Irondequoit Bay Monitoring Report

2015

Monroe County Department of Environmental Services
Water Quality Assessment Program
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Cheryl Dinolfo
County Executive

For questions or further information regarding this report contact:

Andy Sansone
Industrial Waste Engineer
Monroe County Pure Waters
145 Paul Rd, Rochester NY 14624
asansone@monroecounty.gov

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INTRODUCTION

Irondequoit Bay is a body of water off the southern shore of Lake Ontario and located northeast of the City of Rochester, New York (Figure 1). Fresh water flows into the bay at the south end from Irondequoit Creek and exits to Lake Ontario at the north end through a channel approximately 2m deep and 20m wide. The water level in the bay is controlled by the water level of Lake Ontario. The total drainage basin is approximately 63 square miles and is comprised of a mix of urban, suburban and agricultural lands (Table 1).

The bay has been in a eutrophic state for several decades. It has been subjected to many of the problems of advanced eutrophication such as algal blooms, organically rich deep sediments, and hypolimnetic oxygen depletion during summer stratification. As long ago as 1968, plans were undertaken to improve the water quality of the bay. In 1978-79, point source nutrient loadings from wastewater were diverted from Irondequoit Creek to the Van Lare Wastewater Treatment facility. This was followed by significant work to reduce sewer overflow discharges into the bay. Subsequent monitoring indicated a significant reduction in phosphorus loading from the creek to the bay. The improved water quality was sufficient enough to classify the bay trophic state as eutrophic rather than hypereutrophic.

Table 1. Data for Irondequoit Bay

Metric	Value
Surface Area	1,660 acres
Length	4.2 Miles
Maximum Depth	22m(73 ft)
Maximum Width	0.5 Miles
Hydraulic Retention Time	116 days
Shore Length	17.7 Miles
Average Elevation	250 ft
Watershed Size	40,481 acres (63 mi^2)
Watershed Primary/Secondary Land Use	Residential/(Agricultural/Vacant Land)
Land Use (% of watershed area)	
Agricultural	13
Residential	55
Vacant Land	13
Commercial	4
Recreation & Entertainment	4
Community Service	3
Industrial	2
Wild, Forested, Conservation Lands & Public Parks	5
Municipal Jurisdiction	Mendon (40%), Perinton (20%), Pittsford (18%), Penfield (17%), E. Rochester (2%), Pittsford V. (1%), Brighton (1%), Fairport (1%)

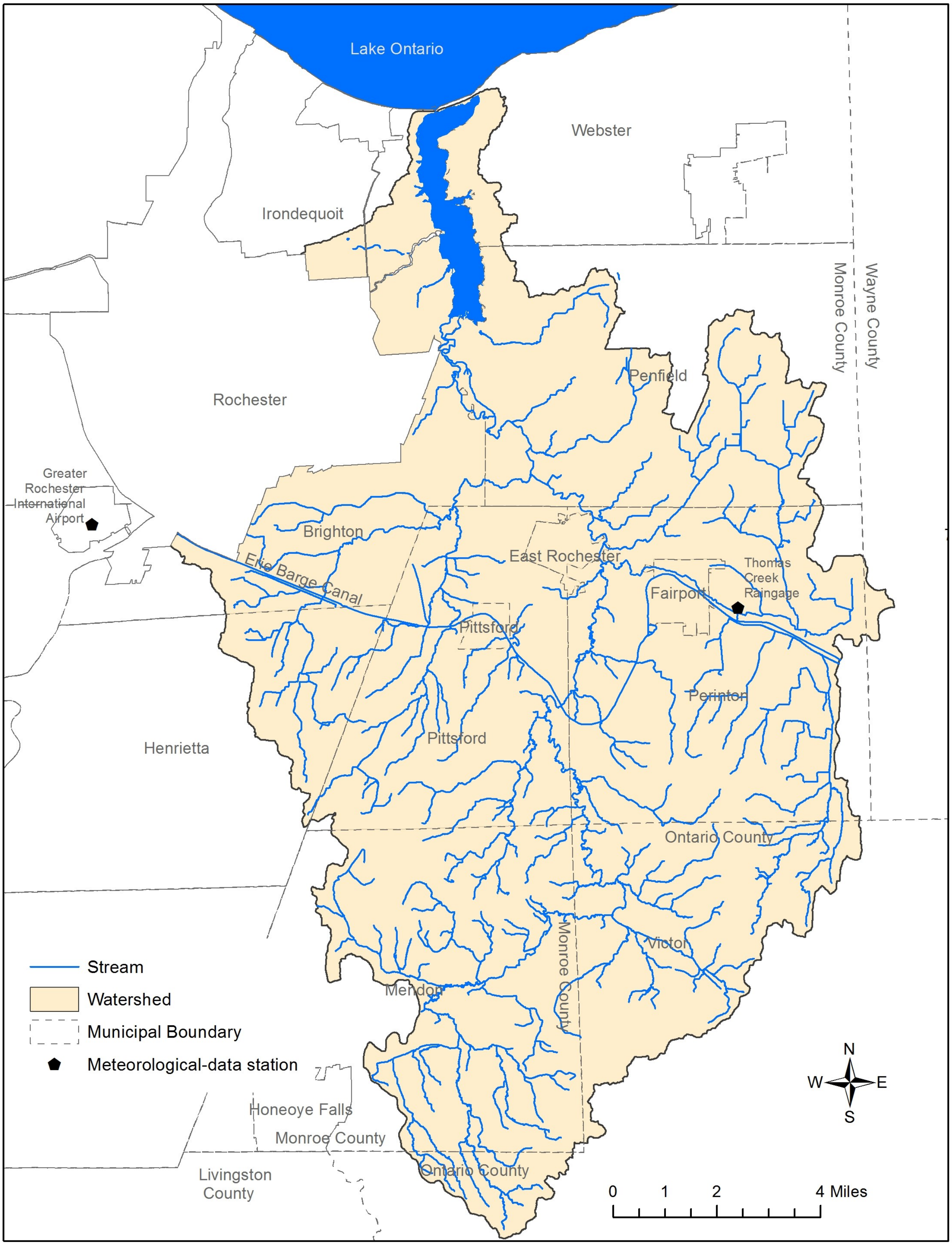


Figure 1 Irondequoit Bay drainage basin.

While the external nutrient loads were being greatly reduced, it was also known that these loads alone were not enough to account for the high levels of nitrogen and phosphorus present in the bay. It was determined that a large internal load of nutrients was being recycled from the organically rich sediments through various processes of biological degradation. This was apparent in the large increase in phosphorus in the hypolimnion in the summer months (June-September). Several restorative techniques were explored for the bay including dredging, aeration, chemical deactivation and sediment sealing. In 1986, a layer of aluminum sulfate (alum) was applied to the deep water areas of the bay to cover the sediment in an effort to control this internal load. The improved water quality was observed immediately with hypolimnetic phosphorus levels 60-75% lower than before treatment.

In an effort to maintain the improvements made from the alum treatment, it was recommended to implement a program of oxygenation of the hypolimnion. The goal was to maintain metalimnetic oxygen to a level that would promote a cold-water ecosystem which would harvest the algal crop and reduce the amount of biomass settling to the deep sediments. This would break the cycle of deposition and re-suspension of dissolved phosphorus from the bottom sediments. In 1993 a system was installed to deliver oxygen to the deep water area of the bay through five diffusers. Two diffusers were installed in 1993, and the other three were installed in 1994. Since then, oxygen supplementation is initiated every year in early July when the median dissolved oxygen concentration in the metalimnion shows signs of anoxia (complete lack of oxygen) and ended in mid to late September, when nighttime temperature begins to decline enough to cause natural dissolution of atmospheric oxygen.

ANNUAL MONITORING PROGRAM

The Monroe County Department of Health has managed the monitoring program in partnership with the Monroe County Department of Environmental Services. Irondequoit Bay has 31 years of monitoring records dating back to 1984. The frequency of monitoring has varied over this period ranging from daily, weekly, bi-weekly, monthly and bi-monthly during winter ice cover. For example, in 1993 the bay was monitored on 25 different days at 11 locations. In 2015, staff visited the bay on 17 days and monitored at 2 locations, Station 1 and Station 2 (Figure 2) Years of high intensity monitoring were often the result of a large scale intervention such as the alum treatment or the start of oxygenation. Current monitoring can be thought of as "strategic monitoring" where staff and resources are utilized to continue the decades long effort to provide the specific data required to determine the health of the bay.

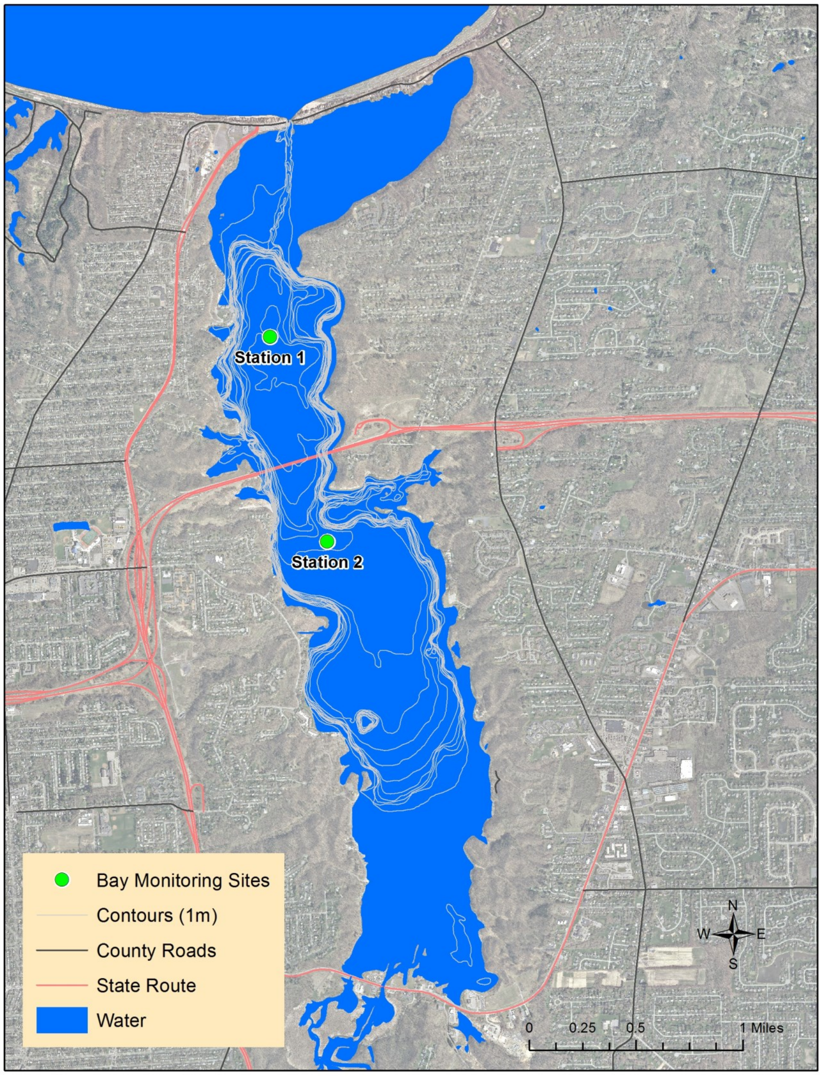


Figure 2 Irondequoit Bay 2015 monitoring stations.

The primary tool for bay monitoring is the Hach Surveyor 4a Hydrolab. The hydrolab is a multi-parameter probe that is lowered into the water and readings are taken at various depths creating a "profile." Every monitoring visit to the bay includes a hydrolab profile along with station observations. Measurements are taken for the following:

Hydrolab Profile

Depth
Temperature
pH
Dissolved Oxygen
Specific Conductance
Oxidation/Reduction Potential
Turbidity

Station Observations

Secchi Disk
Total Depth
Air Temperature
Cloud Cover
Surface Elevation
Wind Direction
Wind Speed

During the hydrolab profile, the probe is lowered into the water and the readings for the various parameters are recorded on a field log sheet. Measurements are taken at every meter and half meter when the bay begins to stratify. Figure 3 shows an example of a hydrolab profile for depth, temperature, dissolved oxygen and specific conductance and how data can be compared from different profiles.

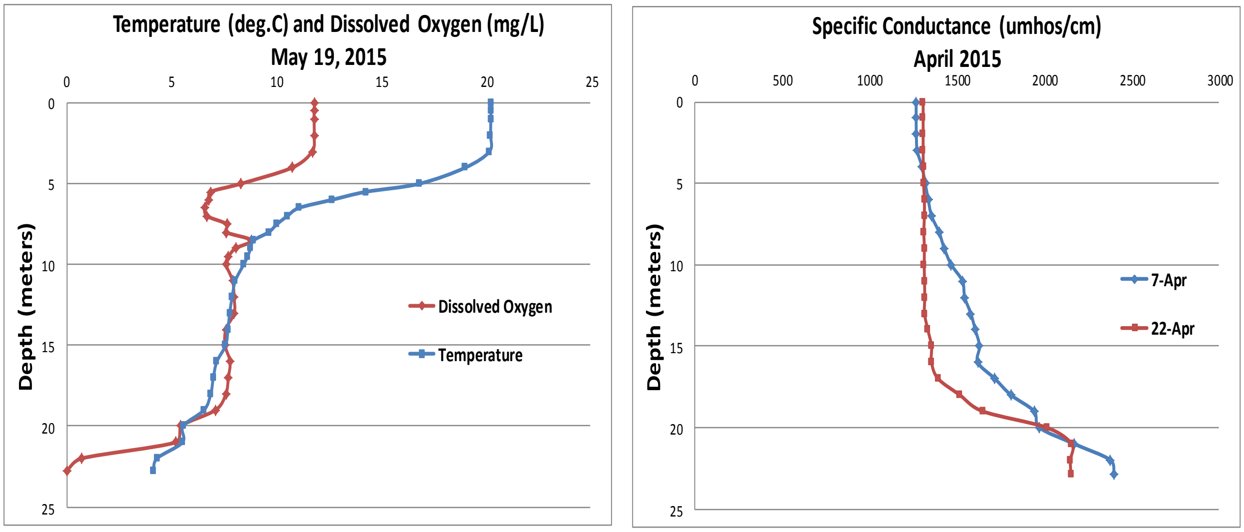


Figure 3 Examples of 2015 hydrolab profiles showing temperature, dissolved oxygen and specific conductance.

In 2015 the bay was monitored twice per month. Each visit included a hydrolab profile at both Stations and every other visit included collection and chemical analysis of water samples from Station 1. The chemical analysis allows us to investigate other parameters such as nutrients, metals and solids.

Collected samples are then analyzed at the Monroe County Environmental Lab. Chemical analysis includes the following:

Irondequoit Bay Chemical Analysis

Total Phosphorus	Dissolved Phosphorus	Ammonia
Total Kjeldahl Nitrogen	Nitrate/Nitrite	Chloride
Conductivity	Chlorophyll-a	Alkalinity
Hardness	Total Dissolved Solids	Fecal Coliform
Total Suspended Solids	Iron	Manganese

Samples are drawn from the water at various depths by a pump with a tube connected to the hydrolab cable. The pump is operated continuously as the hydrolab is lowered to various depths. This allows the sample line to be purged and fresh water from each depth to always be collected. Composite samples are made from the stratified layers, (Figure 4) as measured by the temperature and specific conductance probes on the hydrolab. These depths can vary during the year as temperatures change, so the technician collecting the sample determines where the boundaries are and when one layer ends and the next begins. In general, the epilimnion (warmer surface waters) comprises the top 6 meters, the metalimnion (transition zone) 6-12 meters and the hypolimnion (deep cold water) 12-22 meters. This report uses those fixed depths to define the zones rather than the actual measured position of the thermocline on any given day. This allows for consistency with values in previous reports and ensures that the volume of a discussed segment is consistent over time.

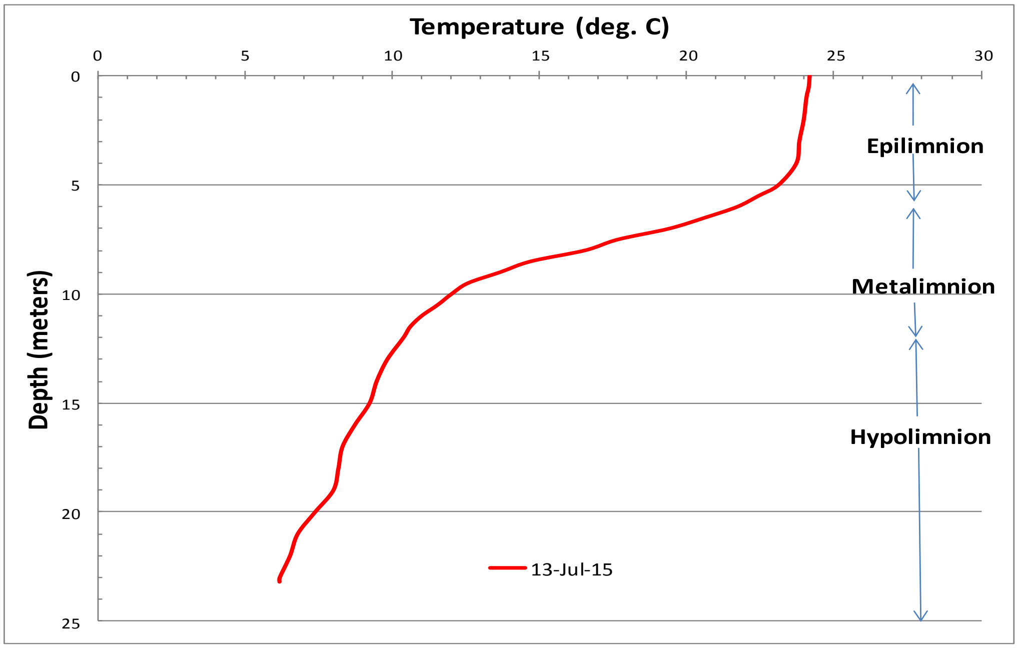


Figure 4 Example of thermal stratification in Irondequoit Bay.

2015 Rainfall

Weather data in Monroe County is collected by the National Weather Service at the Greater Rochester International Airport. That data was used to calculate the 30-year monthly mean precipitation totals for Monroe County for the years 1984-2015. Figure 5 shows the monthly mean precipitation compared to the 2015 monthly measured totals. The 2015 monitoring season was slightly wetter than average with 36.67 inches of precipitation compared to the 30-year annual average of 34.53 in. The departure from the average annual precipitation of nearly 2 in. was largely the result of above average precipitation during the summer months (June-Sept). June was the wettest month with nearly 3 inches above normal.

The Monroe County Department of Environmental Services maintains a rain gage in the Irondequoit Creek watershed at the Thomas Creek wastewater pump station (Figure 1). Measured rainfall for 2015 at Thomas Creek was also higher than the 30 year annual mean precipitation at the airport with a total of 37.5 in. The gage showed similar departures of above average rainfall during the summer months, and a 2 in. difference in the February total. The airport recorded 45.2 inches of snow in February which translated into 2.51 inches of precipitation. Thomas Creek only measures rain and since most of the precipitation in February was snow it showed a lower total than the airport.

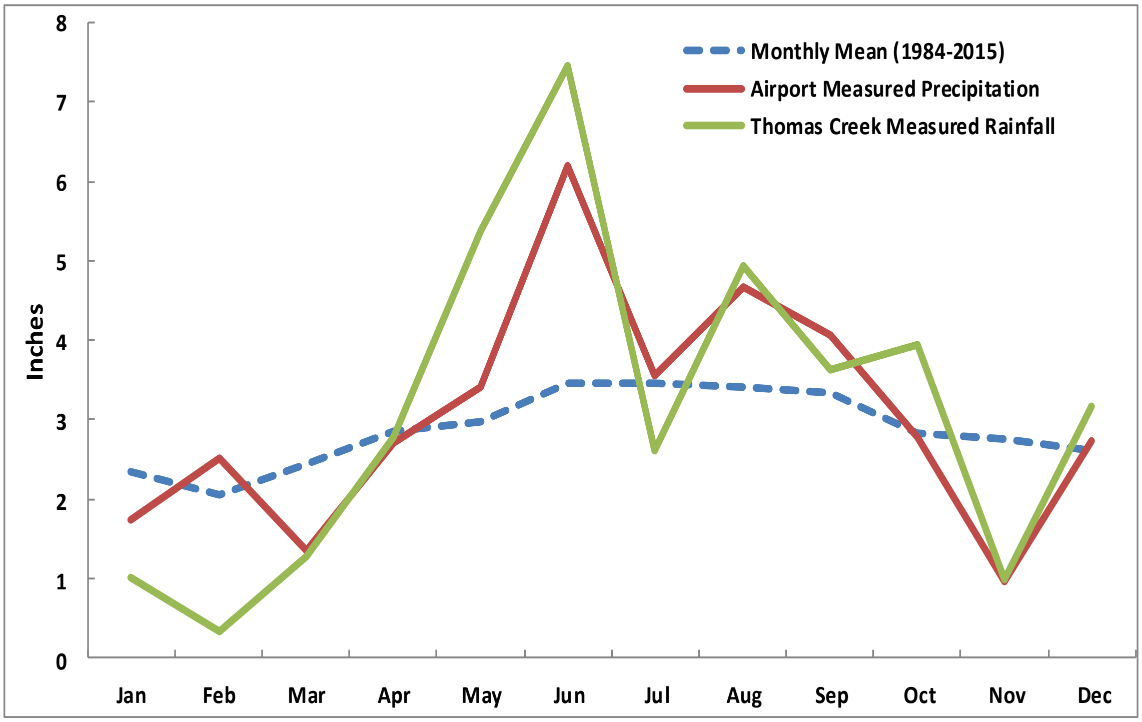


Figure 5 Precipitation at Rochester, NY; monthly measured for 2015 and monthly mean at Rochester International Airport (1984-2015); 2015 measured precipitation at Thomas Creek rain gage.

MONITORING RESULTS

Results and findings from the 2015 monitoring year will be presented in the following two sections: (a) thermal stratification and vertical profiles; (b) lake trophic indicators - Secchi Disk depths, total phosphorus, chlorophyll *a*, oxygen. Metals, chlorides, nitrogen and other analytes are presented in the Additional Monitoring Results section.

For this report, summer is defined as the period from June 1 through September 30. Past reports used the period May 1 through October 31, however the June-September time frame is more consistent with state and federal standards and norms for monitoring.

a. Thermal Characteristics and Vertical Profiles

Thermal stratification is a physical phenomenon which occurs in many lakes and reservoirs, and refers to the formation of distinct temperature layers within a water body. The process of thermal stratification is a consequence of the relationship between the temperature of water and its associated density.

Thermal stratification has profound effects on many physical, chemical, and biological processes within a lake. These effects are largely due to the formidable mixing constraints imposed by thermal stratification. Mixing constraints strongly influence circulation patterns (physical process) within a waterbody. In many ways, the stratified lake begins to behave like two distinct water bodies. The upper portion (epilimnion) behaves much like a shallower version of the previously unstratified lake with well mixed conditions and efficient gas and thermal exchange with the atmosphere, while the lower portion of the lake (hypolimnion) begins to "wall off" with little gas and/or thermal exchange with the overlying waters. This transformation from a nonstratified system into a stratified system, results in a cascade of secondary effects (chemical and biological) within the system. This thermal barrier to vertical mixing can play a critical role in determining the level of dissolved oxygen available within the deep waters of a lake. In effect, thermal stratification forms a physical barrier to mixing between the upper layer of the bay, which can receive oxygen from the atmosphere, and the lower layer of the bay, which is unable to receive oxygen input from the atmosphere, thus, precluding oxygen replenishment of the deep waters.

If dissolved oxygen demand within the hypolimnion is relatively low, then dissolved oxygen levels remain sufficient to sustain a diverse biota. However, if oxygen demand is high and the lower waters become depleted of dissolved oxygen, the result can adversely affect resident biotic communities and modify chemical cycling within the bay.

From a positive perspective, thermal stratification plays a central role in maintaining appropriate temperatures for certain thermally-sensitive organisms (e.g., salmonids). The same thermal barrier responsible for inhibiting oxygen exchange between upper and lower waters also works to limit thermal gain by the lower waters, thus maintaining lower temperatures at depth.

Figure 6 shows spring, summer and fall vertical profiles for Irondequoit Bay during the 2015 monitoring season. This demonstrates the annual process of thermal stratification and oxygen depletion in the hypolimnion.

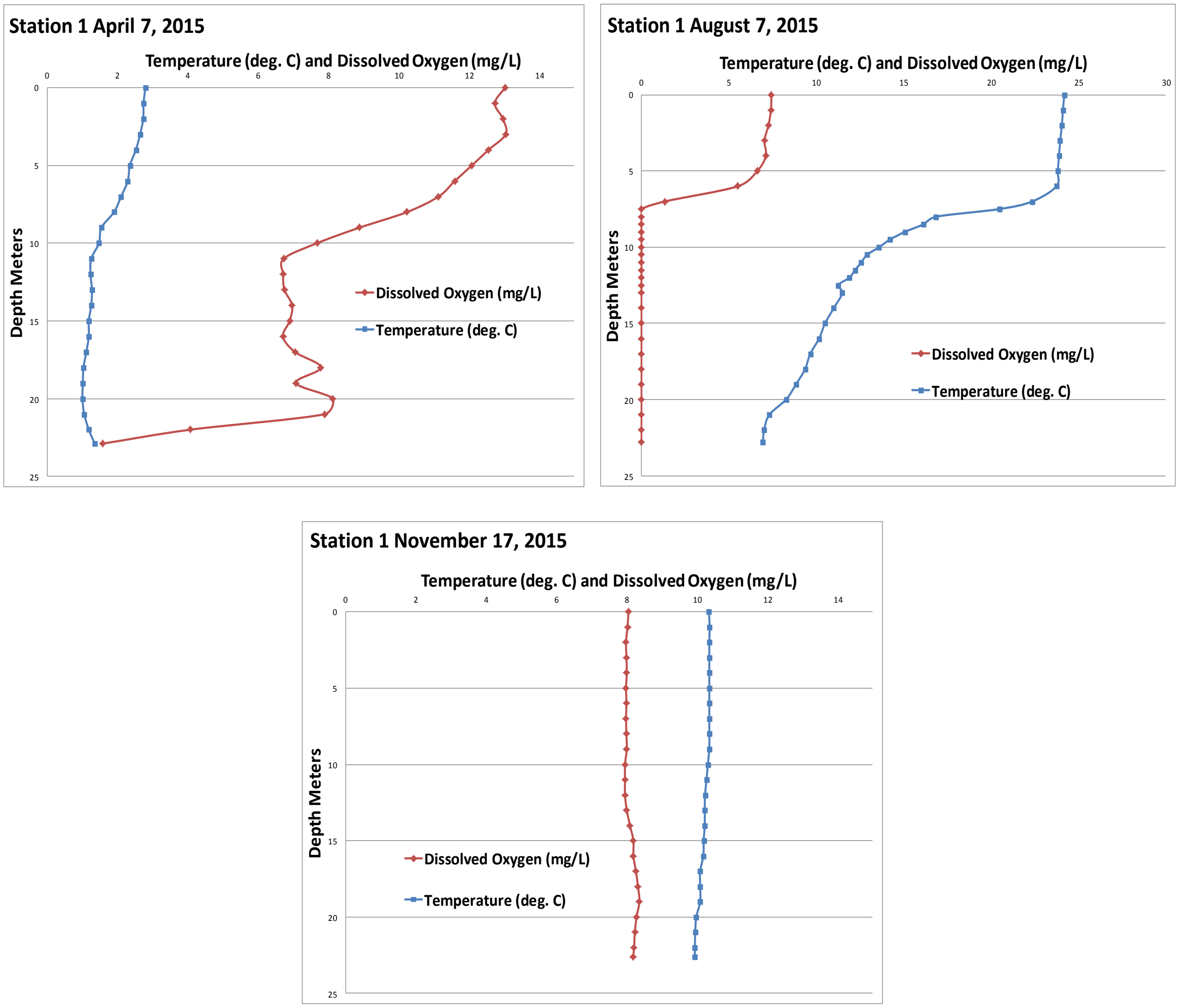


Figure 6 Vertical profiles in Irondequoit Bay showing the seasonal transition in temperature and dissolved oxygen.

b. Bay Trophic Indicators

Trophic state is the principal metric used to assess the relative health of freshwater lakes and bays. Trophic state refers to the level of primary productivity for a given water body. Primary productivity, defined as the mass of algae produced within a water body, is estimated by measurements of chlorophyll *a*, the main photosynthetic pigment in algal cells. There is a natural progression in the “life” of a lake from oligotrophy to eutrophy, which is generally measured in thousands of years. However, anthropogenic (human) activities can greatly accelerate the natural “aging” process in what is termed cultural eutrophication. Cultural eutrophication is characterized by increases in nutrient loading and primary productivity. The process can lead to declines in water quality (e.g., decreased water clarity, increased occurrence of algal blooms).

Irondequoit Bay has had a history of nutrient enrichment and eutrophication stemming from sources such as waste water and stormwater runoff. The thirty year monitoring record provides a useful tool to compare current monitoring results to historical results. In 1985, the Irondequoit Bay Water Quality Management Plan (WQMP) established a goal of a nutrient balanced, mesotrophic state for the bay. Current monitoring data are compared to that goal.

Total Phosphorus

Phosphorus is an essential element for plant life, but when there is too much of it in water, it can speed up eutrophication of rivers and lakes. The water quality in Irondequoit Bay has largely been a story of excess phosphorus and various measures to control the external and internal sources that can drive algae growth. Phosphorus can be measured as total phosphorus (TP) or as soluble reactive phosphate (SRP). SRP is also sometimes called phosphate (PO4) or orthophosphate (ortho-P). SRP represents the fraction of TP that is available to organisms for growth.

During the 2015 monitoring season, the bay was sampled for total phosphorus and soluble reactive phosphorus twelve times from April thru November. Figure 7 shows the results. Hypolimnion phosphorus levels showed a marked increase as the summer season progressed. Metalimnion levels increased along the same pattern indicating that phosphorus was diffusing upwards from the hypolimnion into the metalimnion. The target range established by the 1984 WQMP is for epilimnion total phosphorus concentrations between 10-30 ug/L. The first samples collected in April 2015 were above the target zone but dropped and remained at 20ug/L through most of September. As the bay began fall mixing, epilimnion phosphorus began to increase as hypolimnetic dissolved phosphorus made its way to the surface.

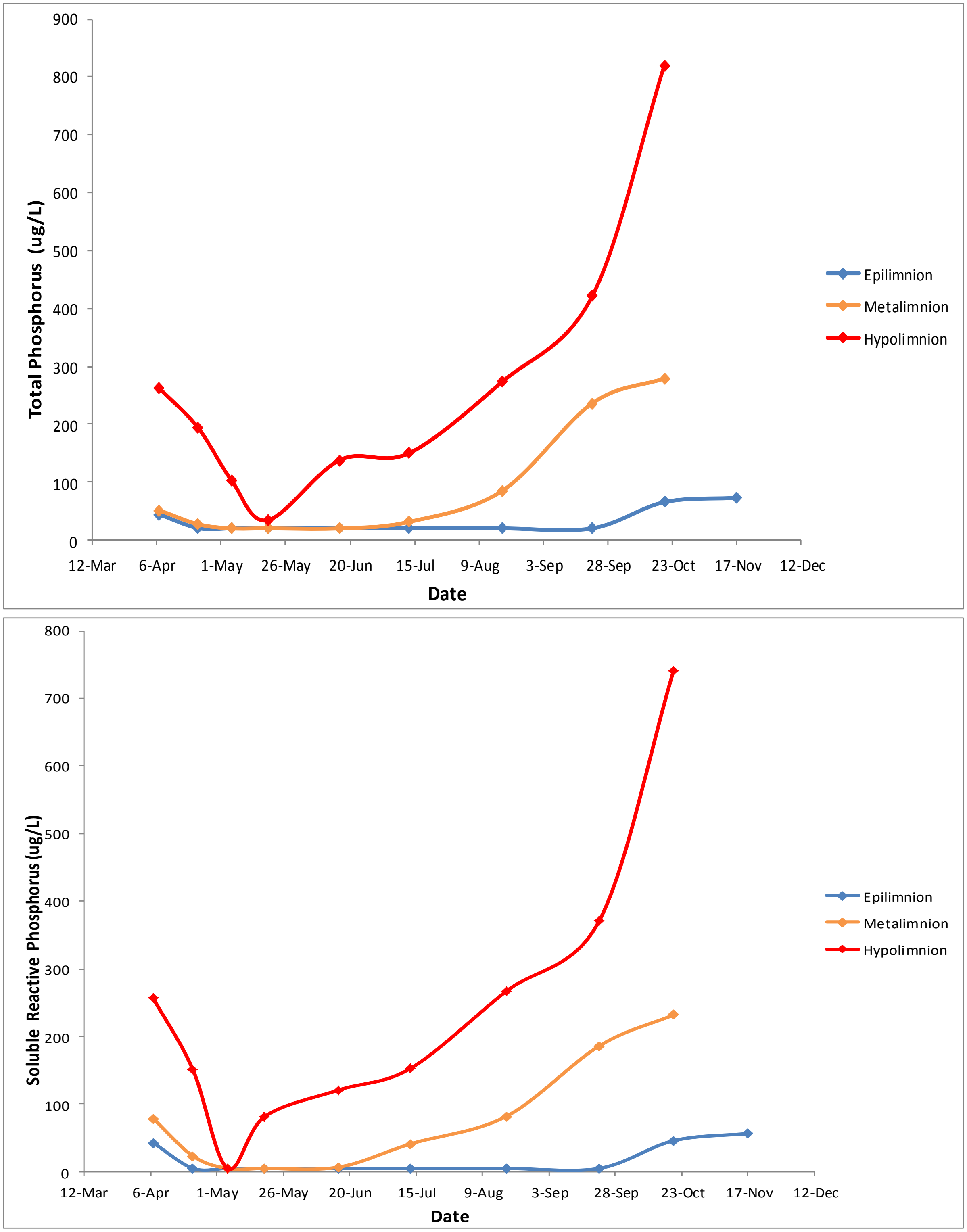
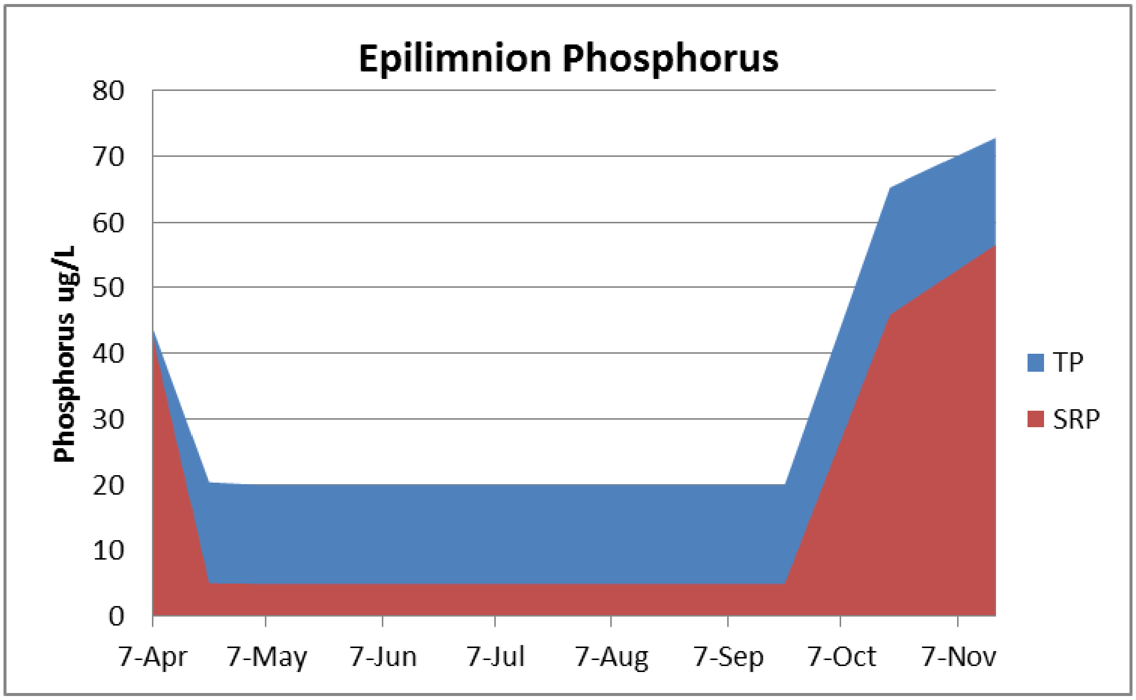


Figure 7 Station 1 2015 Total and dissolved phosphorus.

Figure 8 shows the fraction of total and dissolved phosphorus in the epilimnion and hypolimnion. It clearly demonstrates the increasing levels of phosphorus in the hypolimnion and the fall diffusion of dissolved phosphorus from the deep water to the shallow epilimnion.



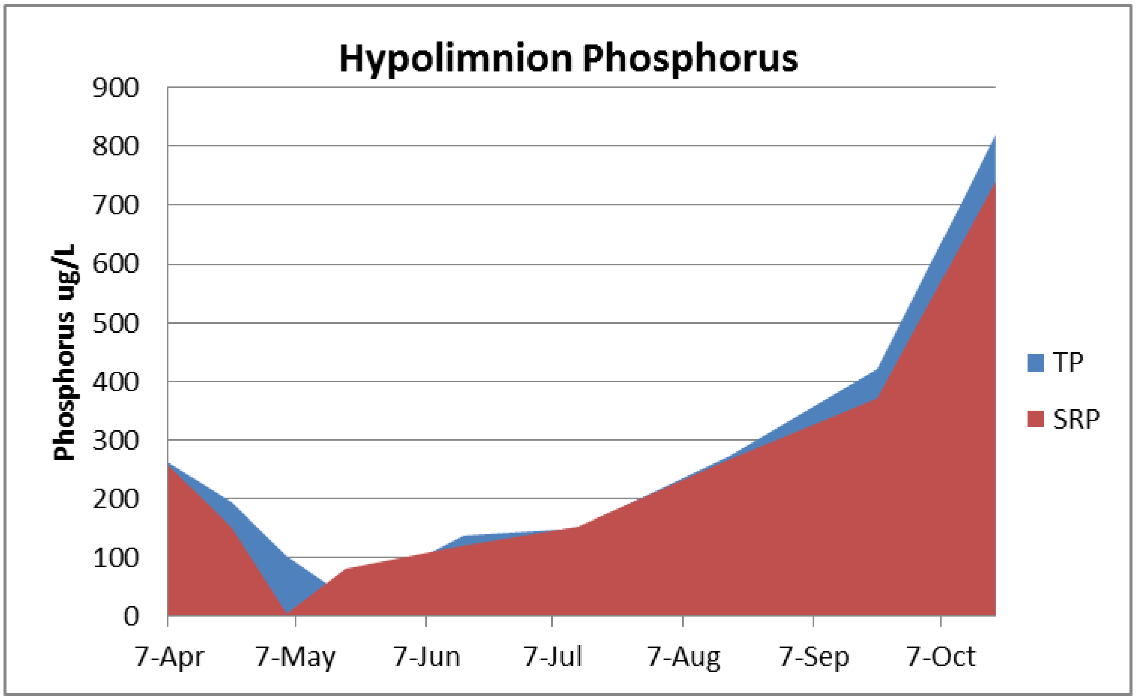


Figure 8 2015 total phosphorus (TP) and soluble reactive phosphorus (SRP) in the epilimnion and hypolimnion of Irondequoit Bay.

Chlorophyll-a

Chlorophyll is the green pigment in plants that allows them to create energy from light for photosynthesis. By measuring chlorophyll, you are indirectly measuring the amount of photosynthesizing plants found in a sample. In a bay water sample, these plants would be algae or phytoplankton. Chlorophyll is a measure of all green pigments whether they are active (alive) or inactive (dead). Chlorophyll-a is a measure of the portion of the pigment that is still active; that is, the portion that was still actively respiring and photosynthesizing at the time of sampling. It is one of the key measures of lake health and eutrophication.

Algae populations, and therefore chlorophyll-a concentrations, vary greatly with bay depth. Algae must stay within the top portion of the bay where there is sunlight to be able to photosynthesize and stay alive. As they sink below the sunlit portion of the bay, they die. Therefore, few live algae (as measured by chlorophyll-a) are found at greater depths.

During the 2015 monitoring season chlorophyll-a was measured 12 times at Station 1. The results from the epilimnion samples are shown in Figure 9 and compared to the WQMP target range of 5-10 ug/L.

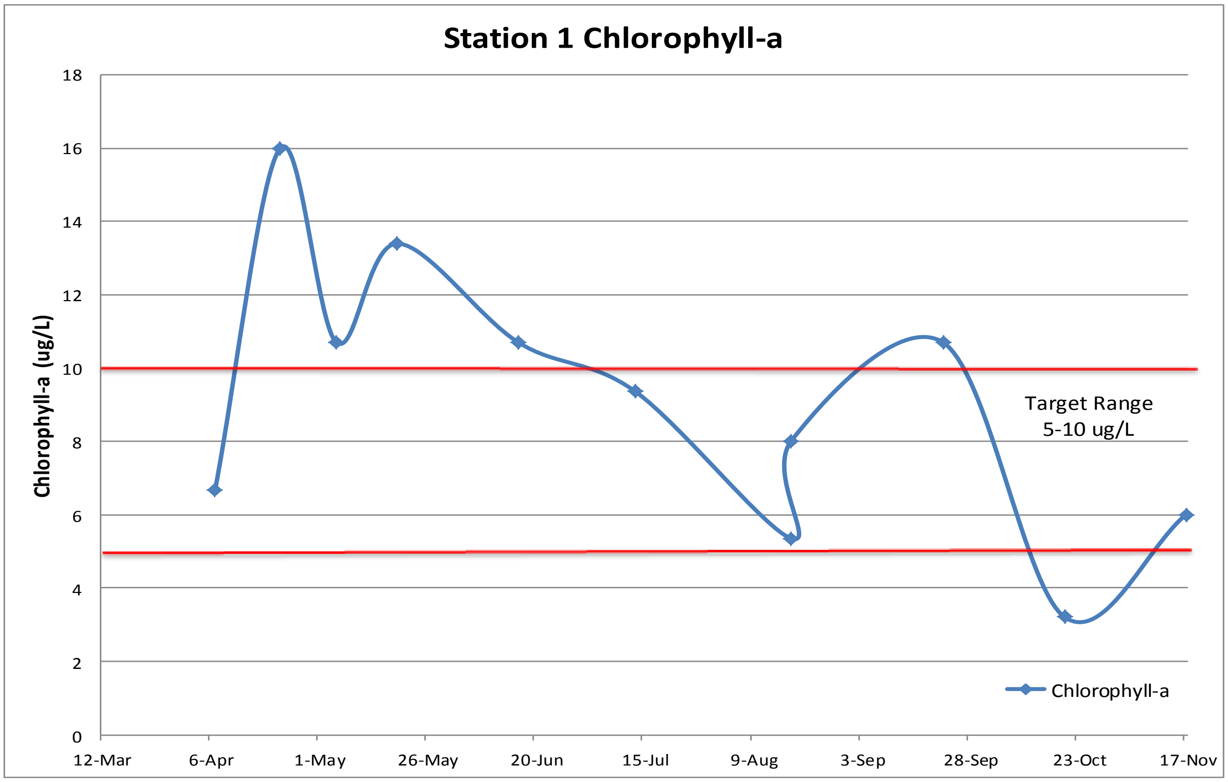


Figure 9 Station 1 epilimnion chlorophyll-a during the 2015 monitoring season.

Secchi Transparency

A Secchi disk is a circular plate divided into quarters painted alternately black and white. The disk is attached to a rope and lowered into the water until it is no longer visible. Secchi disk depth, then, is a measure of water clarity. Higher Secchi readings mean more rope was let out before the disk disappeared from sight and indicates clearer water. Lower readings indicate turbid or colored water. Clear water lets light penetrate more deeply into the bay than does murky water. This light allows photosynthesis to occur and oxygen to be produced. The rule of thumb is that light can penetrate to a depth of 1.7 times the Secchi disk depth.

Clarity is affected by algae, soil particles, and other materials suspended in the water. However, Secchi disk depth is primarily used as an indicator of algal abundance and general lake productivity. Although it is only an indicator, Secchi disk depth is the simplest and one of the most effective tools for estimating the bay's productivity. Readings for Irondequoit Bay can sometimes be influenced by sediment particles entering the bay from Irondequoit Creek following heavy rains. The high particulates present in the runoff can result in cloudy water thus yielding a lower Secchi reading.

During the 2015 monitoring season Secchi disk was measured 15 times at Station 1. The results are displayed in Figure 10.

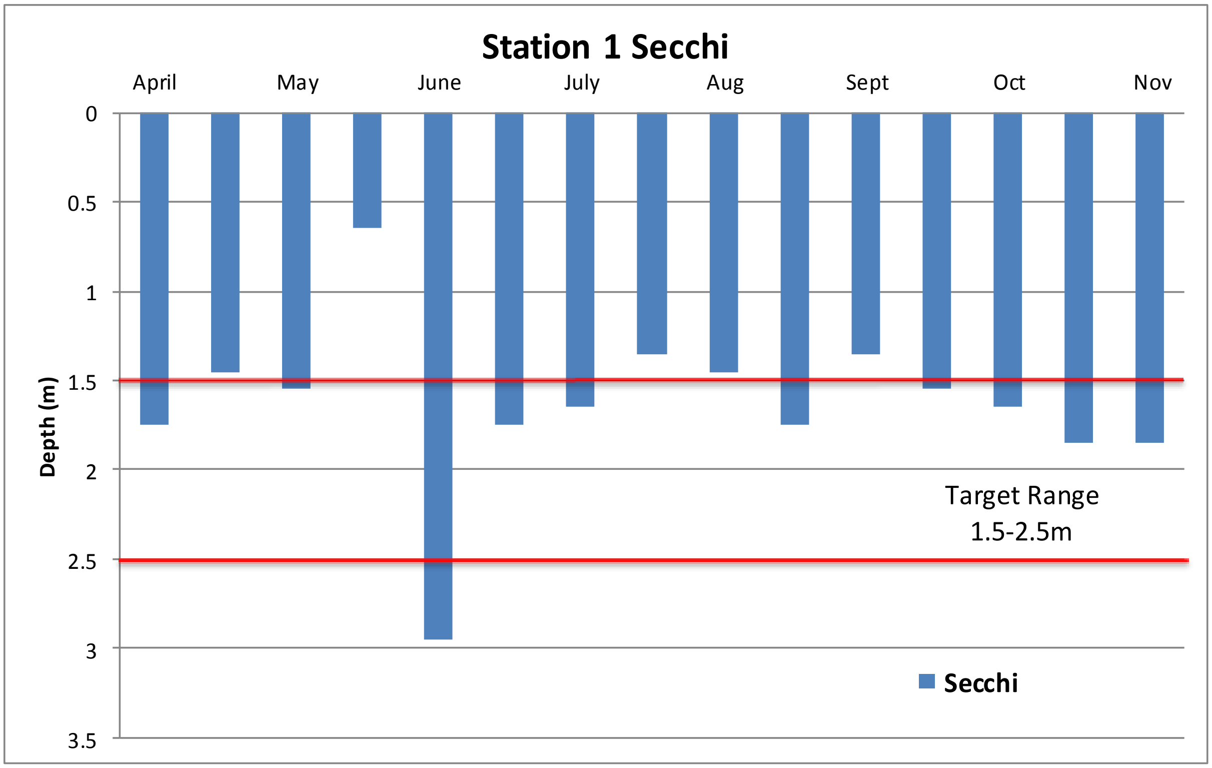


Figure 10 Secchi disk readings at Station 1 during the 2015 monitoring season.

Oxygen

The final parameter which is frequently used to determine the trophic status of a lake is the level of dissolved oxygen (DO) in the hypolimnion (colder waters). Oxygen is more soluble in cold water than in warm water. Thus, all other factors being equal, the colder the water the higher the level of dissolved oxygen. However, increasing trophic levels can lead to decreasing dissolved oxygen levels in the hypolimnion in a process referred to as DO depletion.

The nomenclature for dissolved oxygen depletion include the terms: (1) anoxia – which is defined as a complete absence of oxygen (DO 0 mg/L); and (2) hypoxia – which is defined as reduced levels of oxygen (DO 1-4mg/L). DO depletion within the hypolimnion of a lake is the result of several factors, including: (a) lake stratification - which creates a thermal/density barrier to oxygen transfer between the epilimnion and the hypolimnion of a lake thus, inhibiting reoxygenation of hypolimnetic waters; (b) the biological aging of algae which results in the settling of organic matter, decay, and exertion of DO demand within the hypolimnion; (c) bottom sediment oxygen demand – which exerts additional DO demand within hypolimnetic waters; and (d) morphological factors such as the volume of the hypolimnion relative to the epilimnion.

Irondequoit Bay has a long history of hypolimnetic oxygen depletion from eutrophication. Every monitoring visit to the bay includes a dissolved oxygen profile to determine the depth and extent of hypoxic/anoxic conditions. Figure 11 shows the anoxic area at Station 1 during the 2015 monitoring season. Anoxia starts in May and ends in November when the bay mixes.

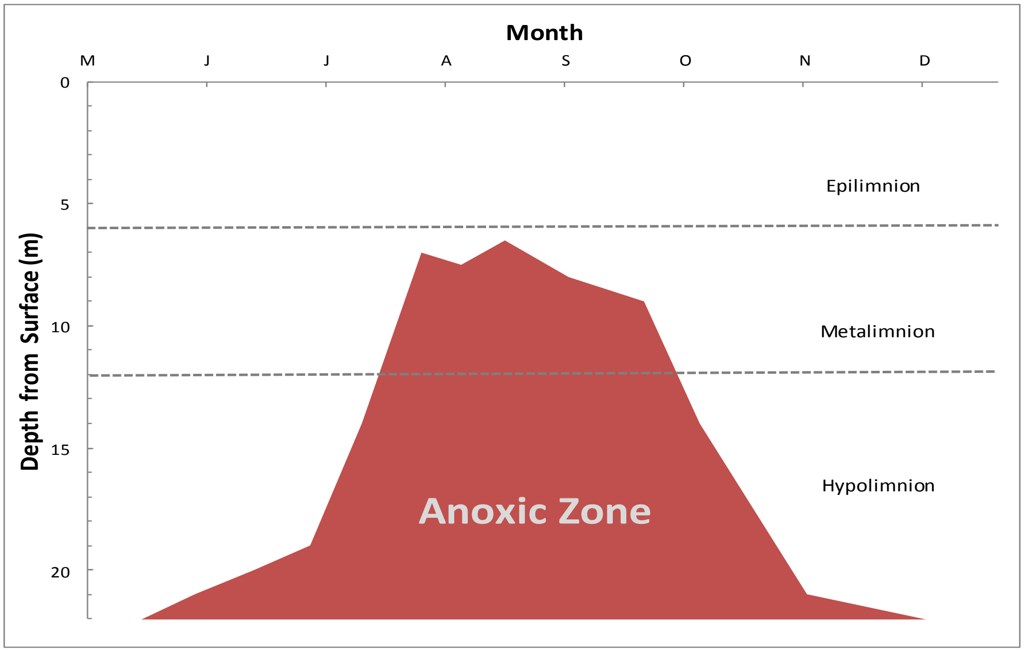


Figure 11 Station 1 anoxic zone during 2015 monitoring season. The shaded area represents the depths with dissolved oxygen depletion.

Oxygenation Program

Beginning in 1993 a program was initiated to supplement the deep waters of the bay with oxygen. The purpose of this project is to increase control of phosphorus by both biological and chemical processes leading to improved conditions in Irondequoit Bay. The original project hypothesis was that as oxygen conditions improved, cold-water fish species would be drawn back into the system to graze on microscopic plants and animals and reduce the amount of algae settling to the bottom and decaying. This would reduce the deep water use/depletion of oxygen. The goal for this was to maintain oxygen levels in the metalimnion between 0.5 and 1.5 mg/L thereby creating an oxygenated zone for this process to occur.

Oxygenation is accomplished through the use of a Liquid Oxygen Injection (LOI) system. Liquid oxygen passes through an evaporator and is gravity fed into the hypolimnion through five diffusers (Figure 12) located approximately six feet above the bottom of the bay. Oxygen supplementation is initiated in early July when the median dissolved oxygen concentration in the metalimnion shows signs of anoxia (low measured dissolved oxygen, negative oxidation reduction potential), and ended in mid to late September, when nighttime temperature begins to decline enough to cause natural dissolution of atmospheric oxygen.

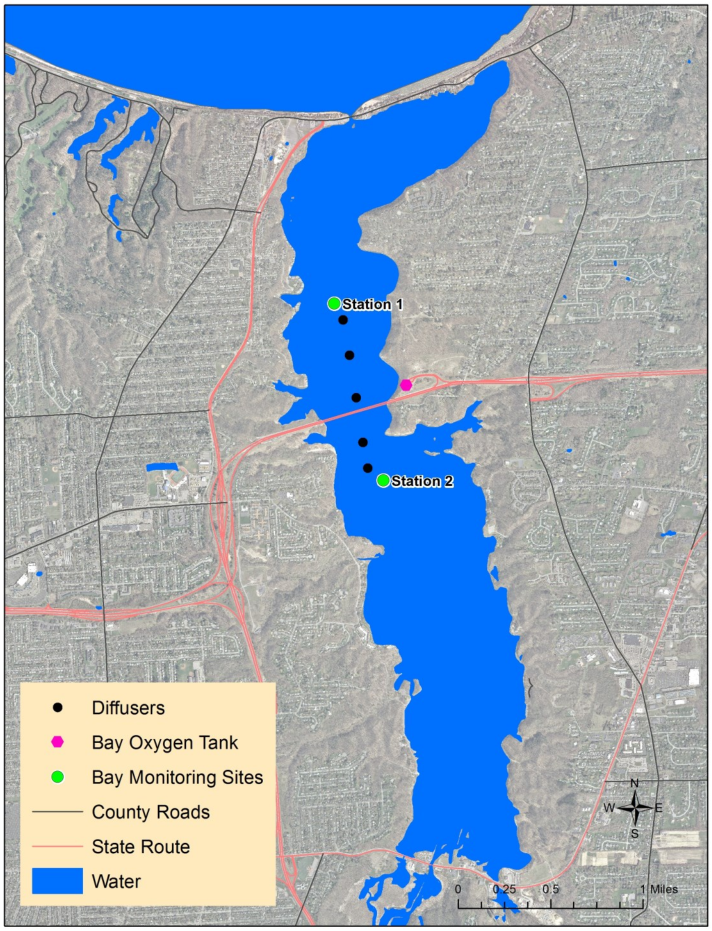


Figure 12

The location of the oxygen tank and 5 diffusers on Irondequoit Bay.

A potential secondary benefit from oxygenation is limiting the release of soluble reactive phosphorus (SRP) from the bottom sediments. A study funded by the Great Lakes Protection Fund in 2002-03 concluded that oxygenation was effectively inhibiting release of sediment phosphorus associated with iron, thereby preventing dispersion of this phosphorus into the surface waters of the bay during the summer growing season. Dissolution of manganese, which is soluble at low levels of oxygen, does occur, however the conclusion that iron/manganese ratios of approximately 10/1 indicates that internal loading is potentially much higher without the addition of oxygen.

Figure 13 shows summer average annual hypolimnetic manganese (Mn), iron (Fe) and soluble reactive phosphorus. There is an upward trend in SRP (R^2 =0.76) but this pattern is not seen as strongly in the iron and manganese data. The SRP data does not correlate well with the metals having correlation coefficients of 0.22 (Mn) and 0.12 (Fe). It does not appear that this increasing concentration of phosphorus in the hypolimnion is mixing with the upper level waters until later in the year when fall mixing starts to occur.

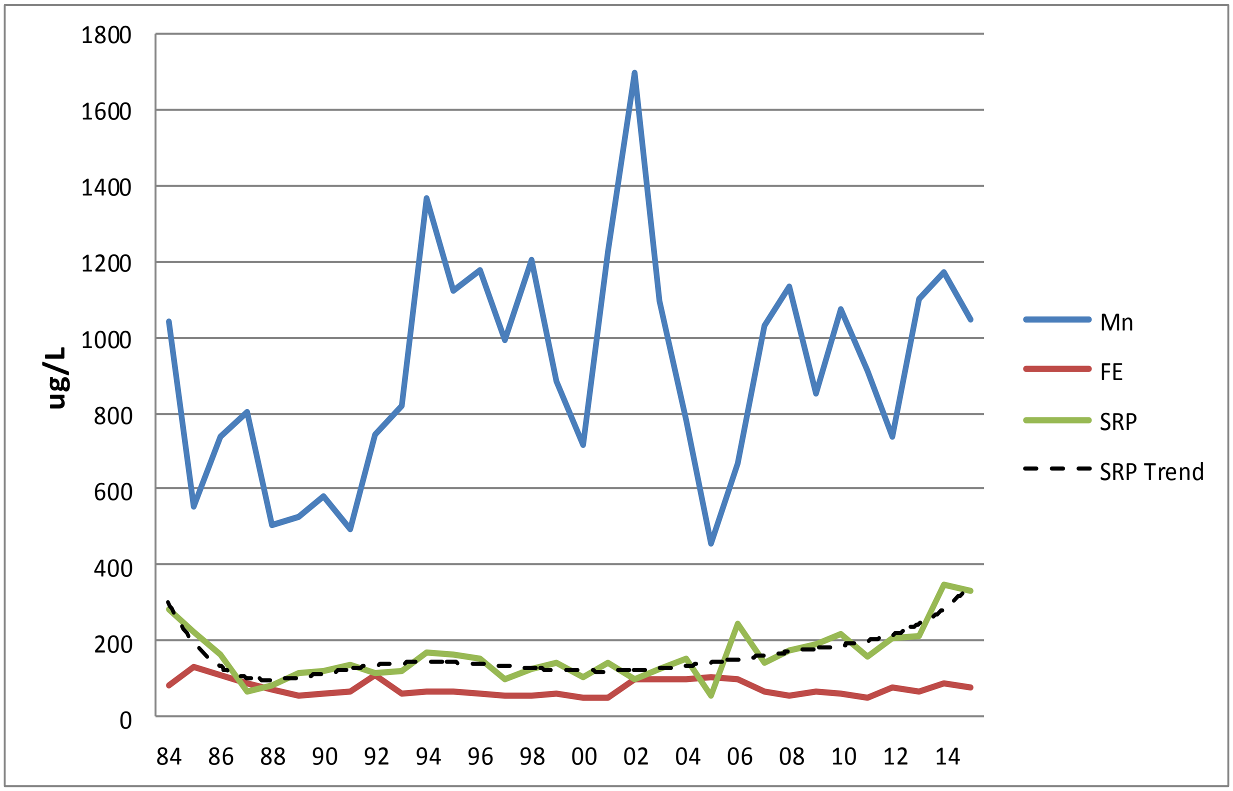


Figure 13 1984-2015 hypolimnion summer average iron (Fe), manganese (Mn), soluble reactive phosphorus (SRP) and the long term trend for hypolimnion SRP.

ADDITIONAL MONITORING RESULTS

This section will provide data and brief narrative descriptions for additional parameters monitored during 2015. These include metals (iron & manganese), chloride, nitrogen, total suspended solids, fecal coliform, total dissolved solids and hardness.

Metals

Phosphorus cycling in lakes may be strongly influenced by the release of sediment bound phosphorus during periods of anoxia. Phosphorus has a strong affinity for sorption onto surfaces of iron (Fe) and manganese (Mn). A measure of the concentration of these metals can indicate if the conditions are present that will lead to phosphorus being released from the bottom sediments and potentially making its self available for use in the epilimnion.

Levels of hypolimnetic iron and manganese are presented in Figure 14.

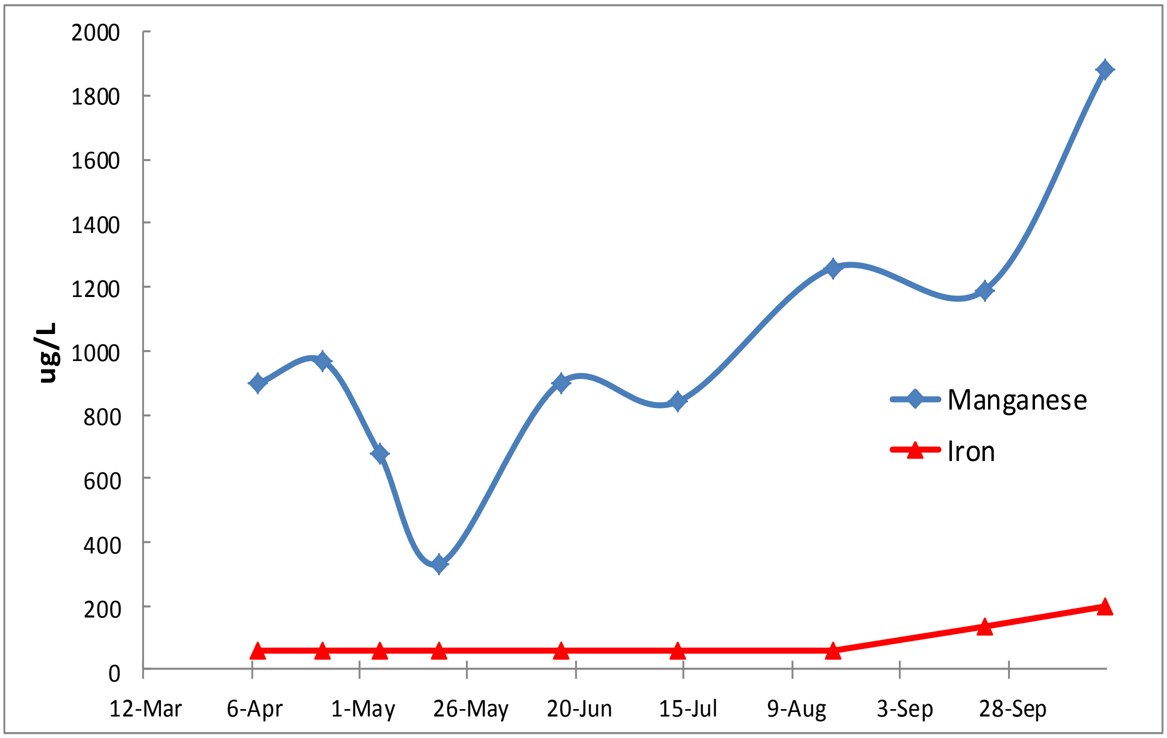


Figure 14 Hypolimnion iron and manganese during the 2015 monitoring season showing the upward trend towards fall mixing.

Chloride

Monroe County winters demand an effective and affordable means of de-icing roadways. The primary agent used for this purpose is sodium chloride (road salt), which is composed of 40 percent sodium ions (Na+) and 60 percent chloride ions (Cl-) . Generally, the concentration of chloride found in surface waters correlates with the proportion of impervious surfaces in the watershed. Chloride cannot be treated or filtered with best management practices such as storm ponds, so once road salt is applied, chloride remains in the watershed until it is flushed downstream. Water contaminated with chloride creates a higher water density and will settle at the deepest part of the water body. This can lead to chemical stratification which can impede natural turnover and mixing, preventing the dissolved oxygen within the upper layers of the water from reaching the bottom layers, and nutrients within the bottom layers from reaching the top layers. This leads to the bottom layer of the water body becoming void of oxygen and unable to support aquatic life. This process of chemical stratification, and lack of mixing, occurred in the bay during the 1970's and early 1980's due to high chloride levels.

The annual average hypolimnion chlorides from 1984– 2015 are shown it Figure 15. Levels in 2015 eclipsed previous highs by a wide margin with the maximum chloride on April 7, 2015 of 591 mg/L being the highest concentration recorded in Irondequoit Bay since 1984. The spring (March-May) average for 2015 of 404 mg/L was nearly double the long term average of 205 mg/L making 2015 noteworthy as a year of exceedingly high chloride levels in the bay.

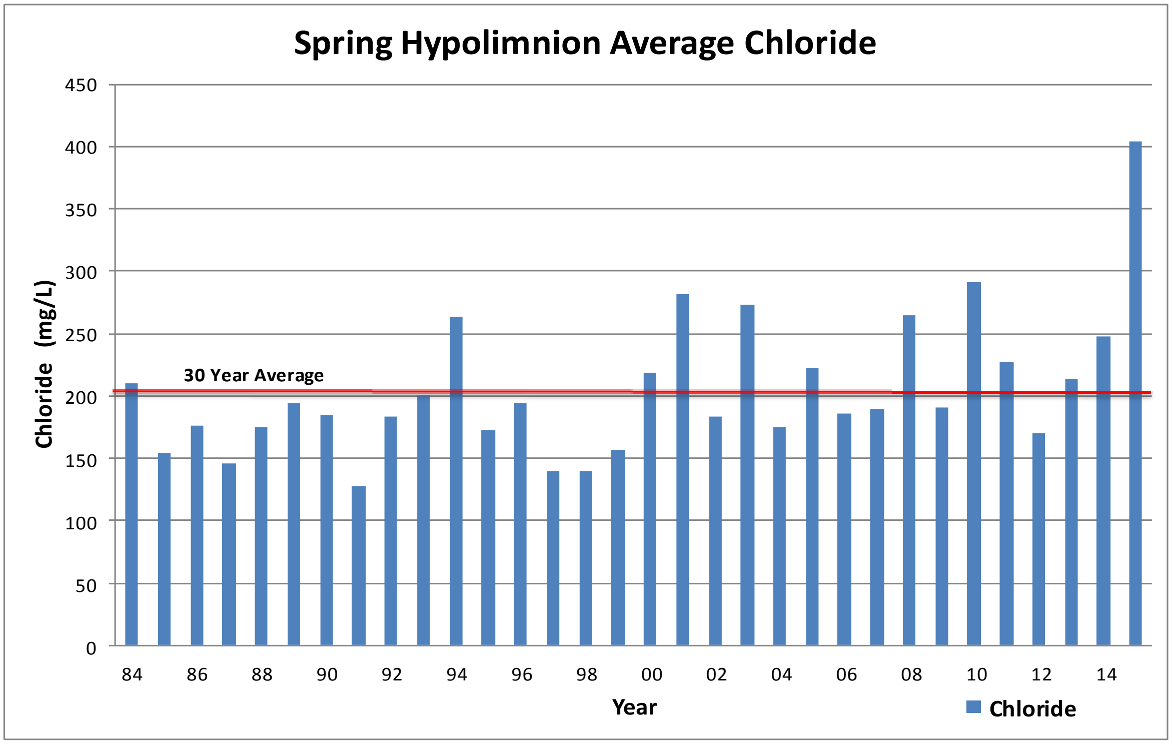


Figure 15 Average spring (March—May) hypolimnion chlorides from 1981-2015.

During each monitoring profile, the specific conductance (SC) of the water column is measured. SC is another means of detecting the concentration of chloride ions in water. The higher the value, the greater the amount of chloride. The advantage of looking at the SC is that the value is recorded at every meter depth so a profile can be established from epilimnion to hypolimnion. SC has been measured in the bay since the early 1970's.

As previously discussed, high chloride levels often prevented the bay from fully mixing in the spring during the 1970's and early 80's. This can be attributed to higher use of road salts during those years. A voluntary reduction in road salt usage by the municipalities in the watershed from 76,000 tons in 1969-70 to 43,000 tons by 1974-1985 had, for the most part, corrected this problem. However, in 1984, the Bay failed to completely overturn because of a substantial usage of road salt. Figure 16 shows August specific conductance profiles for 1971, (when the bay failed to mix completely), 1982, (when salt usage had been decreased and the bay fully mixed), and 2015, (a year of record salt concentrations in the spring hypolimnion). We can see that the 2015 profile, while not quite as high as 1971, very closely mirrors the pattern in 1971 when the bottom 11 meters of the bay failed to mix.

Irondequoit Bay did fully mix in 2015.

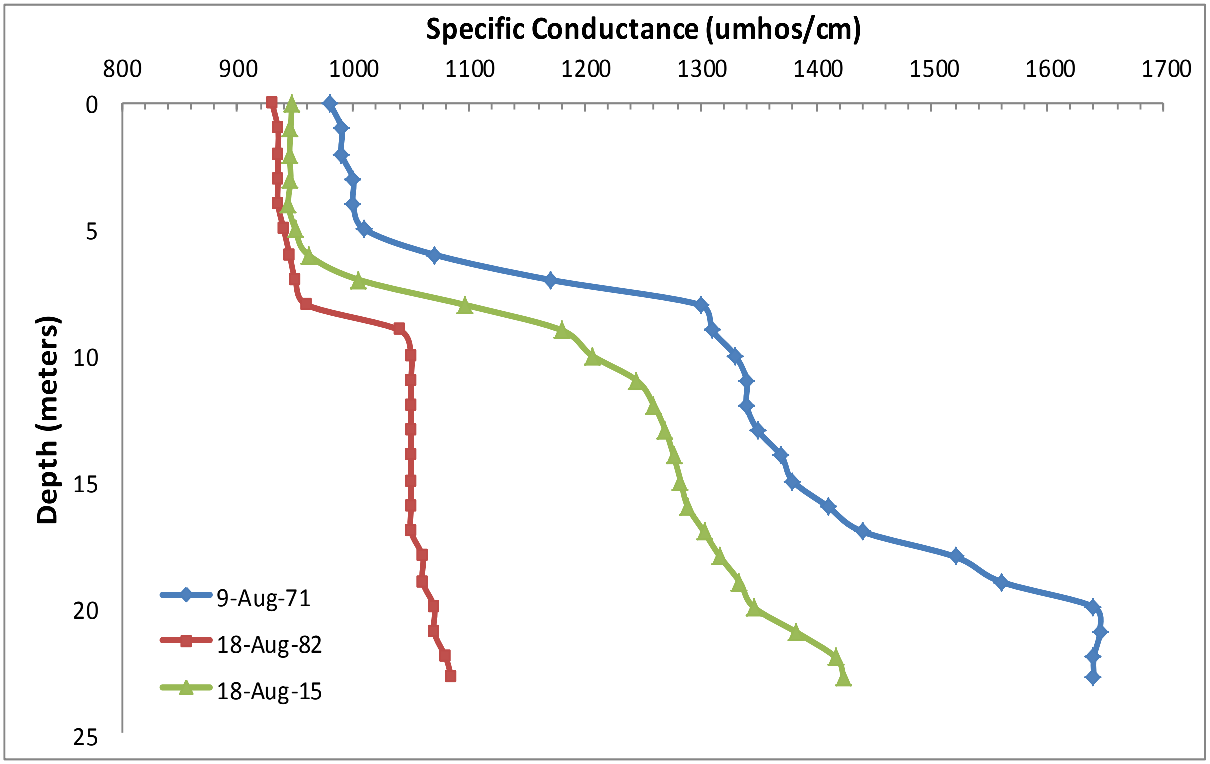


Figure 16 Specific conductance vertical profiles for August 1971, 1982 and 2015.

Nitrogen

Nitrogen is another key nutrient in the monitoring program along with phosphorus. Together, they provide the "food" for aquatic plants and algae to grow. Managing excessive amounts of phosphorus has long been thought to be the key to managing the health of the bay but too much nitrogen can also have adverse effects and lead to cyano-bacteria (blue-green algae), a toxic form of algae that has caused problems in several nearby lakes and bays.

Nitrogen can be measured as total nitrogen (TN), total Kjeldahl nitrogen (TKN), nitrate-nitrogen (NO3), nitrite-nitrogen (NO2). These are usually measured as nitrate-nitrite-nitrogen (NO3 – NO2), or ammonia-nitrogen (NH4). TN is similar to TP and is used to represent the total amount of nitrogen in a sample. TKN represents the fraction of TN that is unavailable for growth or bound up in organic form. The remaining fractions, NO3 – NO2 and NH4, represent bioavailable forms of nitrogen. If they are summed, they can be compared to the SRP fraction of phosphorus.

The annual monitoring program includes sampling for Total Kjeldahl Nitrogen (TKN) , Ammonia(NH4) and Nitrate-Nitrite (NO3-NO2). Results can be found in Figures 17-18. All results are typical of past years and show a pattern of increasing concentration of ammonia in the hypolimnion as the season progresses. This is a result of ammonia being released from the bottom sediments, a similar pattern to soluble reactive phosphorus release. As the bay begins to mix in the fall, the concentration in the epilimnion rises slightly.

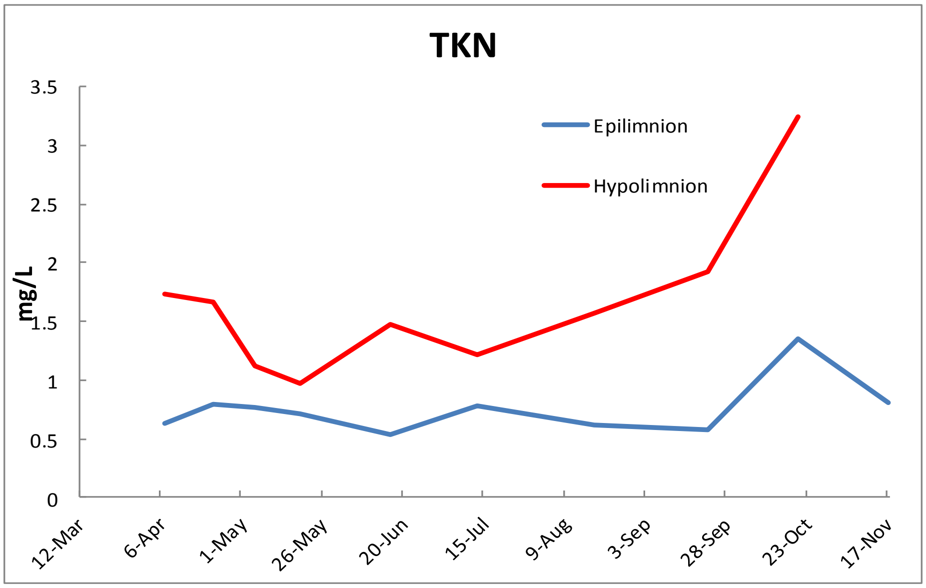
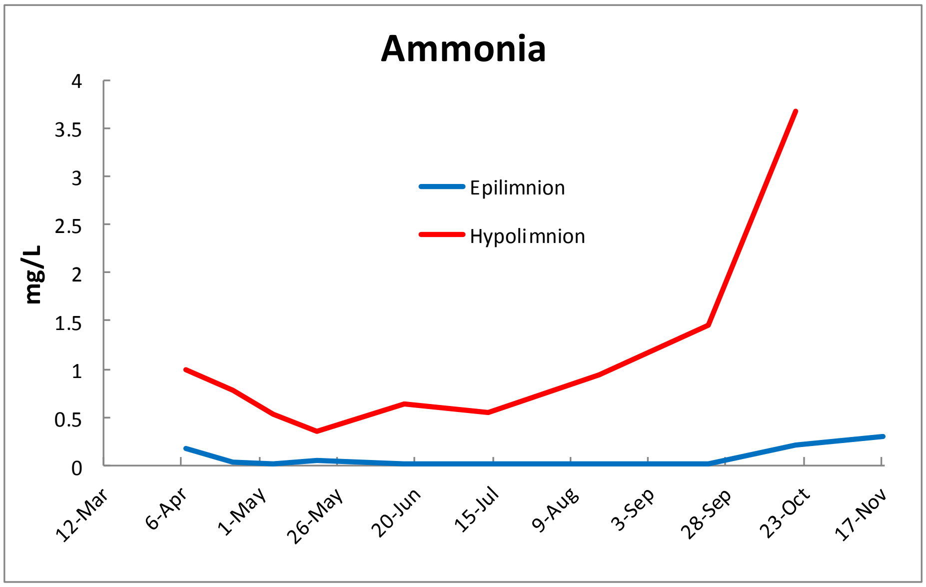


Figure 17 2015 Monitoring results for Total Kjeldahl Nitrogen (TKN).



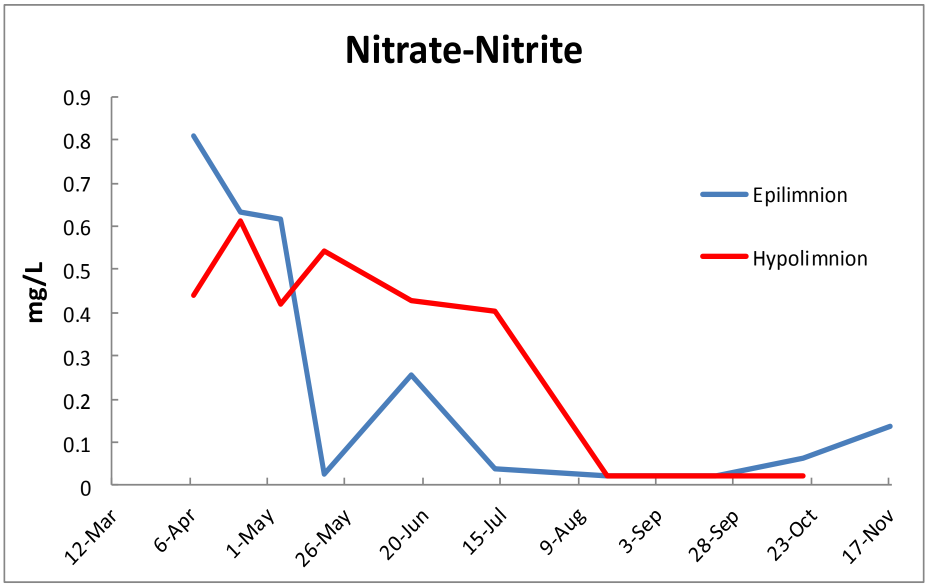


Figure 18 2015 Monitoring results for ammonia and nitrate-nitrite.

Total Suspended Solids

Total suspended solids (TSS) concentrations indicate the amount of solids suspended in the water, whether mineral (soil particles) or organic (algae) . High concentrations of particulate matter affect light penetration and productivity, recreational values, and habitat quality. Particles also provide attachment places for other pollutants, notably metals, nutrients and bacteria. Results for 2015 were typical of past years.

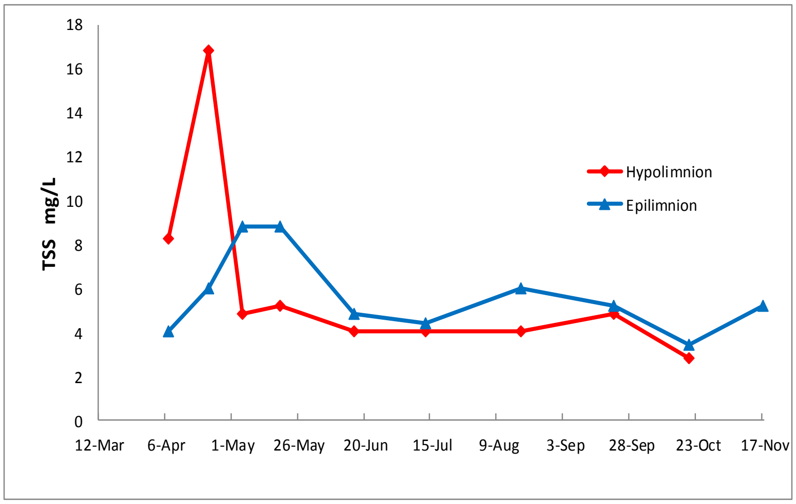


Figure 19 2015 Monitoring results for Total Suspended Solids.

Fecal Coliform

Human and animal wastes carried to water bodies are sources of pathogenic or disease-causing, bacteria and viruses. Fecal coliform are not usually disease-causing agents themselves, however, high concentrations can suggest the presence of other disease-causing organisms such as pathogens. Results for 2015 are very low as is typical in the bay.

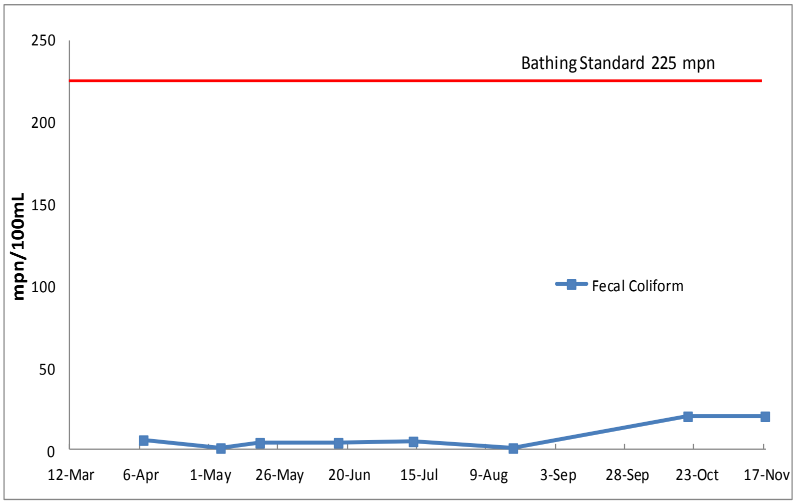


Figure 20 2015 Monitoring results for Fecal Coliform samples taken at the surface.

Total Dissolved Solids

The concentration of total dissolved solids (TDS), primarily reflects the concentrations of the major cations and anions (calcium, sodium , magnesium, potassium, bicarbonate, chloride, sulfate). The higher spring time values likely reflect the influence of road salt.

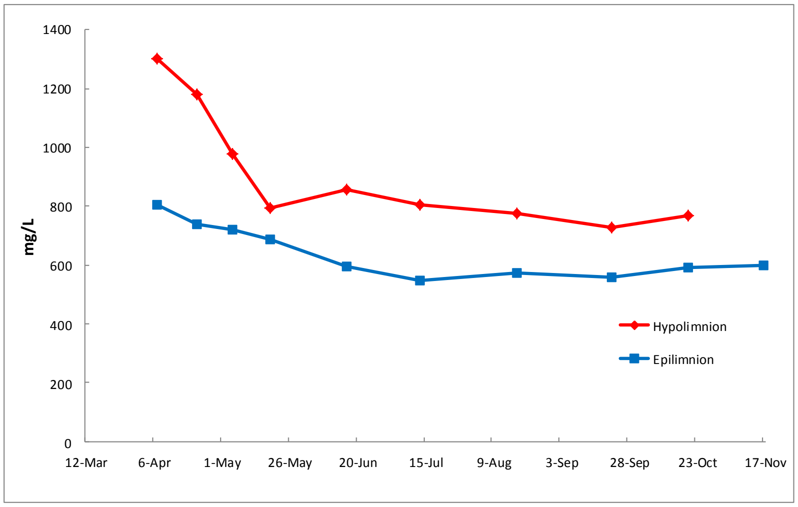


Figure 21 2015 Monitoring results for Total Dissolved Solids.

Hardness

Hardness is defined as the amount of dissolved calcium and magnesium in the water. Hard water is high in both these dissolved minerals. The long term average for the epilimnion is approximately 300mg/L. The hypolimnion average is slightly higher, likely due to the influence of road salts.

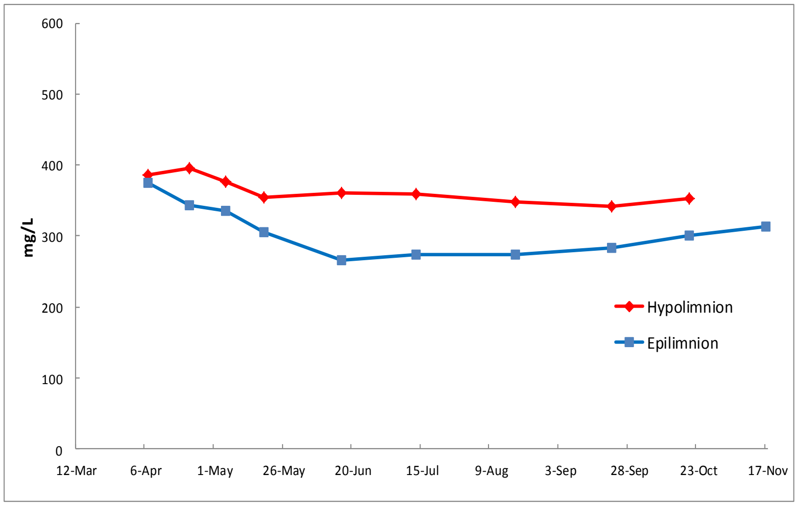


Figure 22 2015 Monitoring results for Hardness.

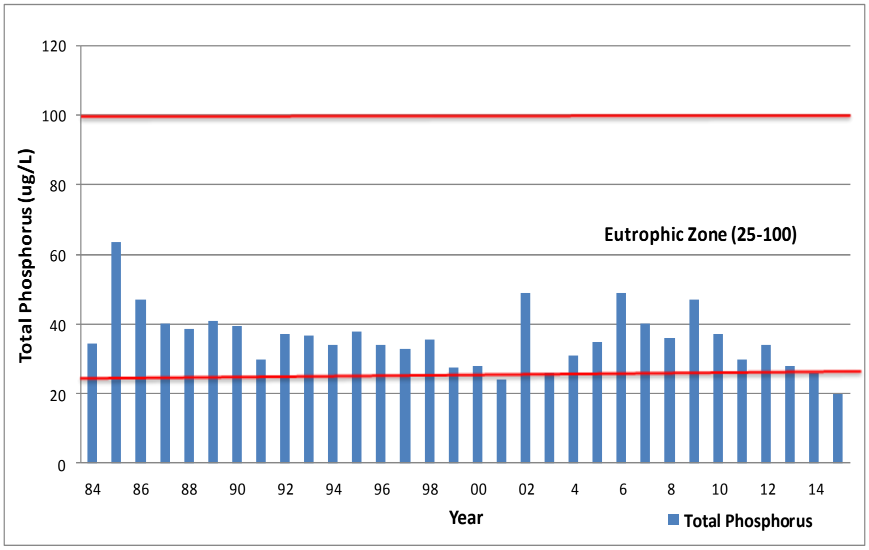
TROPHIC INDICATOR ANALYSIS

Data for the key trophic indicators, total phosphorus, chlorophyll-a and secchi transparency for the 2015 monitoring season have been presented earlier. This section will relate the 2015 data to the long term record and show the current trophic state of Irondequoit Bay.

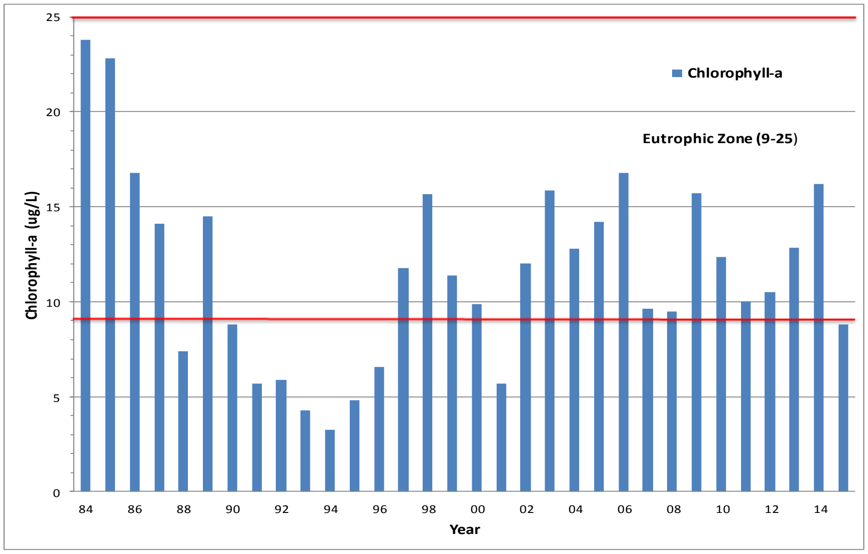
Summer (June-September) average annual values for total phosphorus, chlorophyll-a and Secchi disk transparency are presented in Figure 23. Based on these parameters, the trophic conditions in the bay have varied somewhat over the 31 year monitoring record, but have mostly remained in the eutrophic state. Eutrophication is defined by the US EPA as “The enrichment of bodies of fresh water by inorganic plant nutrients.” Nutrients such as nitrogen and phosphorus are chemical elements that are essential to plant and animal nutrition. They are nutrients that are important to aquatic life, but in high concentrations they can be problematic in water and lead to eutrophication.

Such has been the case with Irondequoit Bay. In the early 20th century nutrient loads from wastewater discharges lead to high production and frequent algae blooms. In the late 1970’s and early 1980’s many of the wastewater sources of nutrients were diverted and the bay saw dramatic improvement. The next big challenge became limiting the internal cycling of phosphorus being generated from the bottom sediments during summer anoxic conditions. Efforts to manage that process resulted in the 1986 project to seal the deep sediments with alum and the 1993 oxygenation project. Results showed that the amounts of phosphorus and chlorophyll in Irondequoit Bay had been decreasing to the extent that in 1995, 1999, and 2001, the Monroe County Department of Health declared that the established goal of a mesotrophic state, for Irondequoit Bay water quality, was met in terms of amount of microscopic plant growth. When comparing current data to the long term summer averages, we see that 2015 also met the goal of mesotrophic conditions as total phosphorus and chlorophyll-a levels were both below the eutrophic zones.

Total Phosphorus



Chlorophyll-a



Secchi Disk Transparency

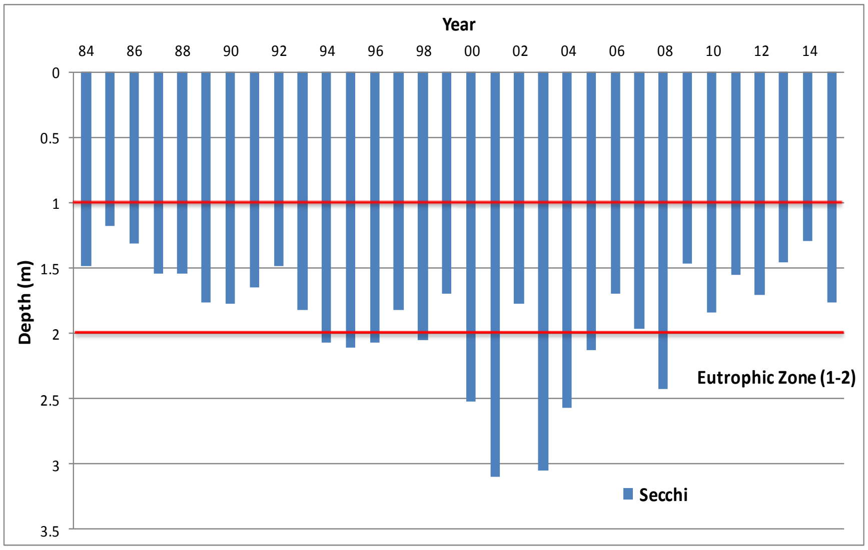


Figure 23 Trophic state indicators based on epilimnion summer average data 1984-2015.

The Carlson Trophic State Index (TSI), is a tool used by many, including the US Environmental Protection Agency, for lake trophic categorization. It has advantages over other trophic categorization systems including: (1) a numerical system which provides for a large number of lake classes, thus, more realistically representing the continuum of lake trophic conditions; (2) a numerical approach is less ambiguous than one based on nomenclature; and (3) linkages are established between the three principal trophic indices (Secchi Disk depth, total phosphorus, and chlorophyll *a*), thus, enabling determination of trophic status from any of the three indicators. The TSI is based on a unitless scale from 0 to 100, with each 10 point increment representing a doubling of biomass. A TSI score over 50 would indicate eutrophic conditions. Figure 24 shows the TSI scores for Irondequoit bay with 2015 falling just below the eutrophic level for total phosphorus.

A trophic state index is not the same as a water quality index. The term quality implies a subjective judgment that is best kept separate from the concept of trophic state. A major point of confusion with the existing terminology is that eutrophic is often equated with poor water quality. Excellent, or poor, water quality depends on the use of that water and the local perceptions of the community. The definition of trophic state and its index can remain neutral to such subjective judgments, remaining a framework within which various evaluations of water quality can be made. Thus, the TSI provides an objective standard of trophic state.

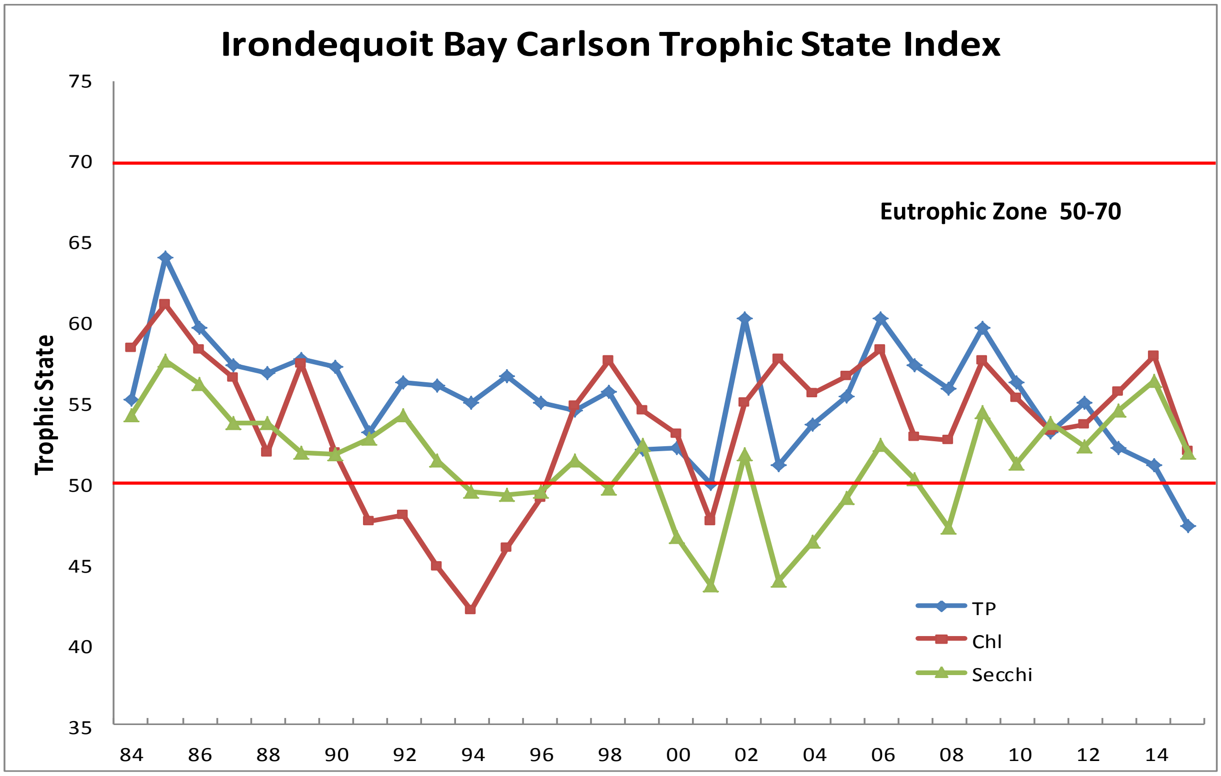


Figure 24 Trophic State Index scores for total phosphorus, chloroyphyll-a and Secchi disk 1981-2015 using summer mean concentrations.

Summary

The annual monitoring program for Irondequoit Bay will continue for the foreseeable future. Data gathered over the last 30 years will provide an extremely useful record with which to compare current and future results.

Water quality in the bay is vastly improved from where it was in the 1960's and 70's due to a tremendous community effort to reduce pollutant sources. Waste water inputs were the main driver of eutrophication during that time and have been largely eliminated. Today, much focus remains on the watershed and the varied sources of stormwater pollutants that enter the bay via Irondequoit Creek. The county Water Quality Assessment Program has completed a series of stormwater assessments for the Irondequoit Creek basin. These assessments include pollutant load modeling for phosphorus and nitrogen as well as recommendations for measures to reduce these pollutant loads through various management practices.

Determining the trophic state of the bay is one of the keys to understanding the state of the bay. Measures of phosphorus, chlorophyll-a and Secchi disk transparency allow us to determine the level of eutrophication and the degree to which various management measures are succeeding. In 2015, we saw summer total phosphorus and chlorophyll-a levels lower than they had been in many previous years and were outside what we call the "eutrophic zone". Since 2012 the total phosphorus measured in the epilimnion has been decreasing. The chlorophyll-a and Secchi transparency have not followed that same trend but are lower than they have often been in the past.

Chloride levels in the bay were much higher in 2015 than anything seen during the 30 year monitoring record. There were no adverse effects seen with regard to spring mixing.

Oxygen levels in the bay were typical of past years. An anoxic zone began to develop in May and continued until the fall mix. In July, the anoxic zone stretched from 6.5 meters to the bottom. The oxygenation of the bay continued in 2015 with the injection process beginning on June 23rd and lasting until September 18th. The anoxic conditions in the hypolimnion can lead to release of soluble reactive phosphorus from the bottom sediments. While there was an increase in hypolimnion phosphorus during the summer months (June-September) it did not appear that this phosphorus made its way into the epilimnion. Had this occurred, we may have seen algae blooms and higher chlorophyll-a numbers. Past management practices have attempted to control the internal phosphorus loading and assessing this remains a high priority in the annual monitoring program.

Recommendations

A draft copy of this report was circulated for review to various staff from the Environmental Services, Health and Planning Departments of Monroe County as well a staff from the Monroe County Soil and Water Conservation District and the Towns of Penfield, Webster, Irondequoit and Perinton. The comments received from these various reviewers were tremendously helpful in the writing of this report. Some of the suggested recommendations are listed below in no particular order:

1. Continued collecting data and calculating trophic state of Irondequoit Bay.
2. Increase collection of chemistry data from every other monitoring visit to every visit. This would be a total of two sampling events per month.
4. Consider different locations for monitoring in addition to Station 1 including areas that would be far enough away from the oxygen diffusers so that there was not influence from the oxygen.
5. Consider dropping some of the analytes that are less significant to trophic state analysis such as Alkalinity, Hardness, pH, Conductivity.
6. Develop a better understanding of the contributions of phosphorus from internal loading vs. watershed load.