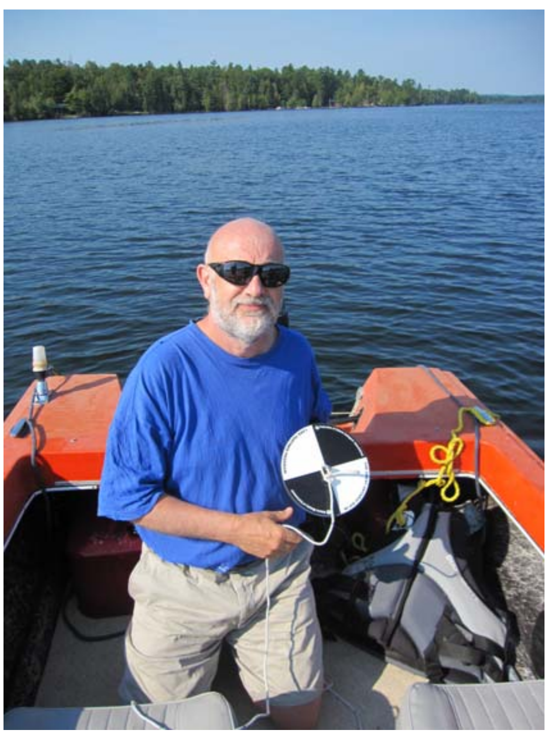
WHITE LAKE PRESERVATION PROJECT

REPORT

Water Quality Monitoring Program 2015

David Overholt Taking Secchi Depth Readings



Conrad Gregoire Heading Out to Sample White Lake

Students from the Mississippi Valley Conservation Authority Taking a Water Sample for Chlorophyll-a Measurement

Water Quality Monitoring Program
2015
Main Findings

D. Conrad Grégoire, Ph.D

The 2015 Water Quality Monitoring Program completed by the White Lake Preservation Project and the Mississippi Valley Conservation Authority added hundreds of new data to our knowledge base. These data have contributed greatly to an understanding of the nature of White Lake and how human activities can affect water quality. Continued monitoring in future may provide greater evidence in support of the findings given blow or suggest new or alternate explanations for these data. We will also be able to track trends in water quality resulting from both natural and human activity impacts on White Lake.

Below is a list of new findings resulting from the research reported in this paper:

1. Most parts of the lake studied exhibited a similar rise and fall of phosphorous concentrations with time. They all differed in the maximum concentration level attained with Three Mile Bay being the highest. This highest phosphorous concentration measured was 21.3 ppb.

2. The water quality for samples from one location (The Canal) was concluded to be influenced by the ingress of local surface and ground waters.

3. There is little or no upstream (from North to South) mixture of waters in White Lake. Waters in Hayes Bay cannot mix with about 90% of the volume of White Lake, and flow directly out to the Narrows into the White Lake Village Basin.

4. For research purposes, White Lake could be divided into up to 5 different zones connected by areas of mixing. Each zone could be treated as a separate lake or basin for study since each zone exhibits different chemical and physical behaviours.

5. Water temperature and sediment surface disturbance could have an important influence on the release of phosphorous from sediments into the water above.

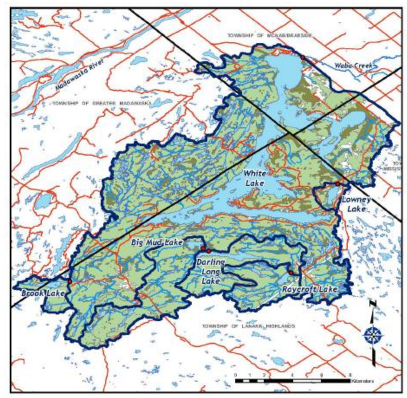
6. The contribution of surface runoff and ground water input from undisturbed parts of the lake to phosphorous levels could be minor in comparison to phosphorous originating from septic systems and sediments.

7. Intense development of shoreline in shallow and isolated parts of the lake present an added threat to water quality and may increase pollutants from surface runoff and phosphorous release from sediments both possibly resulting in more frequent nuisance and toxic algal blooms.

WHITE LAKE PRESERVATION PROJECT

Water Quality Monitoring Program
2015
Results and Discussion

D. Conrad Grégoire, Ph.D



Introduction and Summary of Results: The quality of the water in White Lake is of great importance to anyone wishing to use the lake for recreational purposes and also for the maintenance of a healthy ecosystem including fisheries. The long term monitoring of water quality will provide a record of how the lake is changing with time. The effects of climate change, increasing use by humans and the influence of invading species on White Lake need to be recorded so that we can take whatever actions are required to ensure the long term health of the lake.

White Lake is characterized as a shallow warm water lake. The drainage basin (pictured in the map above) is relatively small compared with the total area of the lake. The Northern and part of the Southern shores of the lake are comprised mainly of pre-Cambrian (acidic) rocks whereas the remainder of the shoreline and the rocks under the lake are calcium rich in nature (basic). It is the calcium rich rocks that give the lake its chemical signature with a basic pH and high calcium content. Both of these factors strongly favour the growth of zebra mussels, an invasive species which was documented in late 2015 to be present in all parts of White Lake.

An examination of the drainage basin map in concert with topographical maps reveals that the parts of the lake located near the pre-Cambrian rocks are fed by surface and ground waters emerging from heavily forested and hilly terrain. The remainder of the lake, including areas starting at Hayes Bay and stretching through the Canal, the Narrows and finally the White Lake Village Basin is surrounded by deforested landscape including some farms.

The forested areas, which include numerous beaver dams and ponds, serve as a buffer storing much of the water falling as rain or melting from snow. Trees also have a significant uptake of water during the growing season. On the other hand, the remainder of drainage basin comprising deforested landscape offers little or no storage of water above the natural water table. In parts of the lake which are surrounded by dense forest, and which also contains the deepest waters, rain and runoff reach the lake at a slower pace relative to the deforested areas. As a consequence of this, the shallowest parts of the lake including parts of the Canal and areas leading to and including parts of the White Lake Village Basin receive rain and snow melt surface waters as well as ground water infiltration (up through the bottom of the lake) at a much higher rate especially after a weather event such as heavy rains.

The net effect on lake water changeover is that waters located in Three Mile Bay, Sunset Bay and areas almost up to the Narrows are held back by the more rapid drainage of shallow areas of the lake. Very much like a car parked farthest away from the exit in an underground parking lot, the entire lot has to empty before that car can also exit. The waters contained in Three Mile Bay, especially, are like that car and thus likely have a higher residence time in the lake than most other parts of the lake. Since Three Mile Bay is one of the most populated and heavily used parts of the lake, special care must be taken by cottage owners and residents there to preserve water quality. The data presented below support these observations.

One of the more important findings of the 2015 water Quality Monitoring Program was that no single part of the lake can be taken to represent the entire lake. Each sampling site (with the exception of The Canal sampling site) exhibited similar but significantly different behaviour when comparing phosphorous concentrations and other factors. Taken together, the different sampling sites and their relative locations on the lake reveal a pattern showing that much of the phosphorous entering the lake stays in the lake as sediments. The accumulation of phosphorous in sediments increases as one travels on White Lake from North to South from Jacob's Island towards Three Mile Bay. The phosphorous data curves presented below clearly show this phenomenon, especially for the Three Mile Bay and N. Hardwood Island sampling locations. In theory, White Lake could be divided into as many as five separate zones with each zone exhibiting different chemical behaviours. These zones would be connected by areas where mixing takes place, for example, at the Jacobs Is. site just south of the narrows leading to the White Lake village Basin.

In future, in order to cover all parts of the lake it will be necessary to continue to monitor the current sites as well as add a few more. This will ensure that changes taking place in the lake can be accurately tracked over time. Certainly, sampling the lake for phosphorous content only once at the beginning of the summer season, is entirely inadequate. Data must be obtained each month during the ice free season in order to obtain an accurate picture of lake water chemistry.

Water Quality Monitoring Program: The water quality monitoring program for 2015 consisted of two parts. The first part was carried out by WLPP volunteers and involved the collection of water samples mid-month for 6 months starting in May. Duplicate water samples were collected for phosphorous analysis and a single separate sample was collected for calcium analysis. Water samples were filtered through an 80 micron mesh to remove any suspended particles and biota. Note that the phosphorous data obtained is for available or free phosphorous and does not reflect the phosphorous bound in suspended living or dead organisms. Secchi depth readings as well as temperature at the Secchi depth were recorded at the same time. Additionally, Secchi depth and temperature readings were taken every two weeks during the summer season providing additional data for these parameters.

All water samples for the determination of phosphorous content were shipped to the Dorset Environmental Science Centre (Ontario Ministry of the Environment and Climate Change) for analysis under the auspices of the Lake Partners Program. The method used for the determination of phosphorous is described in the publication: B.J. Clark et al, *Assessing variability in total phosphorous measurements in Ontario Lakes*, Lake and Reservoir Management, 26:63-72, 2010. The limit of detection for phosphorous using this method is 0.2 parts per billion (ppb).

The second sampling protocol was carried out under contract with the Mississippi Valley Conservation Authority (MVCA). Transportation to sampling sites on the lake was provided by WLPP volunteers. Sampling was carried out on three days mid-month in May, July and September. In addition to Secchi depth, readings were taken at metre or half-metre intervals for temperature, dissolved oxygen and pH. Water samples were also taken for chlorophyll-a and alkalinity measurements. A separate report has been generated by the MVCA which is available on the WLPP website at www.WLPP.ca. The results obtained from this study confirm previous reports on White Lake water chemistry. Water clarity was judged to be fair with an annual mean Secchi depth of 3.4 m. The phosphorous levels of the lake (provided by WLPP) indicated that White Lake was mesotrophic in nature indicating that the lake is in a transition phase toward eutrophication (filling up) should nutrient levels rise. The pH of the lake indicated that waters were alkaline with pH rising as the season progressed. The alkalinity or hardness of the water was an average of 133 ppm (as calcium carbonate) making White Lake a hard water lake. Chlorophyll-a values increased as the Secchi depth decreased indicating that water clarity was a function of phytoplankton content and not suspended inorganic matter. For all of the sites, dissolved oxygen content was adequate to support the species of fish found in White Lake. The MVCA report also confirmed the 'special status' of the Canal sampling site as will be discussed below.

An important finding resulting from the research discussed below is that an important source of phosphorous entering White Lake during the summer months originates from sediments releasing previously bound phosphorous into the water as a result of wind and wave mixing and boating activities. Intense developments such as campgrounds, trailer parks, etc. in shallow isolated areas such as Hayes Bay and other locations will result in even more serious nuisance and toxic algal blooms than we have experiences in the recent past.

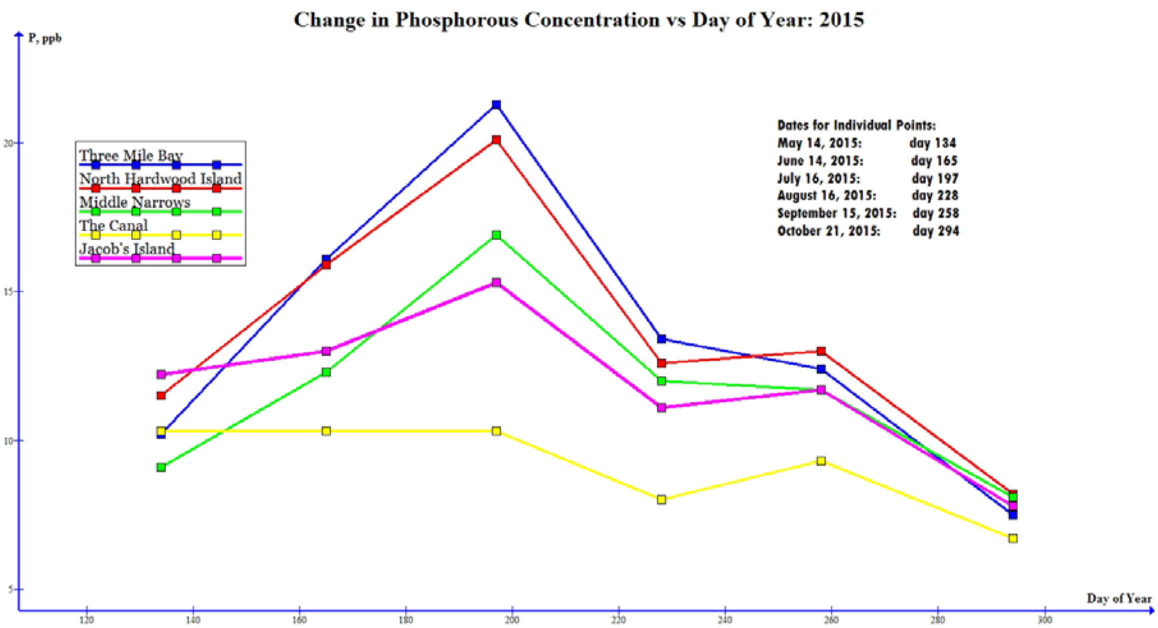
This finding does not in any way diminish the importance of phosphorous coming from septic systems which is known to be a major source. The changing climate tending towards warmer and longer summers (and ice-free periods) means that everyone using the lake, be they cottagers, permanent residents, campers, or casual users need to increase vigilance and care to ensure that their septic systems are working properly and that they use the lake in a sustainable manner. Protecting the shoreline and maintaining a healthy 'zone of life' are also very important factors in preserving White Lake.

Note: The sections that follow below are more technical in nature and form the basis of the conclusions presented above.

Phosphorous

Phosphorous Concentration vs Day of Year:

The Phosphorous (P) concentration in lake water at any give time reflects the rate of P input less the rate P loss. When P levels are rising over time (positive slope), the rate in P input is greater than the rate of P loss. When P levels are decreasing over time (negative slope), the rate of P loss is greater than the rate of P input. At the maximum of the P vs Time curve is a point of zero slope indicating that at that time, the rate of P input is equal to or balanced by the rate of P loss.



The following observations and conclusions arise from the examination of the above graph of P concentration vs day of year:

1. The graph showing the change in P concentration vs Day of Year shows an increase of P concentration with time up to approximately mid-July. After this date, P levels decrease.

2. The marked decrease in P levels on day 228 (August 16, 2015) may have resulted from the dilution effect of runoff following two days of heavy rains prior to the sampling day for these samples. Examination of the P concentrations for the Canal site indicated that the dilution factor may be as high as 15%. Other factors may be responsible for this, but these are not evident at this time. Future observations may provide data supporting alternate reasons for this effect.

3. The maximum P level was obtained from samples taken at the Three Mile Bay Site with a concentration of 21.3 ppb.

4. The farther away subsequent sampling sites are from Three Mile Bay, the lower is the maximum P concentration obtained.

5. The rate of rise in P concentrations during early summer is greatest from the Three Mile Bay site and diminishes for subsequent sampling sites farther away from Three Mile Bay.

6. Samples taken at the Canal site are uncharacteristic when compared to all other samples. At this site, the P concentration was nearly invariant during the entire sampling season. The ‘dilution dip’ on day 228 is also prominent as it is for all other sampling sites.

7. Temperatures taken at the Canal site were often lower than those of the rest of the lake which may indicate that cooler water is entering there from ground water infiltration. The depth of the water at the Canal is only 2.4 m and should be warming more rapidly than the rest of the lake. The consistently low value for P at this site may indicate that this area is always being efficiently flushed by the ingress of ground water from the lake bed. Another indication that this may be so is the fact that at this site, no aquatic plants cover the bottom of the lake. The lake bed there is composed of fine-grained gravel with little organic content.

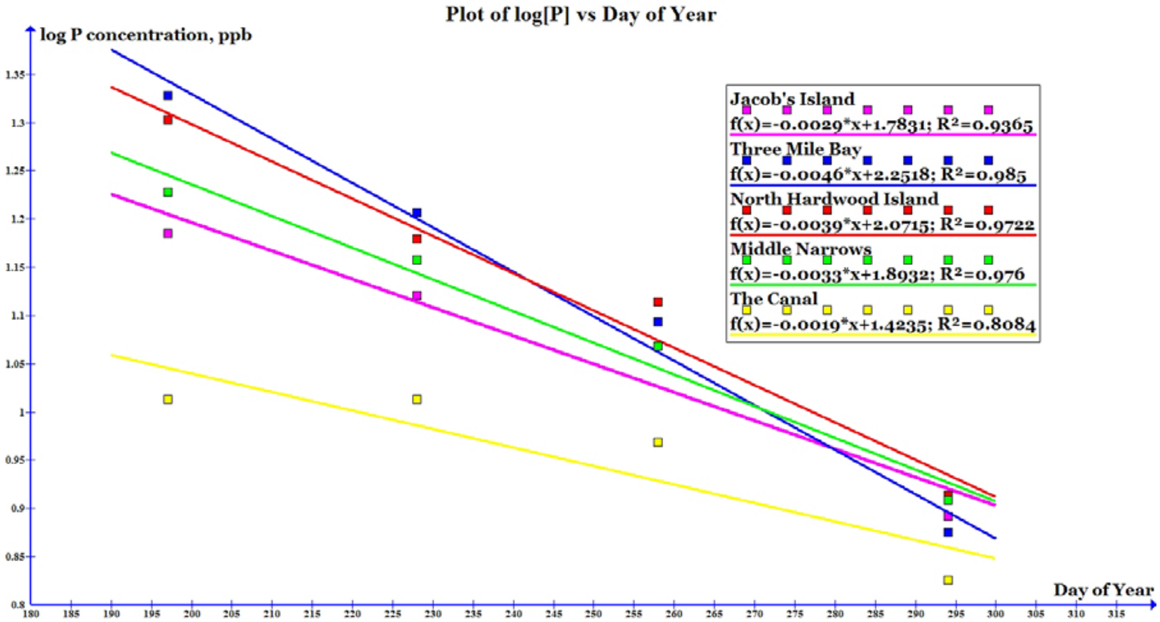
8. The lowest concentration for P was for the sample taken on October 21, 2015 at The Canal. With a value of 6.7 ppb. This may indicate the upper limit for the concentration of P in ground water infiltrating into the lake.

9. Note that no water samples from Hayes Bay were analyzed for P. Hayes Bay has a bottom covered with dense water plants indicating that P levels in the water column are more in keeping with the remainder of the lake and not similar to The Canal Site. Sampling at this location in 2016 and in future years is planned.

10. An independent P concentration for Hayes Bay was reported by the consulting firm Hutchinson Environmental Sciences Ltd. A value of 12.1 ppb was obtained on day 148. This concentration is close to that obtained for the Jacob’s Island site during the same time period. No information was provided on the sampling procedure or analytical method used or the exact location of the sampling site on Hayes Bay.

11. The White Lake Property Owners Association (WLPOA) reported on day 171 the concentration of P at three locations: Sunset Bay (16.8 ppb); Three Mile Bay (13.7 ppb); Pickerel Bay (15.1 ppb). Samples were sent to the Dorset Laboratory for analysis under the Lake Partners Program. The results obtained for the WLPOA are in line with those we obtained at those or close locations by the WLPP as shown in the above graph.

Log of Phosphorous Concentration vs Day of Year:



The following observations and conclusions arise from the study of the above graph:

12. A plot of the log of P concentrations for the part of the P vs Time curve that is decreasing (past the maximum value on July 16, 2015) gives a straight line indicating that the loss of P in the water column is governed by a first order rate process. Therefore a comparison of the slopes of these straight lines (for each sampling site) can be used as a measure of the rate constant for P loss in the water column. This result also shows that the rate of loss of P is proportional to the concentration of P in the water column.

13. The correlation coefficients for these plots (shown on the plot legend as R^2) are very high indicating that the lines are straight and the correlation between the two parameters is statistically high.

14. The plot of 'log[P] vs day of year' shows that after July 16, 2015 P concentration levels are decreasing at the highest rate at the Three Mile Bay site with all other sampling site locations decreasing at a lower rate. The rate of P loss was less for each site the farther away it was from the Three Mile Bay site.

15. Part of the P loss during this time period (after July 16, 2015) may occur because the lake level is being significantly drawn down (see graph below) which may contribute to the rate of decrease of P at all downstream sites.

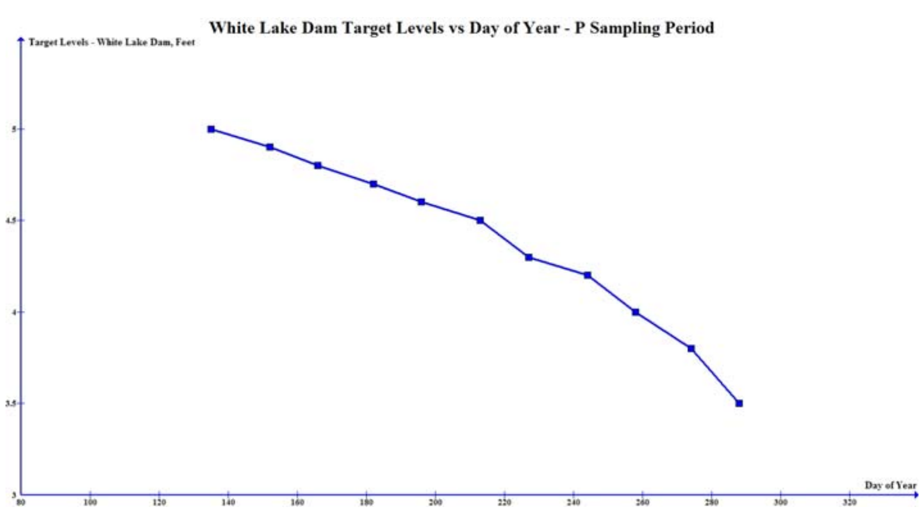
16. The slower rate of loss of P for sites downstream from Three Mile Bay (towards the White Lake Dam) was likely due to the movement and mixing of higher P concentration water with downstream sampling sites as we sample closer towards the White Lake Village dam.

17. The higher rates of P loss from the water column, for example at Three Mile Bay, may be attributed to a higher biological activity due to the availability of higher levels of available P in the water column (see #12 above).

18. There are no significant water inlets into Three Mile Bay, especially after the spring freshet, leaving water turnover to occur by ground water infiltration or wind action. These sources of water renewal may be relatively small in this part of the lake.

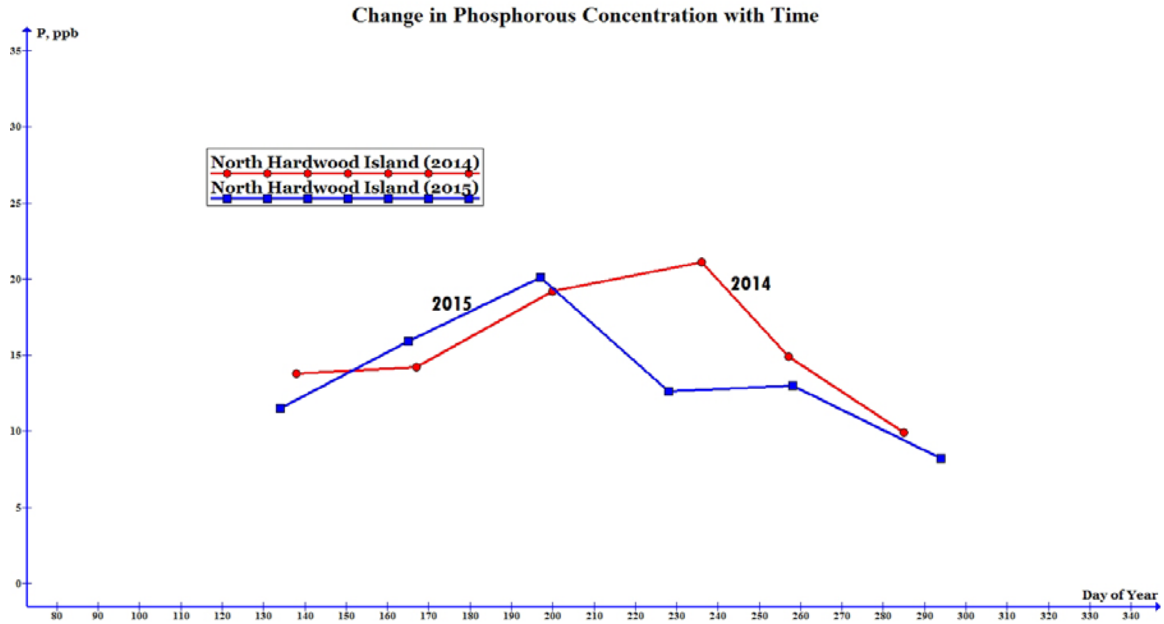
19. As a general observation, it is likely that the waters of Three Mile Bay are among the least mobile during the ice free season. The ingress of ground and surface waters in the shallowest part of the lake (The Canal and area and large parts of the White Lake Village Basin) results in these parts of the lake being refreshed most by incoming new waters leaving the deeper and more distant parts of the lake (from the only outlet at the dam) more ‘stagnant’. The increased residence time of waters in the Western parts of the lake promote the accumulation of excess quantities of P there in relation to downstream locations nearer the only outlet at the White Lake Village dam.

20. White Lake has a single outlet at the White Lake Village dam. During the summer months, water largely enters the lake from ground water infiltration and surface water runoff. A consequence of these facts coupled with the P graphs above show that there are no mechanisms by which water in the downstream parts of the lake (Hayes Bay, The Canal, White Lake Village Basin) can mix with waters from the deeper upstream parts of the lake. Consequently, for example, pollutants, algae, etc. originating in the Canal – Hayes Bay regions cannot be diluted by the approximately 90% of the volume of the lake lying upstream of these sites (see map page 15)



Comparison of P Concentration with Day of Year for 2014 and 2015:

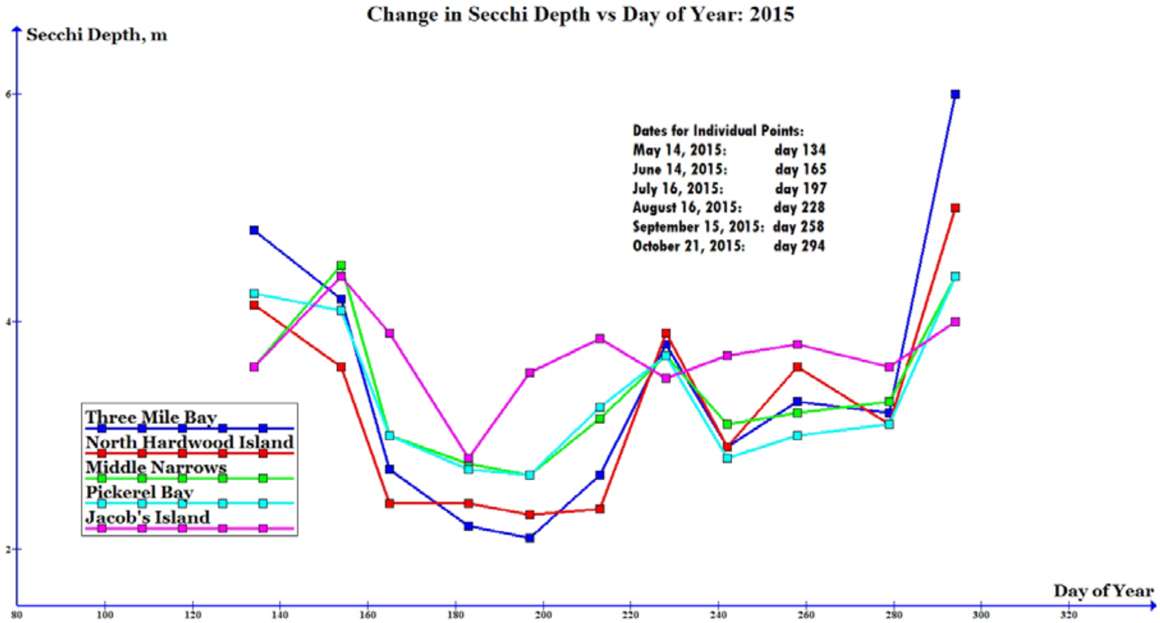
Below is a comparison of P concentrations obtained at the North Hardwood Island sampling site during 2014 and 2015. At this time, this is the only site for which we have multi-year data. Although it is too early to detect a trend in these data, the numbers for the two years compare well with one another. Notwithstanding the dip in 2015 P data on day 228 due to heavy rains, the two curves are virtually coincident.



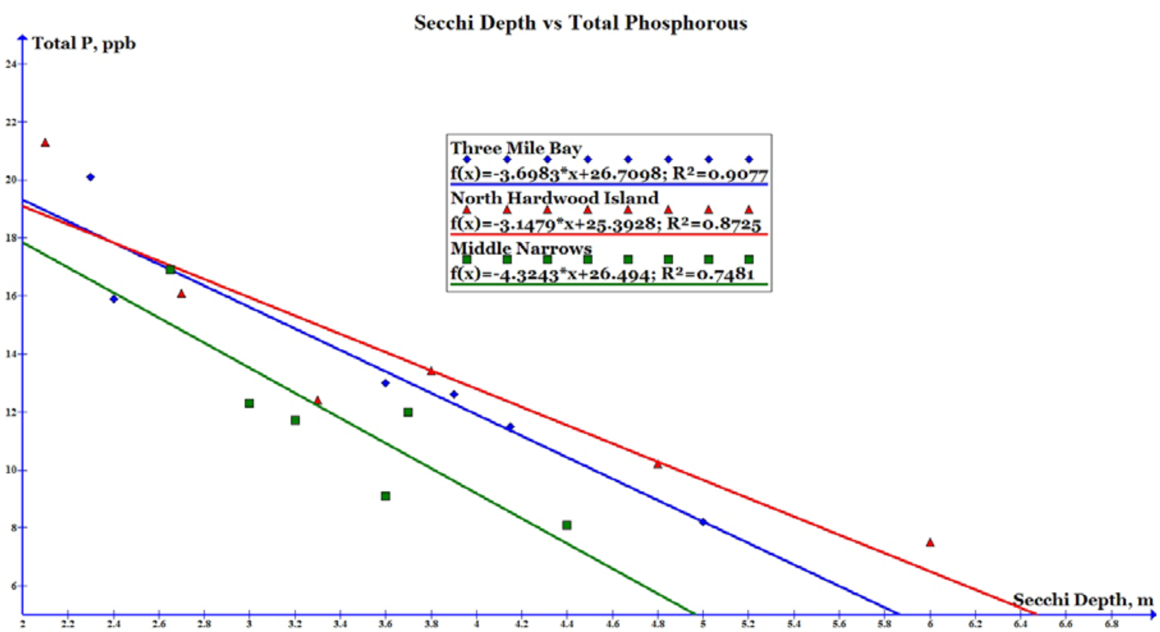
Secchi Depth vs Day of Year:

Secchi Depths are measured by lowering an approximately 12 inch disk, painted black and white, into the lake and noting the depth at which the disk no longer appears visible. This test is used as a measure of water clarity. It is useful to compare Secchi Depths with such parameters as P concentration as well as levels of chlorophyll-a.

Below is a graph of the Secchi Depth vs day of year. When comparing this graph to the graph of P vs day of year, it is clear that there is an inverse relationship between these two parameters. When the clarity of the water is high, the amount of P in the water column is low and vise-versa.



In order to further investigate the relationship between the Secchi Depth and P concentrations, a plot can be generated using these two parameters. The resultant plot (below) shows a strong straight-line relationship for most of the data. The correlation coefficient (R^2) was highest for Three Mile Bay at 0.9077, is somewhat less for N. Hardwood Island at 0.8725 and is still lower for Middle Narrows at 0.7481. The data for the Jacob's Island produces a plot with a very low correlation coefficient of 0.0035 (graph not shown). No such plot for The Canal site is possible because the depth of the water there is much less than the actual Secchi Depth.

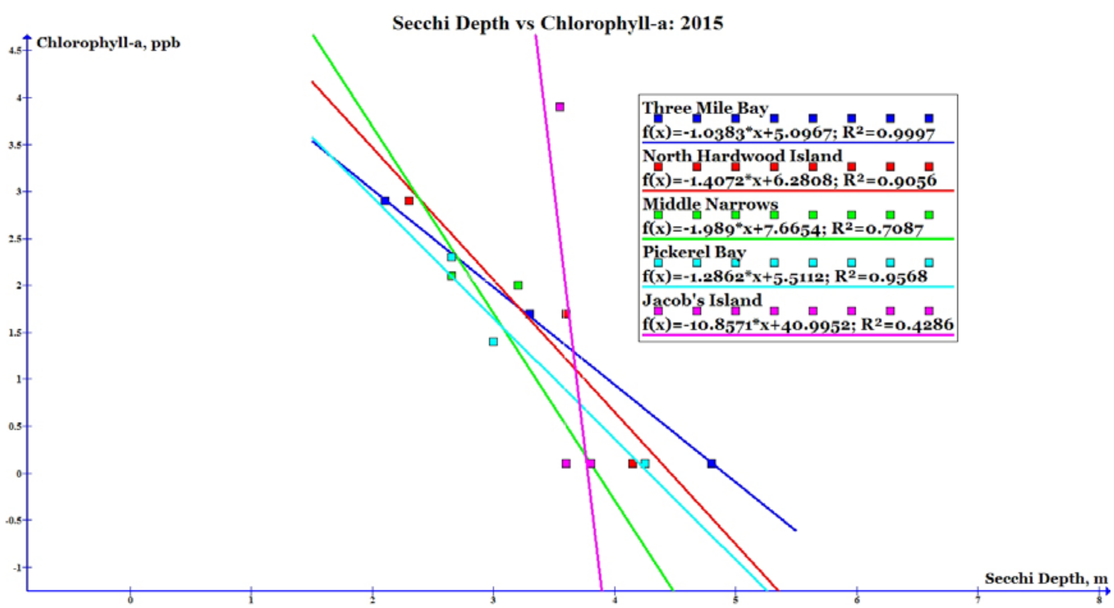


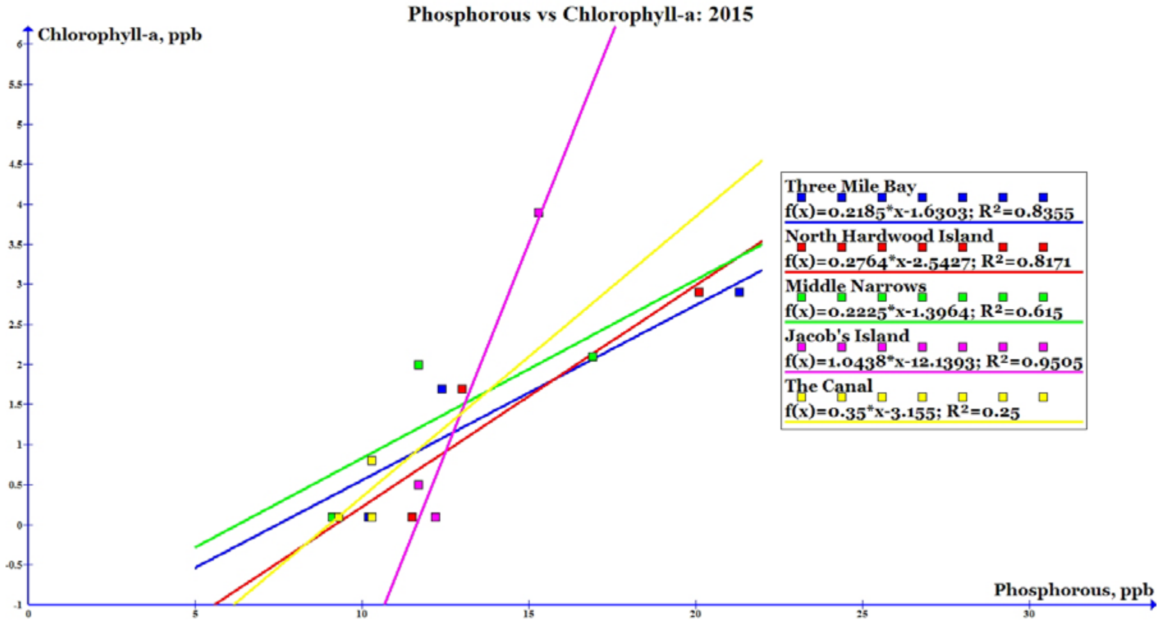
When the Secchi Depth data for the Jacob's Island site is studied separately it is clear that there is no correlation for these two parameters at this site. In other words, the waters of the Jacob's Island site are far clearer than they should be in relation to the concentration of P found there. It is difficult to explain this phenomenon other than to state that some mechanism is in play which quickly precipitates particulate matter to the sediments below. During the sampling season, however, we did observe that the Jacob's Island site was the only site that produced large quantities of aquatic plants and sediment attached to the raised boat anchor. This may indicate an accelerated rate of sediment formation relative to other sampling sites.

For the remainder of the sampling sites, the usual data trend was observed with Three Mile Bay having the highest correlation coefficient with numbers weakening in sites further downstream towards the lake outlet.

<u>Secchi Depth vs Chlorophyll-a and Phosphorous</u>:

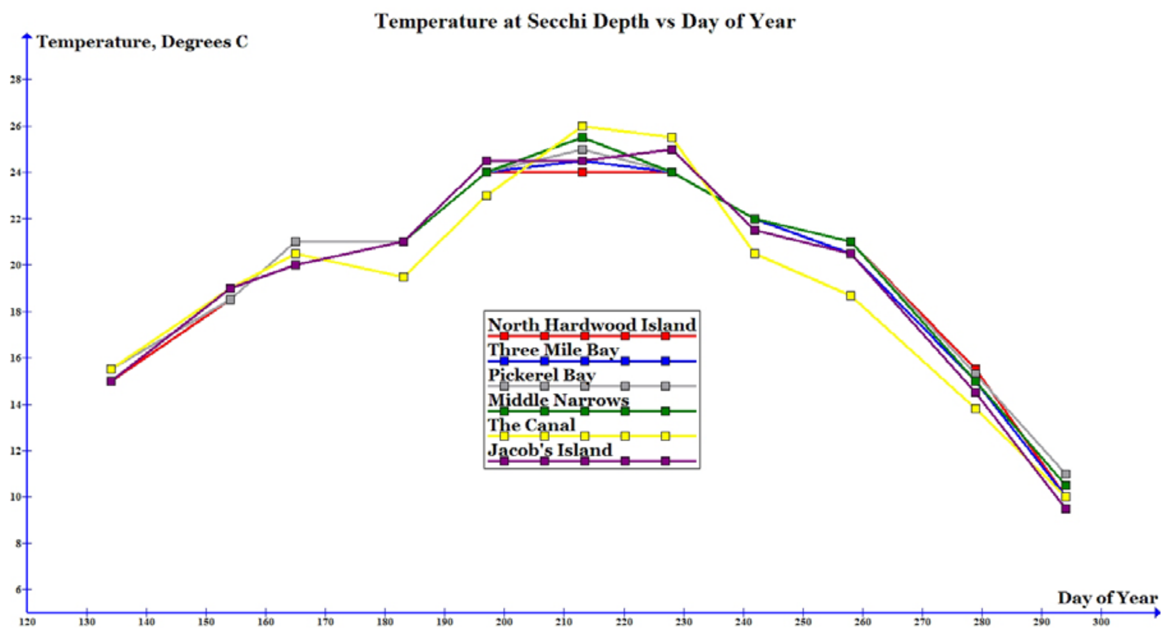
Chlorophyll-a is a molecule present in plants and algae which is responsible for the conversion of sunlight into energy which can be used by the plants to produce food. By measuring chlorophyll-a and comparing it to levels of P and to the Secchi Depth we can determine whether the clarity of the lake is governed only by phytoplankton and algae or in some part to suspended inorganic material. If the correlation is high between any of these two parameters, this indicates that any lack of clarity in the water is due to the presence of algae or phytoplankton and not to other matter which could affect clarity such as suspended inorganic matter from, for example, shoreline erosion. The plot of both total P and Secchi Depth vs Chlorophyll-a shows a very high correlation (R^2) for all sites, with the exception of The Canal, where the correlation between P and Chlorophyll-a is poor (0.25). All other data show a high correlation for both parameters with the usual highest correlation being observed for Three Mile Bay diminishing as the sampling site approaches the East end of the lake. These results show that water clarity is primarily governed by the presence of phytoplankton and algae.



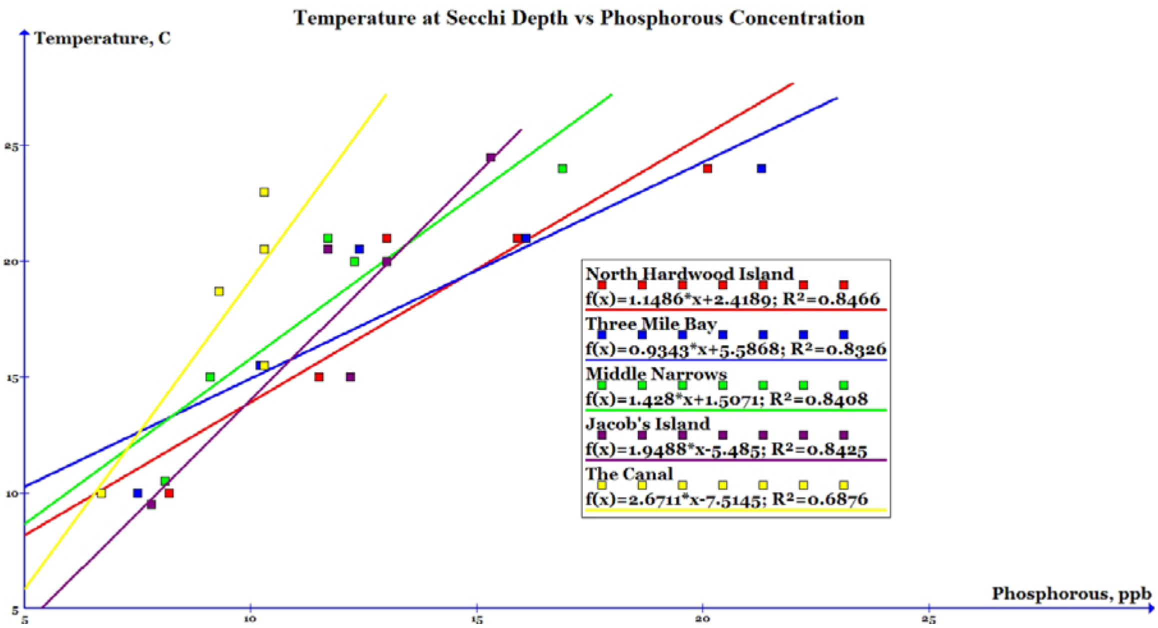


Water Temperature at Secchi Depth vs Day of Year:

All sites demonstrated a high correlation of lake temperature with Secchi depth. However, the temperature readings for The Canal show some divergence from the other sampling sites. At times, the temperatures there were lower than those of the rest of the lake (more often than not) and at other times, especially in August (hottest month) are higher. It is possible that the lower temperatures reflect the temperature of infiltrating ground waters with higher temperatures attributed to radiant heating during hot dry periods when ground water infiltration would be diminished.

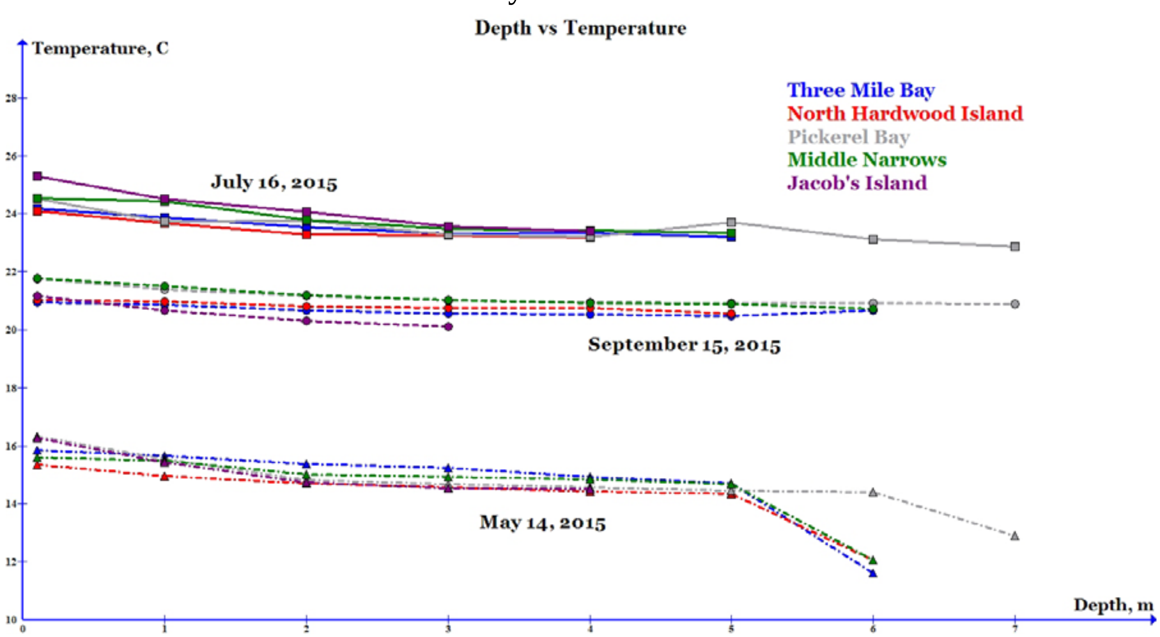


<u>Water Temperature at Secchi Depth vs Phosphorous Concentration:</u>



A plot of the water temperature taken at the Secchi depth versus the concentration of P produces a series of straight lines for all of the sampling sites on White Lake. The correlation coefficients (R^2) are very high for four of the five sampling sites with values above 0.8. The remaining site, The Canal, has a respectable correlation coefficient of nearly 0.7.

Also, during most of the summer, the temperature of the water column from the surface to the bottom was essentially invariant as shown below.



WHAT IS THE MAIN SOURCE OF PHOSPHOROUS IN WHITE LAKE WATER DURING THE SUMMER MONTHS?

The results reported above are important in determining the source of phosphorous which gives the typical 'phosphorous vs day of year plots' as shown in the first graph in this report. The data from a single sampling year may not provide conclusive evidence to support a conclusion or assertion, but do give important clues to what may be controlling the phosphorous concentration in White Lake. Continued monitoring of lake chemistry over several years may provide more conclusive evidence is support of some of the statements made below. Completing a phosphorous budget study for White Lake would give a more accurate picture of all sources of phosphorous entering the lake. Unfortunately, these studies are difficult to perform and can be quite expensive.

Of all the sampling sites, Three Mile Bay exhibited the highest levels of phosphorous measured anywhere on the lake. Although this is the most intensively populated and used part of White Lake, the phosphorous concentration dipped as it did for all other sites when water samples were taken following two days of heavy rains (August 16, 2015). As mentioned above, the lake water may have been significantly 'diluted' by water entering the lake during and following these heavy rains. This indicates that incoming groundwater, surface runoff and rainwater laden with atmospheric particulates did not contribute significantly to the phosphorous entering the lake during this storm event.

The role of septic systems in contributing to the phosphorous concentration in the lake is very important, but it is clear that some phosphorous loading from sediments during the summer months also contributes to free phosphorous levels in the lake. For Three Mile Bay in particular, if phosphorous emanating from septic systems was the only source of the element to Three Mile Bay, then the 'Phosphorous vs Day of Year' plots (first graph in this report) would not exhibit a relatively rapid rise to a maximum followed by a relatively rapid decrease in P concentration with time. Instead, the concentration of phosphorous would rise and then plateau during the period of heavy use from late June to the end of August. This was not observed. Instead, there is an added 'peak' to the 'Phosphorous vs Day of Year' plots which may indicate that sediments also have a role.

The very strong correlation of phosphorous concentration and lake water temperature (shown above) suggests that an additional source of phosphorous loading during the ice free season comes from lake sediments, which is also called back loading by limnologists.

Although the concentration of phosphorous in lake water is measured in the low tens of parts per billion (ppb), the concentration of phosphorous in the sediments occurs in the parts per million (ppm) range. This means that the concentration of phosphorous in the sediments is literally thousands of times greater than that found in the waters above them. The waters of White Lake have a very low turnover, estimated to less than 0.9 times per year. Thus, phosphorous entering the lake by whatever means is efficiently sequestered by living organisms which in turn die and settle to the bottom of the lake. Lake sediments become the phosphorous reservoir for White Lake, with those sediments holding the accumulation of most of the phosphorous entering the lake over many centuries, or even thousands of years.

Oxygen levels in water and sediment contribute greatly to the availability of phosphorous for phytoplankton and algal growth. Phosphorous bound in sediments, organic sediment particles or chemically bonded to inorganic species such as iron only remain chemically bound if there is sufficient dissolved oxygen present. When oxygen becomes depleted due to consumption by rotting vegetation, for example, a change in redox (reduction/oxidation) potential in the sediment takes place which creates chemical conditions favouring the release of phosphorous (reducing conditions) back into the lake water above. When this happens, however, not all of the phosphorous is available for mixing with the water column above. Some of the phosphorous is tightly bound and remains that way. However, a significant portion of the phosphorous does become mobile. For White Lake, sediments will hold their phosphorous unless there is a mechanism in place to disturb the sediment as I believe may be the case. The scientific literature suggests that phosphorous in about the first 18 inches of sediment are available for reintroduction in to the water column under the right conditions. We can speculate and propose a mechanism by which phosphorous could enter the lake from sediments even though the water column has significant dissolved oxygen content.

The interface between the bottom water of White Lake and the sediment is not as distinct or as sharp as one would imagine for a sandy-bottomed lake. Organic matter settling out of the water column is generally in a very fine particulate form. When these particulates reach the bottom of the lake, they form an unconsolidated layer of what could be described as dense 'smoke' increasing in density as one moves further down the sediment column. Over time, and with the arrival of more material settling out of the water column, these sediments become more compacted and dense. The nature of White Lake bottom sediments, as described above, was verified by scuba diving during the summer of 2015.

Anoxic (no dissolved oxygen) conditions were not detected in White Lake waters during measurements taken during the ice-free months of 2015. However, during these measurements, if the oxygen measuring probe was lowered into the initial layers of sediment, the oxygen content did drop considerably, especially in Three Mile Bay. This observation may mean that in the unconsolidated layer of sediments, phosphorous could exist in a weakly bound or even free state. Movement of any free phosphorous out of this layer and into the water column could occur by such processes as diffusion and partial mixing events such as wind and storms. Displacement of this phosphorous could also occur as a result of fish movements (likely small) and the disturbance of bottom water/sediment by the underwater wake created by outboard motors.

As shown above, there is a strong correlation between phosphorous concentration and water temperature. Water temperatures measured during the May 14 sampling did show a decrease in water temperature with depth above 5m indicating thermal stratification in the lake. During the later two samplings, however, the temperature of the lake was invariant from the surface to the bottom. This means that White Lake is well mixed from wind and waves and also boating to some extent allowing for at least the upper parts of the sediment layer to be disturbed and remobilized resulting in the release of bio-available phosphorous to the water column. In short, the same mechanism(s) responsible for efficiently thermally mixing the water column could also be responsible for remobilizing loosely bound or free phosphorous from the unconsolidated lake sediment layer.

The release of phosphorous from sediments is also accelerated by an increase in water temperature over the summer season. During that time, bottom waters increase in temperature by about ten degrees. The rate of chemical reactions (such as those releasing phosphorous from sediments) roughly doubles for each 10 degree rise in ambient temperature. So we can expect that over the course of the summer, the rate of phosphorous released to the water column will also double further increasing the total amount of free phosphorous available to lake waters. The effects of diffusion and microbial action in sediments will also increase accordingly with increases in temperature.

In conclusion, the studies reported above show that although shoreline development in the form of cottages and campgrounds will certainly contribute to phosphorous loading from septic systems, a very important additional factor to consider is the INTENSITY of development. Three Mile Bay is from 3.5 m to 5.0 m in depth and its sediments could be contributing significantly to phosphorous loading and possibly more so than other locations on the lake. If large or intense development is permitted in other more sensitive parts of the lake, such as Hayes and Bane Bays where the water depth is only from 1.5m to 2 m, then it is reasonable to expect that sediment back loading of phosphorous will be even more intense and promote nuisance and toxic algal blooms in those areas. In these very shallow areas, boat traffic may become the most important force promoting redistribution of phosphorous from sediments to surface waters.

White Lake Preservation Project
March 17, 2016

CHEMICAL AND PHYSICAL DATA
2015

North Hardwood Island N. 45° 16.162'; W. 076° 33.203' Depth: 5.0 M

Date	Time	Day of Year	Secchi Depth, M	Temp, °C	Ca, ppm	Total P, ppb	Comments
May 14	10:20	134	4.15 Chl-a : <0.5	15.0	37.3	10.8,12.2 (11.5)	Alk: 120 pH= 7.76
June 3	11:55	154	3.60	18.5		-	
June 14	9:43	165	2.40 **Chl-a = ppb**	21.0	37.2	16.0,15.8 (15.9)	**Alkalinity = ppm**
July 2	9:15	183	2.40	21.0		-	
July 16	11:15	197	2.30 Chl-a : 2.9	24.0	36.7	19.2, 21.0 (20.1)	Alk: 140 pH= 8.07
August 1	9:04	213	2.35	24.0		-	
August 16	10:05	228	3.90	24.0		13.4, 11.8 (12.6)	
August 30	10:34	242	2.90	22.0		-	
September 15	10:34	258	3.60 Chl-a : 1.7	21.0		12.8, 13.2 (13.0)	Alk: 160 pH= 8.16
October 6	1:20	279	3.10	15.5		-	
October 21	11:21	294	5.0 (bottom)	10.0		7.8, 8.6 (8.2)	

WLPOA – June 20, 2015 : day 171 (**Sunset Bay**); TP: 16.8,16.8 (16.8) ; (Ca 34.5 ppm)

Three Mile Bay N. 45° 15.767'; W. 076° 32.521 Depth: 6.0 M

Date	Time	Day of Year	Secchi Depth, M	Temp, °C	Ca, ppm	Total P, ppb	Comments
May 14	11:00	134	4.80 Chl-a : <0.5	15.5	36.2	10.0, 10.4 (10.2)	Alk: 120 pH= 7.77
June 3	12:05	154	4.20	18.5		-	
June 14	9:25	165	2.70	21.0	36.0	15.6, 16.6 (16.1)	
July 2	9:23	183	2.20	21.0		-	
July 16	11:39	197	2.10 Chl-a : 3.0	24.0	36.3	23.4, 19.2 (21.3)	Alk: 140 pH= 8.08
August 1	9:11	213	2.65	24.5		-	
August 16	9:52	228	3.80	24.0		13.6, 13.2 (13.4)	
August 30	10:09	242	2.90	22.0		-	
September 15	11:00	258	3.30 Chl-a : 1.7	20.5		12.4, 12.4 (12.4)	Alk: 160 pH= 8.16
October 6	1:28	279	3.20	15.0		-	
October 21	11:02	294	6.00 (bottom)	10.0		7.6, 7.4 (7.5)	

WLPOA – June 20, 2015-11-14 June 20: day 171 TP: 14.0, 13.4 (13.7) ; (Ca 34.7 ppm)

Pickerel Bay N. 45° 16.33’; W. 076° 31.03 Depth: 7.5 M

Date	Time	Day of Year	Secchi Depth, M	Temp, °C	Ca, ppm	Total P, ppb	Comments
May 14	11:35	134	4.25 Chl-a : <0.5	15.5	-	-	Sunny, W:5 km/hr **Alk: 120 pH=7.83**
June 3	11:20	154	4.10	18.5	-	-	Sunny, W:7 km/hr, pollen
June 14	10:01	165	3.00	21.0	-	-	Overcast, W:15 km/hr
July 2	9:37	183	2.70	21.0	-	-	Sunny, W:10 km/hr
July 16	12:00	197	2.65 Chl-a : 2.3	24.0	-	-	Sunny, W:0 km/hr **Alk: 140 pH=8.18**
August 1	9:23	213	3.25	25.0	-	-	Sunny, W:5-10 km/hr
August 16	10:22	228	3.70	24.0	-	-	Sunny, W:5 km/hr
August 30	10:39	242	2.80	22.0	-	-	P. Cloud, W:<5km/hr
September 15	11:20	258	3.00 Chl-a : 1.4	21.0	-	-	Sunny, W:<5km/hr **Alk: 160 H=8.18**
October 6	1:37	279	3.10	15.3	-	-	Cloudy, W:<5 km/hr
October 21	11:25	294	4.40	11.0	-	-	Cloudy, W:5-7 km/hr

WLPOA – June 20, 2016: day 171 TP: 15.4, 14.8 (15.1); (Ca: 35.4 ppm)

Middle Narrows N. 45° 18.548’; W. 076° 31.271’ Depth: 6.0 M

Date	Time	Day of Year	Secchi Depth, M	Temp, °C	Ca, ppm	Total P, ppb	Comments
May 14	12:10	134	3.60 Chl-a : <0.5	15.0	35.3	9.0,9.2 (9.1)	Alk: 120 pH= 7.86
June 3	12:33	154	4.50	19.0		-	
June 14	10:30	165	3.00	20.0	33.2	11.8,12.8 (12.3)	
July 2	9:50	183	2.75	21.0		-	
July 16	12:50	197	2.65 Chl-a : 2.1	24.0	35.8	17.2,16.6 (16.9)	Alk: 120 pH= 8.15
August 1	9:31	213	3.15	25.5		-	
August 16	10:37	228	3.70	24.0		12.2, 11.8 (12.0)	
August 30	11:08	242	3.10	22.0		-	
September 15	11:48	258	3.20 Chl-a : 2.0	21.0		12.0, 11.4 (11.7)	Alk: 140 pH= 8.20
October 6	1:48	279	3.30	15.0		-	
October 21	12:03	294	4.40	10.5		8.0, 8.2 (8.1)	

The Canal N. 45° 19.267'; W. 076° 30.013' Depth: 2.4 M

Date	Time	Day of Year	Secchi Depth, M	Temp, °C	Ca, ppm	Total P, ppb	Comments
May 14	12:40	134	> depth Chl-a : <0.5	15.5	35.8	10.2, 10.4 (10.3)	Alk: 120 pH= 8.00
June 3	12:44	154	> depth	19.0		-	
June 14	11:00	165	> depth	20.5	32.2	10.0, 10.6 (10.3)	
July 2	10:10	183	> depth	19.5		-	
July 16	1:12	197	> depth Chl-a : 0.80	23.0	31.1	10.0, 10.6 (10.3)	Alk: 120 pH= 8.28
August 1	9.40	213	> depth	26.0		-	
August 16	10.58	228	> depth	25.0		8.2, 7.8 (8.0)	Two days after heavy rain
August 30	11:15	242	> depth	20.5		-	Rain prior three days
September 15	12:06	258	> depth Chl-a : <0.5	18.7		9.6, 9.0 (9.3)	Alk: 160 pH= 8.16
October 6	1:57	279	> depth	13.8		-	4 days wind, suspended mat.
October 21	12:20	294	> depth	10.0		6.8, 6.6 (6.7)	

Jacob's Island N. 45° 19.989; W. 076° 30.622' Depth: 4.0 M

Date	Time	Day of Year	Secchi Depth, M	Temp, °C	Ca, ppm	Total P, ppb	Comments
May 14	12:55	134	3.60 Chl-a : <0.5	15.0	36.2	12.4,12.0 (12.2)	Alk: 100 pH= 7.83
June 3	12:48	154	4.40	19.0		-	
June 14	11:15	165	3.90	20.0	33.3	13.4, 12.6 (13.0)	
July 2	10:17	183	2.80	21.0		-	
July 16	1:42	197	3.55 Chl-a : 3.9	24.5	35.2	16.0, 14.6 (15.3)	Alk: 120 pH= 8.15
August 1	9:46	213	3.85	24.5		-	
August 16	11:09	228	3.50	25.0		11.0, 11.2 (11.1)	
August 30	11:35	242	3.70	21.5		-	
September 15	12:27	258	3.80 Chl-a : 0.5	20.5		11.6, 11.8 (11.7)	Alk: 140 pH= 8.31
October 6	2:05	279	3.60	14.5		-	
October 21	12:30	294	4.00 (bottom)	9.5		8.0, 7.6 (7.8)	

Notes:

1. Temperatures were taken at Secchi Depth. When sampling site depth was less than Secchi depth, temperatures were taken 1 M from bottom.

2. Water samples for total phosphorous were taken at Secchi Depth or when sampling site depth was less than Secchi depth, samples were taken 1 M from bottom.

3. All water samples were filtered through 80 micron filter prior to determination of total phosphorous.

4. Sampling dates were ideally the first of the month for temperature and Secchi depth and the 15th of the month for Secchi depth, temperature and total phosphorus. Some adjustments in timing had to be done to accommodate inclement weather and availability of personnel.

5. Total phosphorous water samples were not taken at the Pickerel Bay location as this location was not part of the Lake Partners Program for 2015.

6. Water sampling was scheduled, as much as possible, to take place between 11 a.m. and noon on clear sunny and windless days in an effort to produce the highest quality data free from the influence from ambient light and waves.