / silt
627	sand / silt / clay
628	clay / silt
629	clay / sand
623	clay (soft) / silt
620	clay / silt
602	silt
87	-
110	clay / silt
80	clay / silt
81	clay / sand
82	
83	clay / sand
102	clay / sand
97	clay / sand
100	clay / sand
112	clay / silt
601	clay / sand
123	-
104	clay / sand
107	clay / sand
119	clay / sand
99	clay
96	silt / clay
94	clay / silt
90	clay / silt
622	clay (soft) / sand / silt
621	clay / sand / silt

Appendix 4

Photos

Photo 1: Clasped Leaved Pondweed (*Potomogeton richardsonii*)

Photo 2: Eurasian Water Milfoil (*Myriophyllum spicatum*)

Photo 3: Tape Grass (*Vallisneria spiralis*),

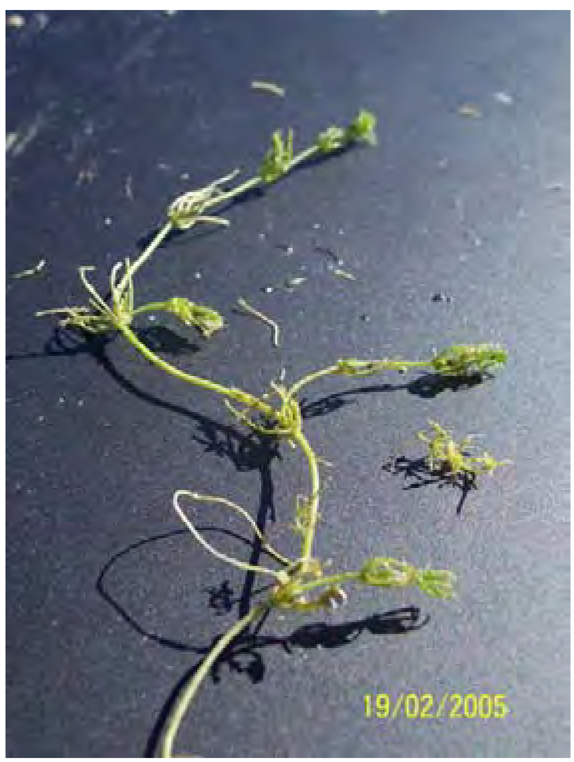

Photo 4: Chara (*Chara spp.*)

Photo 5: Elodea (*Elodea canadensis*)

Photo 6: Emergent Vegetation

Photo 7: Emergent Vegetation

Photo 8: Emergent Vegetation

Photo 9: Emergent Vegetation

Photo 10: Emergent Vegetation

Photo 11: Emergent Vegetation

Photo 12: Emergent Vegetation


Photo 13: Emergent Vegetation

Photo 14: Emergent Vegetation

Photo 15: Floating mass of macrophytes

Photo 16: Floating mass of macrophytes

Photo 17: Under water field of macrophytes

Photo 18: Under water field of macrophytes

Photo 19: Macrophyte sample in rinse bag

Photo 20: Macrophyte sample in ponar grab

Photo 21: Ponar grab

Photo 22: Macrophyte sample, with sediment

Photo 23: Macrophyte sample

Photo 24: Macrophyte sample, in bags

Photo 25 and 26: Boat used for sampling.

Photo 27. Tapegrass with attached zebra mussel.

Photos 28 and 29. Weed harvesters

Appendix 5

Brief Biology of Plants Found in Cooks Bay

Chara (C*hara spp.*), occasionally called stonewort or muskgrass, is most often found in areas with hard water, sandy or muddy substrates, and can sometimes inhabit deeper waters (Borman, 1997). Chara is a favorite food for many waterfowl, and can offer feeding and habitat for many invertebrate and fish, specifically young trout, largemouth and smallmouth bass (Borman, 1997).

Clasped-leaved Pondweed (*Potamogeton richardsonii*) often found growing with Coontail, prefers a variety of sediments with a range of up to 4 meters in depth, and is quite tolerant of disturbance. Numerous ducks and geese eat the fruit produced by *P. richardsonii*, and muskrat, deer, beaver and moose also graze on this particular plant (Borman, 1997). Flat stem pondweed (*Potamogeton zosteriformis*), usually found in softer sediments, has a wide range of depths in which it can grow. This plant is also a good source of food and shelter and food for fish and invertebrates, and is a source of food for waterfowl and local mammals populations, such as deer, moose, muskrat and beaver (Borman, 1997). While these two species of *Potamogeton* have a wide range of distribution, with populations extending across North America. While the northern limit extends up into Alaska, Yukon and Northwest Territories the southern distribution only reaches as far as Michigan, Ohio, northern California (*P. zosteriformis*) and Colorado (*P. richardsonii*) (Flora of North America, 2000). While the distribution is wide it is not continuous but rather in patches throughout this area.

Coontail (*Ceratophyllum demersum*), is not a rooted plant and therefore can drift between different depth zones. It has a tolerance for lower light conditions and can grow in up to several meters of water. Coontail is grazed by a variety of waterfowl, and provides food and shelter for invertebrates and fish (Borman, 1997). Coontail by far has the widest distribution of the species observed in Cook's Bay, extending across North America from coast to coast and reaching as north as Alaska and southern Yukon and Northwest Territories (Flora of North America, 1997).

Elodea canadensis, commonly known as Canadian Waterweed, occurs in areas with slow moving water, such as ponds, canals and lakes and can be found in a range of depths from ankle deep to several meters. Elodea can offer valuable shelter and feeding opportunities for various fish and invertebrate species. Elodea is also a food provider for muskrat and duck populations (Borman, 1997). *E. canadensis* does not extend as far north or south as the previous species discussed, but remains within a more moderate climate zone extending between northern Ontario and down to Tennessee (Flora of North America, 2000).

Tape-grass (*Vallisneria americana*), or sometimes referred to as eel-grass or wild celery, prefers still and fast-flowing waters, with firm substrates. It is tolerant in a wide range of water chemistries as well as turbidity and ranges from several centimeters to several meters. Tape grass is a submersed plant, which spreads by runners, and sometimes forms tall underwater meadows. Of all the native macrophyte species, *V. americana* has the smallest range not extending any further west than Minnesota / southeastern Manitoba and reaching only as far north as Lake Superior/Quebec City, however it does extend as far south as Florida (Flora of North America, 2000).

Eurasian Water Milfoil (*Myriophyllum spicatum*) is an exotic, invasive species originating in Europe and Asia. It was thought that Eurasian Water Milfoil was introduced to North America during the late 1800s but was not positively until identified by Couch and Nelson in 1942 (Couch and Nelson 1985). Since that time, Eurasian milfoil has become the most widely distributed invasive aquatic plant species. Presently, it is found in 44 of the lower 48 states (U.S. Geological Survey (USGS) 1997) and several Canadian provinces from Quebec to British Columbia (Aiken, Newroth, and Wile 1979; Couch and Nelson 1985). This species of milfoil is generally found in 1 to 4 m of water, and prefers fine textured, inorganic sediment, but can grow in a variety of other sediments as well (Barko and Smith, 1986). Higher water temperatures and lower light helps to encourage canopy formation (Borman, 1997). While grazing by waterfowl is limited, *M. spicatum* offers habitat for invertebrates, and when combined with *Vallisneria spiralis* can increase the total numbers and richness of the invertebrate community (Borman, 1997).

Stonewort produced the largest total biomass per unit area at a station, with a total average of 1041.6 g. Based on this number it could be concluded that Chara is has the greatest biomass within the Cook’s Bay area. However, its range is far less than that of either *Vallisneria americana*, which dominated the southern end of the bay, or coontail, which occupies the majority of the rest of the bay. *Potomogeton zosteriformis*, shares a similar trend as the latter two. Although the average mass collected (474.6 g) was not as great as Chara, the area in which it inhabits was much broader.