# BIG STAR LAKE 2013 ANNUAL PROGRESS REPORT

## AN ANNUAL ASSESSMENT OF
## AQUATIC VEGETATION AND WATER QUALITY IN
## BIG STAR LAKE
## LAKE COUNTY, MICHIGAN

DECEMBER, 2013

**Prepared for:** Lake Township/Big Star Lake Association
C/o Don Britten, Lake Township Supervisor
15580 S. Star Lake Rd
Baldwin, MI 49304

**Prepared by:** Restorative Lake Sciences
Jennifer Jermalowicz-Jones, PhD Candidate
18406 W. Spring Lake Rd.
Spring Lake, MI 49456
www.restorativelakesciences.com

## TABLE OF CONTENTS

**SECTION** **PAGE**

**FIGURES**

## TABLES

| NAME | PAGE |
| --- | --- |

**AN ANNUAL PROGRESS REPORT OF AQUATIC VEGETATION AND WATER QUALITY IN BIG STAR LAKE LAKE COUNTY, MICHIGAN**

**December, 2013**

---

## 1.0 EXECUTIVE SUMMARY

This report describes the current distribution of native and exotic submersed, floating-leaved, and emergent aquatic plants, including the exotic species, Eurasian Watermilfoil (*Myriophyllum spicatum;* EWM) within Big Star Lake, Lake County, Michigan. During the initial survey in 2009, Big Star Lake was infested with nearly 144 acres of EWM that was widely distributed throughout the lake. During the summer of 2010 these acres were successfully treated with systemic aquatic herbicides such as Triclopyr (Trade Name: Renovate OTF®) and also 2,4-D (Trade Name: Navigate®) both at 120 lbs per acre dose. A recent survey in late May of 2013 found 16 acres of EWM. These 16 acres were treated on May 24, 2013 with the systemic aquatic herbicide, Triclopyr (Renovate OTF®) at a dose of 160 lbs per acre. This dose was used to compensate for water depth and allow for a lethal plant dose. A final aquatic vegetation survey was conducted in mid-September. The final 2013 survey revealed the presence of only a few sprigs of EWM in the western canal of the lake. This is not uncommon since EWM colonizes disturbed habitats like canals very quickly. Big Star Lake currently has 24 native aquatic plant species which includes 15 submersed, 3 floating-leaved, and 6 emergent species.

Scientists at Restorative Lake Sciences will continue to oversee herbicide treatments and monitor the lake for EWM and any other exotic species that may invade the lake and also monitor any changes in the native aquatic vegetation communities.

The Secchi transparency in 2013 averaged 19.5 feet and nutrient levels such as phosphorus ranged from 0.019 mg $L^{-1}$ at the surface and 0.041 mg $L^{-1}$ at the bottom. Conductivity was low at 127-132 µmho $cm^{-1}$. The alkalinity was between 56-58 mg $L^{-1}$ $CaCO_3$ and pH ranged from 8.3-8.4. Dissolved oxygen levels continued to be high and were only slightly lower at the lake bottom during mid-September.

Phytoplankton communities within the lake appear to be balanced between the diatom and green-algae communities with little evidence of blue-green algae. Nutrient levels in the lake are still low enough to prevent excessive blue green algae blooms. Green algae and diatoms are the preferred food choices for zooplankton.

## 2.0 AQUATIC PLANT SURVEY METHODS

The aquatic plant sampling methods used for lake surveys of macrophyte communities commonly consist of shoreline surveys, visual abundance surveys, transect surveys, AVAS surveys, and Point-Intercept Grid surveys. The Michigan Department of Environmental Quality (MDEQ) prefers that an Aquatic Vegetation Assessment Site (AVAS) Survey, or a GPS Point-Intercept survey (or both) be conducted on most inland lakes following large-scale aquatic herbicide treatments to assess the changes in aquatic vegetation structure and to record the relative abundance and locations of native aquatic plant species. Due to the large size and shallow mean depth of Big Star Lake, a bi-seasonal GPS Point-Intercept grid matrix survey is conducted to assess all aquatic species, including emergent and floating-leaved species.

### 2.1 The GPS Point-Intercept Survey Method

While the MDEQ AVAS protocol considers sampling vegetation using visual observations in areas around the Big Star Lake littoral zone, the Point-Intercept Grid Survey method is meant to assess vegetation throughout the entire surface area of a lake (Madsen et *al*. 1994; 1996). This method involves conducting measurements at Global Positioning Systems (GPS)-defined locations. The points should be placed together as closely and feasibly as possible to obtain adequate information of the aquatic vegetation communities throughout the entire lake. At each GPS Point location, two rake tosses are conducted and the aquatic vegetation species presence and abundance are estimated. In between the GPS points, any additional species and their relative abundance are also recorded using visual techniques. This is especially important to add to the Point-Intercept method, since EWM and other invasive plants may be present between GPS points but not necessarily at the pre-selected GPS points. Once the aquatic vegetation communities throughout the lake have been recorded using the GPS points, the data can be placed into a Geographic Information System (GIS) software package to create maps showing the distribution and relative abundance of particular species. The GPS Point- Intercept method is particularly useful for monitoring aquatic vegetation communities through time and for identification of nuisance species that could potentially spread to other previously uninhabited areas of the lake.

The GPS Point-Intercept method surveys on May 24, 2013 and on September 11, 2013 consisted of 179 grid assessment points on Big Star Lake, using a Lowrance® 50-satellite GPS WAAS-enabled unit (accuracy within 2 feet). The lake bottom in the littoral (shallow) zone was scanned for aquatic vegetation biovolume with a Lowrance® side-scan and bottom-scan sonar unit. A combination of rake tosses and visual data accounted for each point and the distance between points for the survey.

## 3.0 AQUATIC PLANT SURVEY RESULTS FOR 2013

The 2013 aquatic vegetation surveys of Big Star Lake were necessary to record the relative abundance and locations of native aquatic plant species present and to record the current distribution of EWM within the lake.

### 3.1 Big star Lake Exotic Aquatic Plant Species

The May 24, 2013 survey detected significant beds of Southern Naiad (*Najas guadalupensis*), Northern Watermilfoil (*Myriophyllum sibiricum*), Variable-leaf (*Potamogeton gramineus*), Illinois Pondweed (*Potamogeton praelongus*), and Large-leaf Pondweed (*Potamogeton amplifolius*) were noted during that survey and also again during the mid-September survey.
In 2013, there were two invasive species present, including EWM (Figure 1) and Curly-leaf Pondweed (*Potamogeton crispus*; Figure 2). The latter was only found in late May and dies back naturally by early July. Exotic species found in Big Star Lake during 2013 are listed below in Table 1.

| ***Macrophyte Species and Code*** | ***Common Name*** | ***Plant Growth Form*** |
|---|---|---|
| *Myriophyllum spicatum,* 1 | Eurasian Watermilfoil | Submersed; Rooted |
| *Potamogeton crispus,* 2 | Curly-leaf Pondweed | Submersed; Rooted |
| *Phragmites australis,* 50 | Giant Common Reed | Emergent |
| | | |

Table 1. Exotic aquatic plant species present within or around Big Star Lake (May and September, 2013)

Figure 1. Eurasian Watermilfoil with seed head and lateral branches. *© RLS*

Figure 2. Curly-leaf Pondweed
*© RLS*

Figure 3. Phragmites
*© RLS*

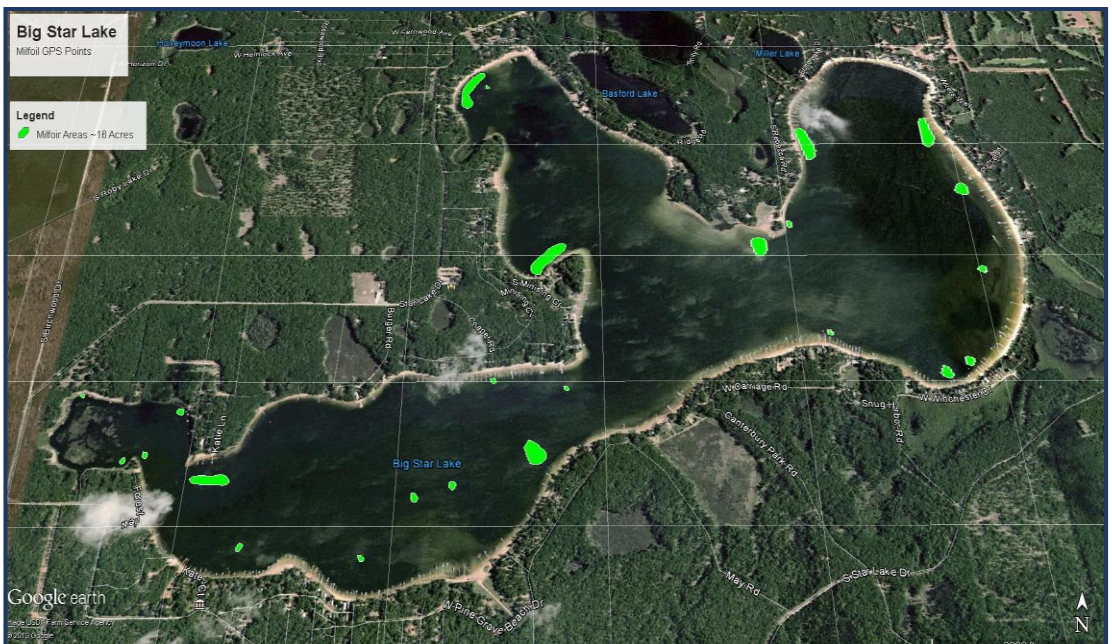


Figure 4. Aerial photo showing the EWM locations in Big Star Lake (May, 2013).

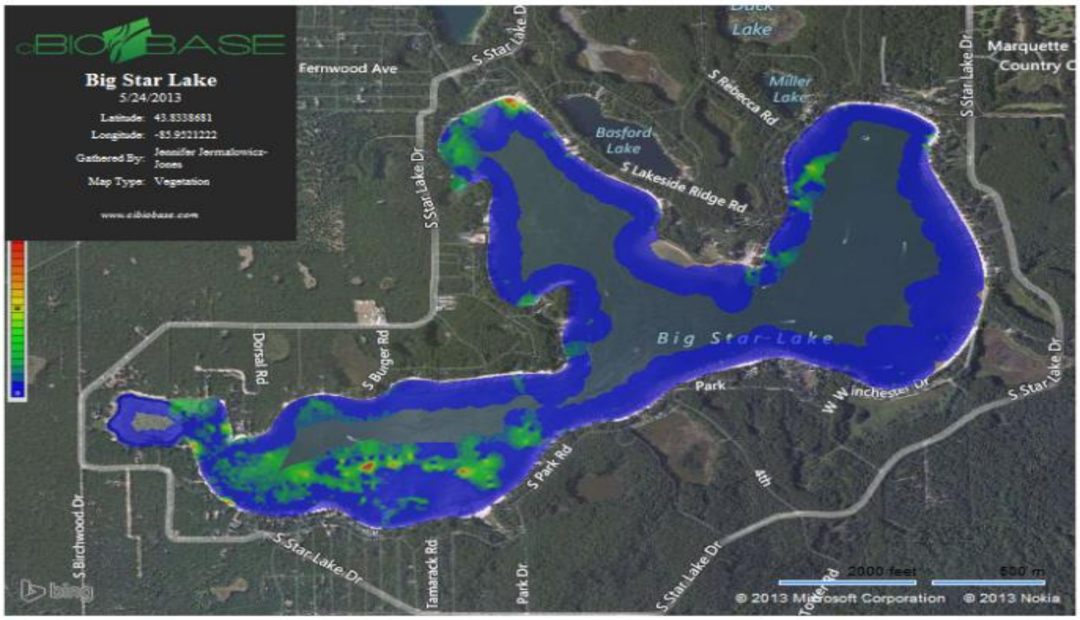


Figure 5. BioBase biovolume map showing low density vegetation areas in blue and green and high density areas in red and orange (May, 2013).

### 3.2 Big Star Lake Native Aquatic Plant Species

The native aquatic vegetation present in Big Star Lake has shown a significant re-bound in quantity since the EWM has been controlled. The May 24, 2013 survey revealed 15 submersed, 3 floating-leaved, and 6 emergent species for a total of 24 native species. This indicates a high biodiversity of aquatic vegetation in Big Star Lake. A few photographs of sparse species found in Big Star Lake can be found on page 13 (Figures 6-9) and common species are displayed on page 14 (Figures 10-13).

| ***Macrophyte Species and Code*** | ***Common Name*** | ***% Cover in Littoral (Shallow) Zone of Big Star Lake (2013)*** |
|---|---|---|
| *Chara vulgaris* (macroalga), 3 | Muskgrass | 7% |
| *Potamogeton pectinatus*, 4 | Thinleaf Pondweed | 14% |
| *Potamogeton zosteriformis*, 5 | Flatstem Pondweed | 3% |
| *Potamogeton gramineus*, 7 | Variable-leaved Pondweed | 11% |
| *Potamogeton praelongus*, 8 | White-Stemmed Pondweed | 21% |
| *Potamogeton illinoensis*, 10 | Illinois Pondweed | 12% |
| *Potamogeton amplifolius*, 11 | Large-leaf Pondweed | 15% |
| *Vallisneria americana,* 15 | Wild Celery | 15% |
| *Myriophyllum sibiricum*, 17 | Northern Watermilfoil | 19% |
| *Utricularia vulgaris*, 22 | Common Bladderwort | 13% |
| *Najas guadalupensis*, 25 | Southern Naiad | 22% |
| *Myriophyllum tenellum,*29 | Leafless Watermilfoil | 27% |
| *Nymphaea odorata*, 30 | White Waterlily | 3% |
| *Nuphar advena*, 31 | Yellow Waterlily | 5% |
| *Brasenia schreberi,* 32 | Watershield | 5% |
| *Typha latifolia*, 39 | Cattails | 7% |
| *Scirpus acutus*, 40 | Bulrushes | 12% |
| *Iris versicolor*, 41 | Blueflag Iris | 4% |
| *Decodon verticillatus*, 42 | Swamp Loosestrife | 3% |
| *Polygonum amphibium*, 44 | Water Smartweed | 1% |
| *Eriocaulon sp.,* 46 | Pipewort | 3% |
| | | |

Table 2. Native aquatic plant species found in and around Big Star Lake, 2013.

Figure 6. A photograph of White-stem Pondweed (*Potamogeton praelongus*) ©RLS

Figure 7. A photograph of Bladderwort (*Utricularia vulgaris*) ©RLS

Figure 8. A photograph of Wild Celery (*Vallisneria americana*) ©RLS

Figure 9. A photograph of Northern milfoil (*Myriophyllum sibiricum*) ©RLS

Figure 10. A photograph of a *Chara vulgaris*.

Figure 11. A photograph of Illinois Pondweed (*Potamogeton illinoensis*) ©RLS

Figure 12. A photograph of Southern Naiad (*Najas guadalupensis*) ©RLS

Figure 13. A photograph of Variable-leaf Pondweed (*Potamogeton gramineus*) ©RLS

## 4.0 BIG STAR LAKE 2013 WATER QUALITY RESULTS

The quality of water is highly variable among Michigan inland lakes, although some characteristics are common among particular lake classification types. The water quality of Big Star Lake is affected by both land use practices and climatic events. Climatic factors (i.e., spring runoff, heavy rainfall) June alter water quality in the short term; whereas, anthropogenic (man-induced) factors (i.e. shoreline development, lawn fertilizer use) alter water quality over longer time periods. Furthermore, lake water quality helps to determine the classification of particular lakes (Table 3). Lakes that are high in nutrients (such as phosphorus and nitrogen) and chlorophyll-*a*, and low in transparency are classified as **eutrophic**; whereas those that are low in nutrients and chlorophyll-*a*, and high in transparency are classified as **oligotrophic**. Lakes that fall in between these two categories are classified as **mesotrophic**. **Big Star Lake is classified as mesotrophic based on its moderate transparency and nutrient concentrations.**

| *Lake Trophic Status* | *Total Phosphorus (µg $L^{-1}$)* | *Chlorophyll-a (µg $L^{-1}$)* | *Secchi Transparency (feet)* |
|---|---|---|---|
| **Oligotrophic** | < 10.0 | < 2.2 | > 15.0 |
| **Mesotrophic** | 10.0 – 20.0 | 2.2 – 6.0 | 7.5 – 15.0 |
| **Eutrophic** | > 20.0 | > 6.0 | < 7.5 |

Table 3. Lake Trophic Status Classification Table (MDEQ)

### Big Star Lake Water Quality Parameters

Water quality parameters such as dissolved oxygen, water temperature, conductivity, turbidity, total dissolved solids, pH, total alkalinity, total phosphorus, total Kjeldahl nitrogen, and Secchi transparency, chlorophyll-*a*, among others, all respond to changes in water quality and consequently serve as indicators of water quality change. These parameters were collected at the central deep basin in early September during thermal stratification and are discussed below along with water quality data specific to Big Star Lake (Table 4 and assorted graphs).

### *Dissolved Oxygen*

Dissolved oxygen is a measure of the amount of oxygen that exists in the water column. In general, dissolved oxygen levels should be greater than 5 mg $L^{-1}$ to sustain a healthy warm-water fishery. Dissolved oxygen concentrations in Big Star Lake may decline if there is a high biochemical oxygen demand (BOD) where organismal consumption of oxygen is high due to respiration. Dissolved oxygen is generally higher in colder waters. Dissolved oxygen is measured in milligrams per liter (mg $L^{-1}$) with the use of a dissolved oxygen meter and/or through the use of Winkler titration methods. The September 4, 2013 dissolved oxygen concentrations in Big Star Lake were normal and lower with increased depth and ranged between 9.8 – 5.0 mg $L^{-1}$ from the surface to the bottom.

### *Water Temperature*

The water temperature of lakes varies within and among seasons and is nearly uniform with depth under winter ice cover because lake mixing is reduced when waters are not exposed to wind. When the upper layers of water begin to warm in the spring after ice-off, the colder, dense layers remain at the bottom. This process results in a "thermocline" that acts as a transition layer between warmer and colder water layers. During the fall season, the upper layers begin to cool and become denser than the warmer layers, causing an inversion known as "fall turnover". In general, lakes with deep basins will stratify and experience turnover cycles. Water temperature is measured in degrees Celsius (ºC) or degrees Fahrenheit (ºF) with the use of a submersible thermometer. The early September water temperatures of Big Star Lake demonstrated a thermocline between the surface and the bottom. Water temperatures ranged between 65.9 ºF at the surface and 51.6 ºF at the lake bottom.

***Conductivity***

Conductivity is a measure of the amount of mineral ions present in the water, especially those of salts and other dissolved inorganic substances. Conductivity generally increases as the amount of dissolved minerals and salts in a lake increases, and also increases as water temperature increases. Conductivity is measured in microsiemens per centimeter ($\mu S\ cm^{-1}$) with the use of a conductivity probe and meter. Conductivity values for Big Star Lake were low and ranged between 127 $\mu S\ cm^{-1}$ and 132 $\mu S\ cm^{-1}$. These values are significantly lower than other lakes in the state.

***Turbidity***

Turbidity is a measure of the loss of water transparency due to the presence of suspended particles. The turbidity of water increases as the number of total suspended particles increases. Turbidity may be caused from erosion inputs, phytoplankton blooms, stormwater discharge, urban runoff, re-suspension of bottom sediments, and by large bottom-feeding fish such as carp. Particles suspended in the water column absorb heat from the sun and raise the water temperature. Since higher water temperatures generally hold less oxygen, shallow turbid waters are usually lower in dissolved oxygen. Turbidity is measured in Nephelometric Turbidity Units (NTU's) with the use of a turbimeter. The World Health Organization (WHO) requires that drinking water be less than 5 NTU's; however, recreational waters may be significantly higher than that. The turbidity of Big Star Lake is low and ranged from 0.6 – 1.4 NTU's during the early September sampling event. The lake bottom is predominately sandy substrate with some marl and silt, which increases the turbidity values near the lake bottom.

***pH***

pH is the measure of acidity or basicity of water. The standard pH scale ranges from 0 (acidic) to 14 (alkaline), with neutral values around 7. Most Michigan lakes have pH values that range from 6.5 to 9.5. Acidic lakes (pH $< 7$) are rare in Michigan and are most sensitive to inputs of acidic substances due to a low acid neutralizing capacity (ANC). pH is measured with a pH electrode and pH-meter in

Standard Units (S.U). The pH of Big Star Lake water ranged from 8.3– 8.4 during the early September sampling. From a limnological perspective, Big Star Lake is considered “slightly basic” on the pH scale.

***Total Alkalinity***

Total alkalinity is the measure of the pH-buffering capacity of lake water. Lakes with high alkalinity (> 150 mg $L^{-1}$ of $CaCO_3$) are able to tolerate larger acid inputs with less change in water column pH. Many Michigan lakes contain high concentrations of $CaCO_3$ and are categorized as having “hard” water. Total alkalinity is measured in milligrams per liter of $CaCO_3$ through an acid titration method. The total alkalinity of Big Star Lake is considered “low” (< 150 mg $L^{-1}$ of $CaCO_3$), and indicates that the water is not hard or highly alkaline. Total alkalinity ranged from 56-58 mg $L^{-1}$ of $CaCO_3$ during the early September sampling period. Total alkalinity may change on a daily basis due to the re-suspension of sedimentary deposits in the water and respond to seasonal changes due to the cyclic turnover of the lake water.

***Total Phosphorus***

Total phosphorus (TP) is a measure of the amount of phosphorus (P) present in the water column. Phosphorus is the primary nutrient necessary for abundant algae and aquatic plant growth. Lakes which contain greater than 20 µg $L^{-1}$ of TP are defined as eutrophic or nutrient-enriched. TP concentrations are usually higher at increased depths due to higher release rates of P from lake sediments under low oxygen (anoxic) conditions. Phosphorus may also be released from sediments as pH increases. Total phosphorus is measured in micrograms per liter (µg $L^{-1}$) with the use of a chemical autoanalyzer. The total phosphorus (TP) concentration for the Big Star Lake deep basin sampling site in early September was 0.019 mg $L^{-1}$ at the surface and 0.041 mg $L^{-1}$ at the bottom.

***Total Kjeldahl Nitrogen***

Total Kjeldahl Nitrogen (TKN) is the sum of nitrate ($NO_3^-$), nitrite ($NO_2^-$), ammonia ($NH_4^+$), and organic nitrogen forms in freshwater systems. Much nitrogen (amino acids and proteins) also comprises the bulk of living organisms in an aquatic ecosystem. Nitrogen originates from atmospheric inputs (i.e. burning of fossil fuels), wastewater sources from developed areas (i.e. runoff from fertilized lawns), agricultural lands, septic systems, and from waterfowl droppings. It also enters lakes through groundwater or surface drainage, drainage from marshes and wetlands, or from precipitation (Wetzel, 2001). In lakes with an abundance of nitrogen (N: P > 15), phosphorus may be the limiting nutrient for phytoplankton and aquatic macrophyte growth. Alternatively, in lakes with low nitrogen concentrations (and relatively high phosphorus), the blue-green algae populations June increase due to the ability to fix nitrogen gas from atmospheric inputs. Lakes with a mean TKN value of 0.66 mg $L^{-1}$ may be classified as oligotrophic, those with a mean TKN value of 0.75 mg $L^{-1}$ may be classified as mesotrophic, and those with a mean TKN value greater than 1.88 mg $L^{-1}$ may be classified as eutrophic. The TKN values in Big Star Lake ranged between 0.50 – 0.70 mg $L^{-1}$ in 2013, which fall in the oligotrophic range.

***Secchi Transparency***

Secchi transparency is a measure of the clarity or transparency of lake water, and is measured with the use of an 8-inch diameter standardized Secchi disk. Secchi disk transparency is measured in feet (ft) or meters (m) by lowering the disk over the shaded side of a boat around noon and taking the mean of the measurements of disappearance and reappearance of the disk. Elevated Secchi transparency readings allow for more aquatic plant and algae growth. Eutrophic systems generally have Secchi disk transparency measurements less than 7.5 feet due to turbidity caused by excessive planktonic algae growth. The Secchi transparency of Big Star Lake averaged 19.5 feet over the deep basin during the 2013 sampling period. This transparency is very high and is likely due to the lack of rainfall runoff that can suspend particles in the water and decrease water clarity. Due to this increase in transparency and the high water temperatures, an overgrowth of native aquatic vegetation and algae were noted on most inland lakes in 2013. Secchi transparency is variable and depends on the amount of suspended particles in the water (often due to windy conditions of lake water mixing) and the amount of sunlight present at the time of measurement.

***Total Dissolved Solids***

Total Dissolved Solids (TDS) is the measure of the amount of dissolved organic and inorganic particles in the water column. Particles dissolved in the water column absorb heat from the sun and raise the water temperature and increase conductivity. Total dissolved solids are often measured with the use of a calibrated meter in mg $L^{-1}$. Spring values would likely be higher due to increased watershed inputs from spring runoff and/or increased planktonic algal communities. The concentration of TDS in Big Star Lake during the early September sampling event ranged from 72 mg $L^{-1}$- 89 mg $L^{-1}$, which is lower than observed in 2012.

***Oxidative Reduction Potential***

The oxidation-reduction potential ($E_h$) of lake water describes the effectiveness of certain atoms to serve as potential oxidizers and indicates the degree of reductants present within the water. In general, the Eh level (measured in millivolts) decreases in anoxic (low oxygen) waters. Low $E_h$ values are therefore indicative of reducing environments where sulfates (if present in the lake water) may be reduced to hydrogen sulfide ($H_2S$). Decomposition by microorganisms in the hypolimnion may also cause the $E_h$ value to decline with depth during periods of thermal stratification. The $E_h$ (ORP) values for Big Star Lake ranged between 204.7 mV and 98.1 mV within the lake during early September, and indicated oxidized rather than reduced conditions.

***Chlorophyll-a and Phytoplankton Communities***

Chlorophyll-*a* is a measure of the amount of green plant pigment present in the water, often in the form of planktonic algae. High chlorophyll-*a* concentrations are indicative of nutrient-enriched lakes. Chlorophyll-*a* concentrations greater than 6 µg $L^{-1}$ are found in eutrophic or nutrient-enriched aquatic systems, whereas chlorophyll-*a* concentrations less than 2.2 µg $L^{-1}$ are found in nutrient-poor or oligotrophic lakes. Chlorophyll-*a* is measured in micrograms per liter (µg $L^{-1}$) with the use of an acetone extraction method and a spectrometer. The chlorophyll-*a* concentrations in Big Star Lake were determined by collecting a composite sample of the algae throughout the water column at the deep basin from just above the lake bottom to the lake surface. The chlorophyll-*a* concentration was 2.37 µg $L^{-1}$ during the early September 2013 sampling, which was lower than in 2012. This corresponds with higher water clarity in 2013. The genera of algae in Big Star Lake water indicate a favorable balance of green algae, diatoms and blue-green algae to serve as the autotrophic base of the Big Star Lake aquatic ecosystem food chain.

| ***Depth ft*** | ***Water Temp ºF*** | ***DO mg $L^{-1}$*** | ***pH S.U.*** | ***Cond. µS $cm^{-1}$*** | ***Turb. NTU*** | ***ORP mV*** | ***Total Kjeldahl Nitrogen mg $L^{-1}$*** | ***Total Alk. mg $L^{-1}$ $CaCO_3$*** | ***Total Phos. mg $L^{-1}$*** |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 65.9 | 9.8 | 8.3 | 127 | 0.6 | 204.7 | 0.50 | 56 | 0.019 |
| 10.5 | 62.1 | 7.9 | 8.3 | 130 | 1.0 | 134.6 | 0.50 | 58 | 0.020 |
| 20.7 | 51.6 | 5.0 | 8.4 | 132 | 1.4 | 98.1 | 0.70 | 58 | 0.041 |

Table 4. Big Star Lake Water Quality Parameter Data Collected over Central Deep Basin on September 4, 2013.

## 5.0 BIG STAR LAKE 2014 MANAGEMENT RECOMMENDATIONS

The use aquatic chemical herbicide is regulated by the MDEQ under Part 33 (Aquatic Nuisance) of the Natural Resources and Environmental Protection Act, P.A. 451 of 1994, and requires a permit. The permit contains a list of approved herbicides for a particular body of water, as well as dosage rates, treatment areas, and water use restrictions. Wherever possible, it is preferred to use a systemic aquatic herbicide for longer-lasting plant control. There are often restrictions with usage of some systemic herbicides around Big Star Lake shoreline areas that contain shallow drinking wells (such as with 2,4-D).

In the past, systemic herbicides such as 2, 4-D and Triclopyr have been used to control EWM in Big Star Lake and continued spot-treatments with both herbicides are recommended as needed. The September 2013 survey indicated that the June, 2013 treatment was successful and only a few sprigs of EWM were found in the canal area at the southwest region of the lake. The native aquatic plant communities such as the pondweeds, naiads, and Wild Celery continue to thrive in areas once dominated by EWM. The canal area should be treated with multiple herbicides because this area is shallow and is always infested with nuisance algae and other plants such as EWM. This area did not require treatment for natives in 2013.
Water quality parameters as noted above will be monitored during 2014. As was recommended last year, the water quality parameters would be measured in the late summer during maximum stratification. This period reveals the overall health of the lake since the lower water layers usually are low in dissolved oxygen which creates phosphorus release and is detrimental to water quality.

Table 5 below shows the proposed budget for the continuation of the Big Star Lake Improvement Program for 2014. Note that these costs may change in 2014 dependent upon aquatic vegetation growth determined in spring 2014 surveys.

| ***Proposed Aquatic Plant Management Item*** | ***Estimated 2014 Cost*** |
|---|---|
| Systemic Herbicide Control of EWM (approx. 15 acres)@ $610 | $9,150 |
| per acre (includes MDEQ permit, posting fees); *Phragmites* | |
| Treatments (approx 4 acres @ $400 per acre) | $1,600 |
| Newsletter (educational to be mailed to all riparians) | Included |
| Limnologist/Oversight/Surveys/Reports/WQ Monitoring | $7,000 |
| ***TOTAL 2014 ESTIMATED COST OF PROGRAM*** | $17,750 |

Table 5. Proposed 2014 budget for continued Big Star Lake Management Program.

## 6.0 LITERATURE CITED

Madsen, J.D., J.A. Bloomfield, J.W. Sutherland, L.W. Eichler, and C.W. Boylen. 1996. The aquatic macrophyte community of Onondaga Lake: Field survey and plant growth bioassays of lake sediments, *Lake and Reservoir Management* 12:73-79.

Madsen, J.D. G.O. Dick, D. Honnell, J. Schearer, and R.M. Smart. 1994. Ecological assessment of Kirk Pond, Miscellaneous Paper A-94-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.