# Lake Oscawana
# 2010 Annual Monitoring Report

*Prepared For:*

**Lake Oscawana Weed Control District**

Putnam Valley, NY 10579

*Prepared By:*


**Northeast Aquatic Research**

George W. Knoecklein
74 Higgins Highway
Mansfield Center, CT 06250


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# SUMMARY

Lake Oscawana was visited 7 times during the 2010 season. Lake sampling occurred monthly between April and October, skipping May, with two visits in August. Stations 2, and 3, were visited during June, July, twice in August, and September. The 7 identified stream stations were visited during each of the 7 scheduled visits.

Water clarity at Lake Oscawana was very good in 2010. The seasonal average 3.67 meters was the best seasonal average ever recorded at the lake. The best clarity occurred in June when the Secchi disk was 4.3 meters but clarity did not decline during the season as is common. The disk reading remained just better than 3.5 meters during July and August, ending the season at 3 meters in late October.

Epilimnion phosphorus levels in the lake were ranged between 5 and 16 ppb with an average of 11 ppb, the lowest average since 2002.

Maximum bottom water phosphorus, 120 ppb, was the lowest observed at the lake since 1995. Maximum bottom water phosphorus at Stations 2 and 3 was lowest since in the lake since the monitoring at these stations started in 1999.

Dissolved oxygen concentrations were zero in waters below about 6.5 meters during most of the summer. The maximum ascent depth of the zero concentration was 6.67 meters.

Streams #4, and #7 continue to show declines in bacterial indicator organism numbers. Although still present, coliform numbers were lower than historically high values with all total coliform most results below 1,500, and fecal coliform values all below 1,200 col/100 mL.

# INTRODUCTION

## Monitoring Components

### Lake and Stream Sampling Dates

Lake sampling in 2010 was conducted between April and October on the following dates; April 19, June 10, July 30, August 11, August 30, September 28, and October 26, 2010. Stream samples were collected on the same dates. Aquatic plants were not surveyed in 2010. The sampling activities are summarized in **Table 1.**

**Table 1 - Sampling Dates during The 2010 Season**

| | 19-Apr | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep | 26-Oct |
|---|---|---|---|---|---|---|---|
| Lake St. 1 | X | X | X | X | X | X | X |
| Lake St. 2 | | X | X | X | X | † | |
| Lake St. 3 | | X | X | X | X | X | |
| Weed Survey | No Aquatic Plant Surveys Conducted in 2010 | | | | | | |
| Streams | X+B | X+B | X+B | X+B | X+B | X+B | X+B |

*X=Data/samples collected*
*B=Bacteria samples taken*
*† = Skipped due to thunderstorm*

### Lake Profiles

Temperature and oxygen measurements were made at each of the three stations. A profile consists of measuring water temperature and dissolved oxygen at each one-meter depth increment beginning at the surface and ending at the bottom. The profile data is provided in **Appendix 1.** The profiles show temperature and oxygen values recorded at each one-meter depth, the calculated percent oxygen saturation for each depth increment, and the calculated RTRM value between each one-meter depth. The RTRM value is a unit-less number that describes the difference in water density between each meter of depth. Higher numbers indicate stronger stratification. The maximum RTRM demarcates the location of the middle of the thermocline.

### Lake Samples

Lake samples were collected for water quality analysis at Stations 1, 2 and 3 during 2010, data results are given in **Appendix 2.** Water was drawn from 1, 4, 6, and 9 meter depths (about 3, 13, 20, & 30 feet) at Station 1, and from top and bottom depths, 1 meter and 7.5 or 8 meters, from Stations 2 and 3 (see bathymetric map in **Appendix 3** for locations of sampling stations). Station 1 samples were analyzed for total phosphorus, ammonia nitrogen, organic nitrogen, total iron, and pH. Station 2 and 3 samples were analyzed for total phosphorus and total iron. Station 1 had a maximum depth of 11 meters, Stations 2 and 3 had maximum depths of 8.0 meters.

### Secchi Disk/Phytoplankton

During each sampling visit, the Secchi depth was measured at each station visited, and one sample for algae and one for zooplankton analysis were collected from Station 1 only.

### Drainage Basin Sampling

The drainage basin was sampled 6 of the 7 identified inflow stream stations. Stream station 3 was not visited due to unsafe parking conditions along the side of the road. Water quality samples were collected from each visited stream when enough water was present. During the summer, most streams became dry due to lack of rainfall. Water samples were tested for total phosphorus, nitrate nitrogen, alkalinity, specific conductance, turbidity, and pH. Bacterial indicators, total coliform and fecal coliform, levels were measured in streams, #4, & #7.

## Lake and Drainage Basin Characteristics

### Lake Basin

Lake Oscawana is a 368 acre lake in Putnam Valley, New York. The lake has mean and maximum depths of 17.9 feet and 37 feet, respectively. The lake has a steep sided basin with water depths that drop quickly to depths of 20 feet close to most shorelines. The area of the littoral zone, as delineated by the 13 foot contour line, is approximately 108 acres, or 29% of the lake area.

### Drainage Basin

The total watershed area of the lake is 2,875 acres, about 13 times the surface area of the lake. The average annual flushing rate is once in 423 days or about 86% of the total lake volume annually. Seven stream monitor stations water quality of primary inlets to the lake (see Map in **Appendix 4)**. The drainage area captured by these seven sampling sites is 2,047 acres or 62 % of the total drainage area of the lake (see **Table 2**). The remaining 38% is developed shoreline along the southeastern and southwestern shores draining to lake via storm drains.

**Table 2 - Principal Watershed Sub-basin Drainage Areas**

| Sub-basin # | Acres |
|---|---|
| 1 | 452 |
| 2 | 890 |
| 3 | 145 |
| 4 | 32 |
| 5 | 61 |
| 6 | 49 |
| 7 | 418 |

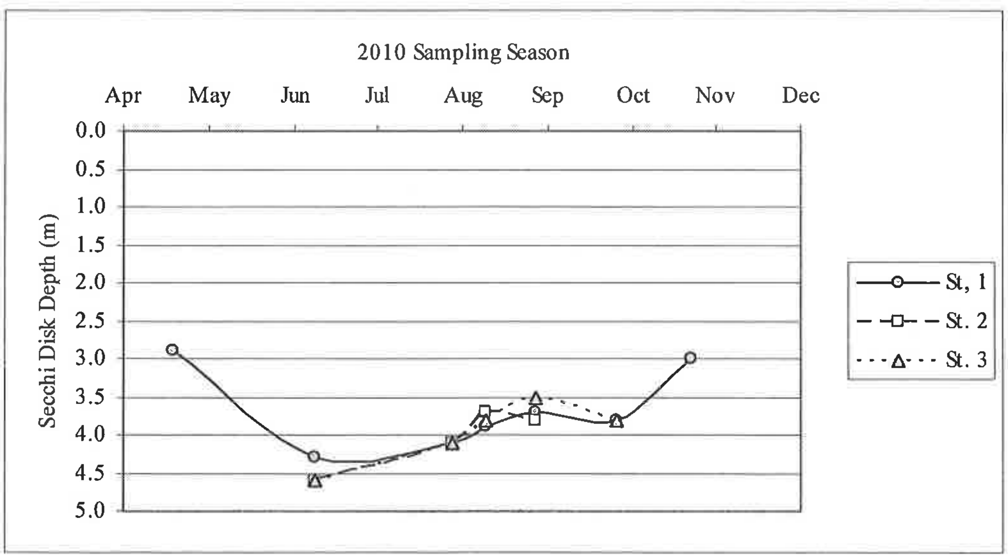
# 2010 LAKE MONITORING RESULTS

## Secchi Disk Depth

During the 2010 season, Secchi disk depth was measured 7 times at Station 1, 5 times at Station 3, and 4 times at Station 2 with measurements shown in **Figure 1**. The vertical axis is arranged with zero on top to represent the surface of the lake. In 2010, the Secchi disk depth varied between a high of 4.3 meters and a low of 2.9 meters. Charts of Secchi disk trends from recent years, 2005 – 2009, are included in **Appendix 5.**

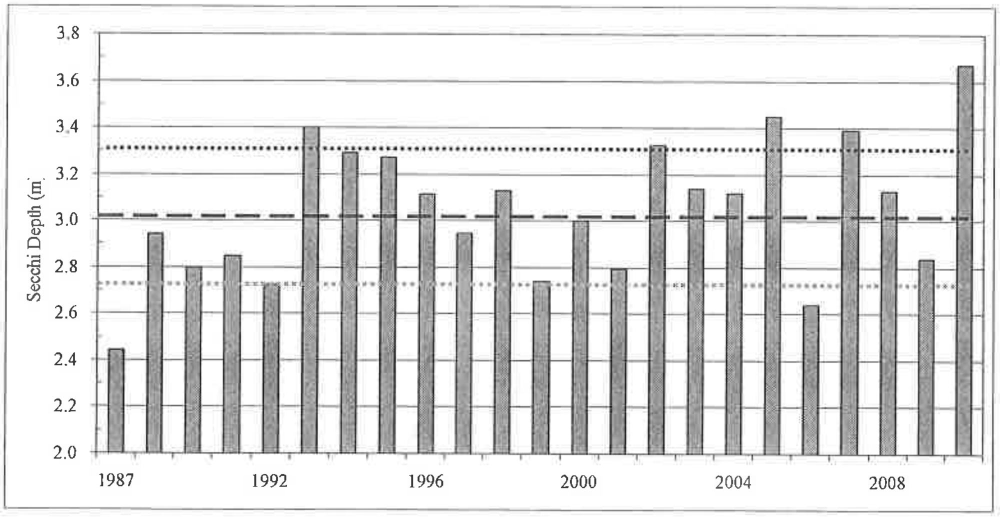
The Secchi disk depth was very good, 4.3 meters, in June and remained good, better than 4.0 meters, in July. Clarity declined only slightly during August and September remaining at 3.9 meters though September. Late in October, water clarity was still 3.0 meters.

**Figure 1 - Secchi Disk Depths In Lake Oscawana During 2010 Season**



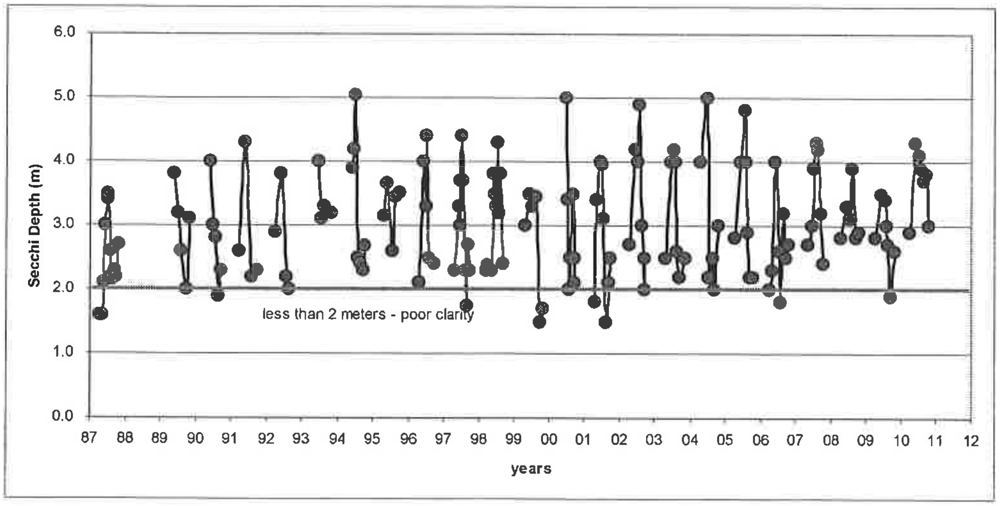
Annual average Secchi disk depths at Lake Oscawana for years beginning in 1987 are shown in **Figure 2.** The average Secchi disk depth for 2010 was 3.67 meters, the best seasonal average ever recorded at the lake. **Figure 2** shows the upper, 3.3 meters, and lower, 2.75 meters, boundaries of one standard deviation around the mean = 3.03 meters. The mean for 2010 was well above the upper boundary of this bracket.

**Figure 2 - Average Annual Secchi Depth in Lake Oscawana, 1987 – 2010**



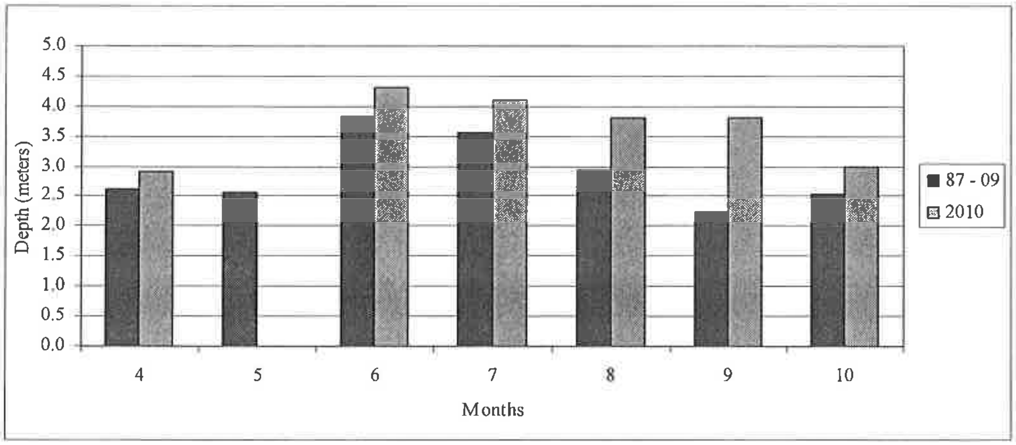

Secchi disk depth trends for each year on record is shown in **Figure 3.** The readings from 2010 were very good in comparison to most prior seasons because all summer readings were better than 3.5 meters. The data collected in 2010 suggests that clarity is not declining as was reported last year. The poorest reading in 2010, 2.9 meters, was well above the poor clarity threshold of 2 meters.

**Figure 3 - Secchi Disk Trend for Lake Oscawana, 1987 – 2010**



The 2010 readings are compared to the average monthly Secchi disk depths using data from all years on record 1987 – 2009, in **Figure 4.** April clarity was about the same in 2010 as the long-term average for April, but clarity measured during other months in 2010 was better than average clarity for those months.

**Figure 4 - Average Monthly Secchi Disk Depth vs. 2010 Monthly Averages**




## Total Phosphorus

The total phosphorus concentrations in Lake Oscawana during the 2010 season are presented in **Table 3**. The concentrations from 2002 - 2009, are included in **Appendix 6**. Total phosphorus ranged from a low of 5 ppb to a high of 120 ppb.

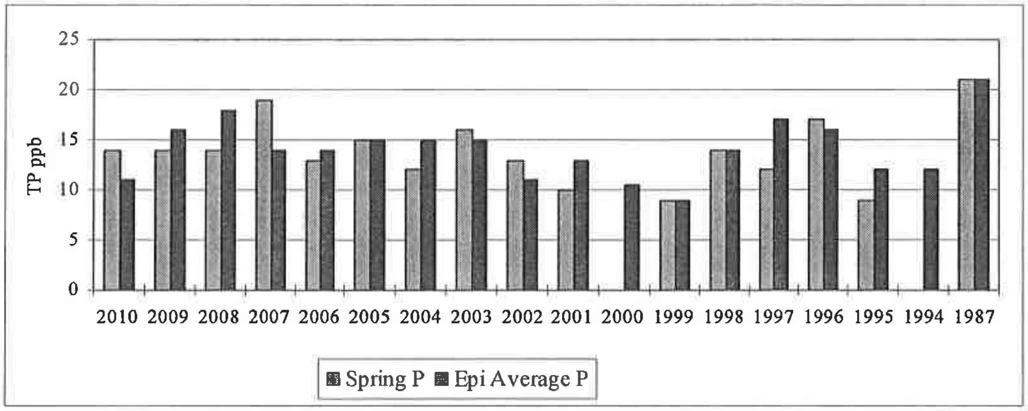
**Table 3 - Total Phosphorus Concentrations (ppb) at Station 1 in Lake Oscawana 2010**

| Depth | 27-Apr | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep | 26-Oct |
|---|---|---|---|---|---|---|---|
| 1 m | 14 | 10 | 11 | 9 | 8 | 13 | 12 |
| 4 m | 12 | 16 | 5 | 9 | 11 | 14 | 13 |
| 6 m | 13 | 18 | 12 | 17 | 15 | 17 | 13 |
| 9 m | 16 | 24 | 84 | 79 | 120 | 68 | 18 |
| mean = | *14* | *17* | *28* | *29* | *39* | *28* | *14* |

### Spring Phosphorus Concentration

The spring phosphorus concentration has shown variation over the years 1987 – 2010, with a low of 9 ppb and high of 21 ppb. The graph in **Figure 5** shows spring phosphorus values and seasonal phosphorus concentration averages from 1 and 4 meters. The 2010 spring phosphorus concentration was 14 ppb, identical to 2009 and 2008, and essentially the same as the long-term average of 13.9 ppb. The epilimnion average (the average of the 1 and 4 meter samples) declined to 11 ppb, the lowest average epilimnion concentration since 2002. The epilimnion average was lower than the spring concentration for the first time since 2007.

**Figure 5 - Record of Spring Phosphorus and the Seasonal Average Concentration from 1 and 4 Meter Depths**




## Bottom Water Phosphorus

In 2010, the maximum bottom water phosphorus concentration was 120 ppb, occurring in late August. The 2010 maximum was the lowest concentration since 1995 (**Figure 6**). The maximum concentration observed in 1995 was the lowest on record.

**Figure 6 - Maximum Bottom Water Phosphorus Concentrations at Station 1, 1987 – 2010**

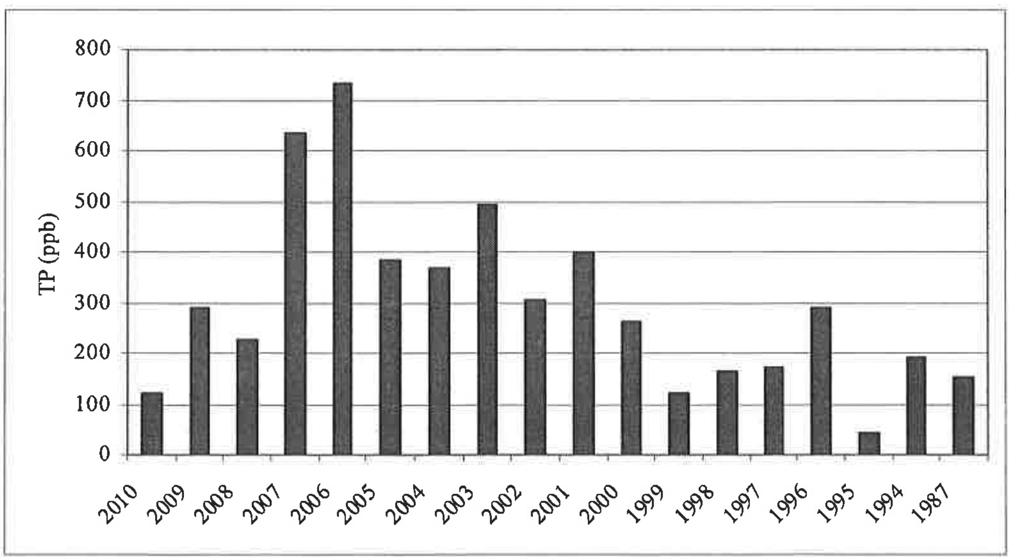
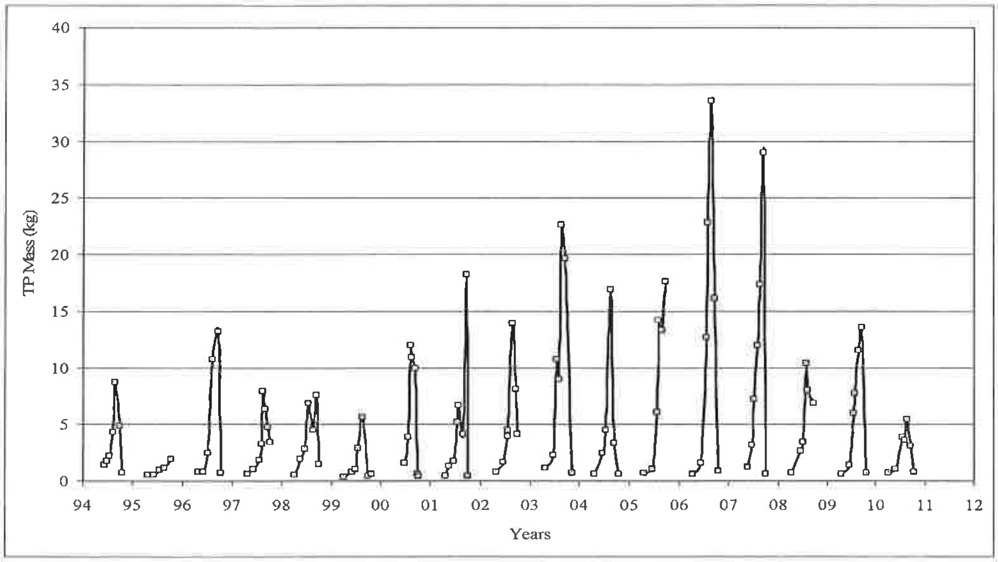



**Figure 7** shows seasonal phosphorus accumulation below 7.5 meters. Phosphorus accumulation in 2010 was 6 kg, the lowest since 1999. The two prior years, 2008 and 2009 also showed considerably lower phosphorus accumulation, between 10 and 15 kg,

than in 2003 to 2007 when the phosphorus was between 30 and 35 kg. Accumulated phosphorus between 2000 and 2005 showed variation between 12 and 22 kg phosphorus. Prior to 2000, maximum accumulated phosphorus was usually less than 10 kg. The data from 2008 - 2010 suggest similarity with conditions that existed prior to 2000.

**Figure 7 -Trend in Total Phosphorus Mass Below 7.5 Meters At Lake Oscawana**




## Phosphorus Data from Station 2 and Station 3

2010 phosphorus data from stations 2 and 3 (**Table 4**) were also lower than prior years providing additional evidence of lower rates of internal loading this year. The data from these stations may be more indicative of conditions lake-wide in Lake Oscawana because they represent more of the bottom area of the lake than does Station 1. Both stations showed maximum values less than most prior observations (see **Appendix 7** for phosphorus data from Station 2 and 3 from the years 2003 – 2009). The maximum at Station 2 was 56 ppb as opposed to 73 ppb from 2008, and at Station 3, the maximum was 48 ppb as opposed to 107 ppb from 2008.

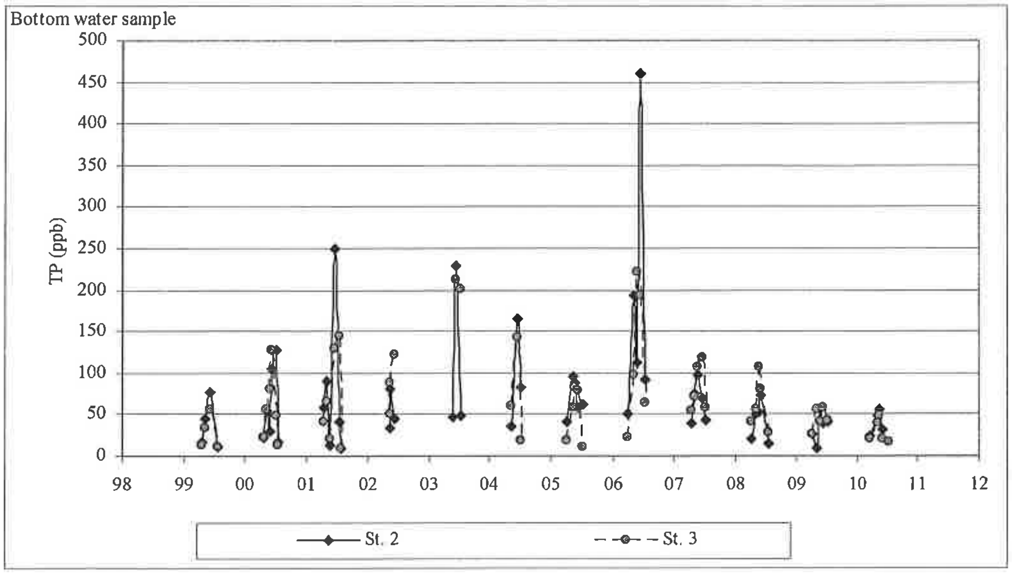
**Table 4 - Total Phosphorus From Stations 2 and 3 In Lake Oscawana 2010**

| Station 2 (TP ppb) | | | | | |
|---|---|---|---|---|---|
| Depth | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep |
| 1 | 10 | 5 | 11 | 10 | NC |
| 7.5 | 24 | 48 | 56 | 32 | NC |
| **Station 3 (TP ppb)** | | | | | |
| Depth | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep |
| 1 | 11 | 7 | 9 | 11 | 9 |
| 7.5 | 21 | 40 | 48 | 21 | 17 |

NC= not collected due to thunderstorm

The twelve-year trend in bottom water phosphorus concentrations at stations 2 & 3 is shown in **Figure 8.** In data from 2010 was lower than all other years shown on the graph. Internal load of phosphorus at these two stations appears to have been low in 2010. Taken together, the years, 2007 – 2010 represent decreasing internal loading rates.

**Figure 8 - Total Phosphorus In Bottom Waters At Stations 2 and 3, 1999 - 2010**




## Temperature / Oxygen

### Temperature

Temperature data is shown on the water profile summary provided in **Appendix 1.** The profile data shows the location of the thermocline in the water column. The thermocline is the boundary between the upper warm water and lower cool water. In Lake Oscawana, the water below the thermocline becomes anoxic beginning in May. All water deeper than the thermocline is anoxic by June. The thermocline acts as a barrier to high phosphorus levels in the water below the thermocline preventing leaching of phosphorus into the upper waters. Analysis of prior seasons at Lake Oscawana, have shown that once the thermocline descends below the anoxic boundary the water clarity declines.

The position of the thermocline during the 2010 season is shown for Station 1 in **Figure 9,** for Station 2 in **Figure 10,** and for Station 3 in **Figure 11.** In each of the three charts, the thermocline is shown as a heavy line, the anoxic boundary as a line with open circles, and the Secchi disk depth by stars and a dashed line. Charts showing seasonal boundary trends from 2005 – 2009 are included in **Appendix 8.**

In 2010, the thermocline descended below the anoxic boundary in early September however, water clarity did not simultaneous decrease as in prior years.

**Figure 9 - Boundaries at Station 1 In Lake Oscawana during 2010 Season**

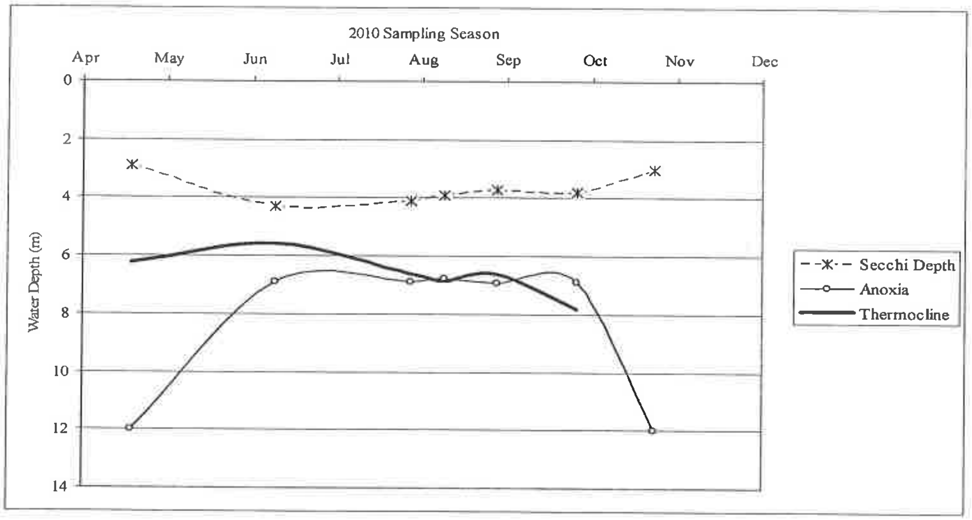



**Figure 10 - Boundaries at Station 2 in Lake Oscawana During 2010**

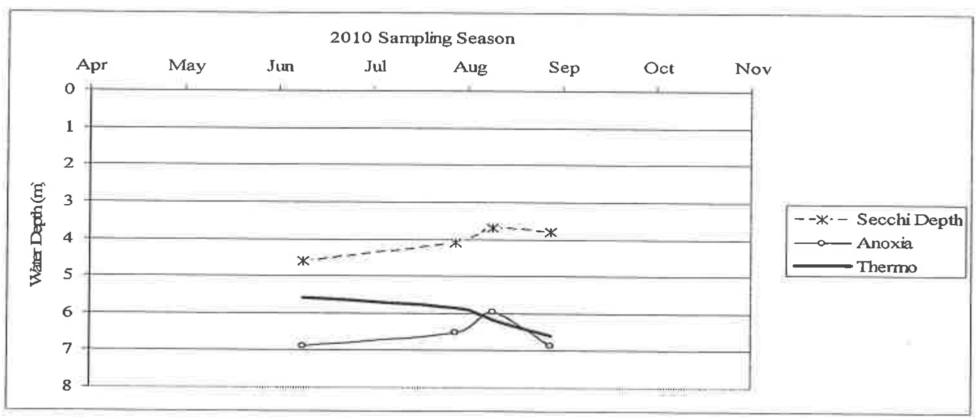
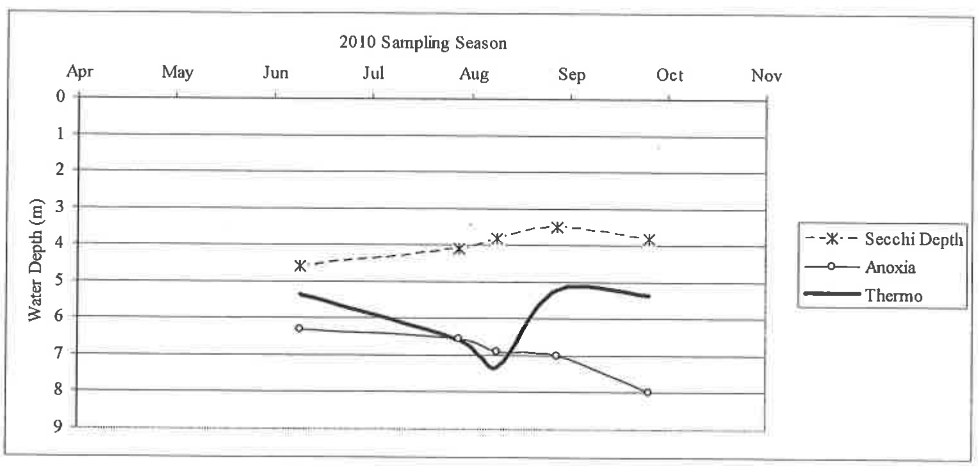


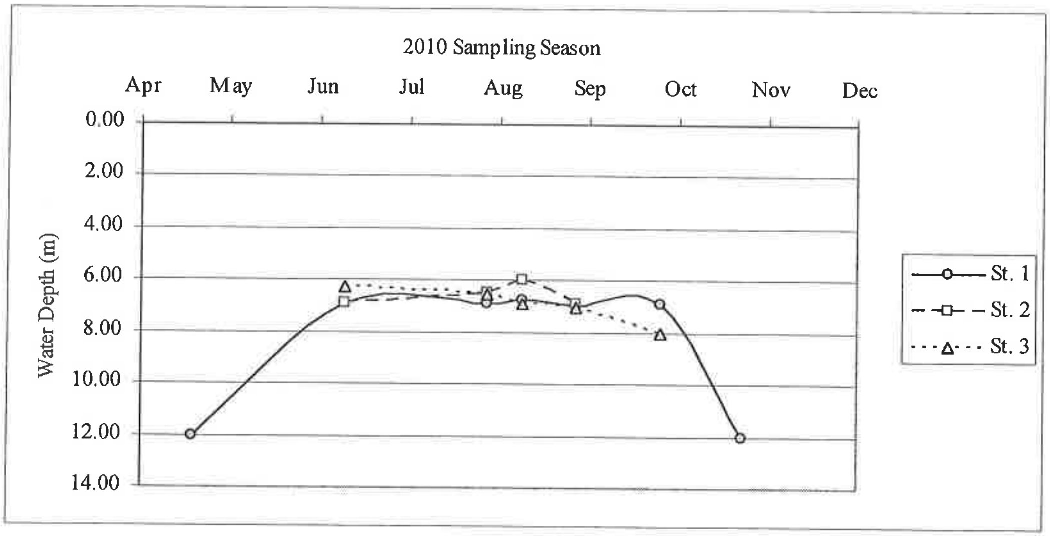

**Figure 11 - Boundaries at Station 3 in Lake Oscawana, 2010**



## Dissolved Oxygen

The anoxic boundary at each station is shown in **Figure 12.** The anoxic boundary at each station was between 6 and 7 meters June though to the end of September. The lake was fully oxygenated by the end of October. Charts of prior annual anoxic boundary trends are included in **Appendix 9.**

**Figure 12 - Anoxic Boundary In Lake Oscawana, 2010**




# Lake Plankton

The lake plankton was sampled in 2010 to determine the trends in numbers of phytoplankton, free floating algae, and zooplankton, free floating microcrustacea, in the lake over the course of the season.

## Phytoplankton

The phytoplankton samples were lost due to poor preservative strength. Qualitative assessment of phytoplankton was made using captured cells in the zooplankton tows. April, June and July phytoplankton was dominated by Diatoms, Asterionella, Fragilaria, and Melosira. Anabaena and Oscillatoria were present in the summer but not in high numbers. Also, since zooplankton tows are whole water column samples it is possible that Oscillatoria populations were in deeper water below the epilimnion. Diatoms become dominant again in the late summer and fall when Melosira became very numerous. Tiny green algae Chlamydomonas and Chlorella were common in the summer and the filamentous green algae, Mougeotia, became abundant in late August.

**Table 5 – Qualitative Phytoplankton Analysis of 2010 Lake Oscawana Samples**

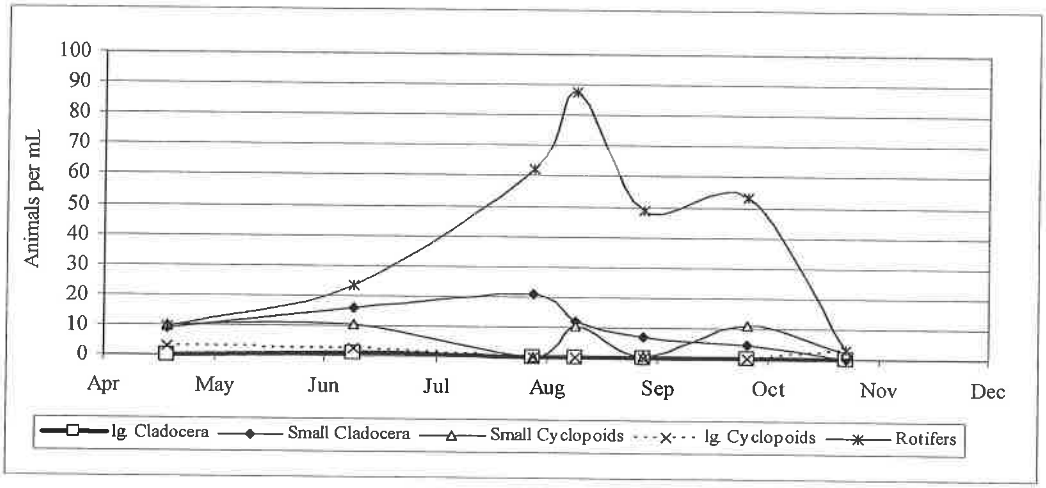
| | 19-Apr | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep | 26-Oct |
|---|---|---|---|---|---|---|---|
| **BLUE GREENS** | | | | | | | |
| Anabaena | | | | C | C | C | S |
| Merismopedia | | | | | C | | |
| Oscillatoria | | | | C | C | C | |
| Spirulina | | | | | S | | |
| **GREENS** | | | | | | | |
| Chlamydomonas | | | C | C | | | |
| Chlorella | C | C | S | | | | |
| Mougeotia | | | | | A | C | |
| Staurastrum | | | | S | S | S | C |
| **DIATOMS** | | | | | | | |
| Asterionella | VA | C | C | C | C | C | |
| Fragilaria | VA | VA | C | C | C | C | |
| Gomphonema | S | | | | | | |
| Melosira | VA | A | C | C | C | A | VA |
| Nitzschia | S | S | | | | | |
| Pinnularia | S | S | | | | | |
| Synedra | C | C | S | S | S | C | |
| Tabellaria | A | C | C | C | C | C | |
| **CHRYSOPHYTES** | | | | | | | |
| Dinobryon | | VA | S | C | | C | |
| Mallomomus | | | S | S | | | |
| **DINOFLAGELLATES** | | | | | | | |
| Ceratium | | C | S | | | | |

VA =Very abundant, A=Abundant, C=Common, S=Scarce

## Zooplankton

The zooplankton community in Lake Oscawana was dominated by tiny Rotifer organisms as shown in **Figure 13**, reached peak numbers in early August. The only cladocera in any sample collected in 2010 where tiny Bosmina which were consistently between 0.2 and 0.4 mm in size. Small cyclopoids were generally present but at low numbers. There were no large bodied zooplankton (>0.6 mm) in any sample collected in 2010 (**Figure 13**).

**Figure 13 - Zooplankton Numbers in Lake Oscawana during 2010**




## Aquatic Plants

Aquatic plants were not surveyed in 2010. On August 11, 2009, aquatic plants within Abele Cove on the east side of the lake were surveyed because prior surveys had been after or during weed harvesting. A last full lake survey was conducted on August 22, 2008. There were eight species of aquatic plants observed in the lake during the 2009 survey, nine species were observed in 2008. The species list, given in **Table 5** is essentially the same as the two prior surveys, 1998 and 2003 (see **Appendix 10**). Results of the 2009 surveys showed the dominant plants in the lake were Eurasian milfoil, Robbins pondweed, large-leaf pondweed, and white water-lily, in that order. The prior whole lake survey showed large-leaf pondweed to be more abundant than Robbins Pondweed indicating that Abele Cove has significant coverage of this plant. **Table 5** gives the total number of observations of each species and the percent occurrence.

**Table 6 - Aquatic Plant Species Observed in Lake Oscawana during 2008 and 2009 Surveys**

| Common Name | Scientific Name | Percent Occurrence 2008 | Percent Occurrence 2009 |
|---|---|---|---|
| | | *187 pts* | *57 pts* |
| Eurasian milfoil | *Myriophyllum spicatum* | 62 | 60 |
| Robbins Pondweed | *Potamogeton robbinsii* | 27 | 57 |
| Large-leaf Pondweed | *Potamogeton amplifolius* | 43 | 32 |
| White Water-lily | *Nymphaea odorata* | 18 | 28 |
| Coontail | *Ceratophyllum demersum* | 1 | 17 |
| Watershield | *Brasinia schreberi* | 2 | 4 |
| Filamentous Algae | Spirogyra / Oscillatoria | 5 | 4 |
| Tape grass | *Vallisneria americana* | 7 | 2 |

| | | | |
|---|---|---|---|
| Yellow Water-lily | *Nuphar variegata* | 1 | 2 |
| Red-leaf Pondweed | *Potamogeton epihydrus* | 1 | 0 |

Aquatic plants in lakes occur in three distinct habitat forms, emergent, floating leaved, and submersed. Emergent plants are those that are rooted in shallow water, between 0.5 and 4 feet of water, but have the majority of the stems and leaves out of the water. Generally, these species grow along natural wetland type shorelines where the soils are mucky and the land has not been cleared. Rarely do emergent plants grow in water past about 1 foot of depth. Species in this group include cattails, bulrush, pickerelweed, and phragmites. Floating leaved plants are the water lilies, water shield, and a few of the pondweeds. These plants produce primarily only floating leaves with little or no underwater leave development. Floating leaved plants are restricted to shallow waters of less than about 6 feet although the large conspicuous beds of water lilies typically form in water depths between 0 and 4 feet deep. Submersed plants are those that grow entirely underwater (sometimes terminal flowers may become aerial). The submersed plants can grow in shallow water under the water lilies and near the shore mixed in with emergent plants but become most numerous in the deeper parts of the lake where sunlight reaches the bottom. The probable depth ranges of these three zones of plant habitats in Lake Oscawana are shown in **Figure 14.**

Generally, submersed plants occur at all depths within the photic zone (the depth in the lake where light reaches the bottom) to a maximum of about 33 feet, as determined by the restriction caused by hydrostatic pressure (Wetzel, 2001[1]). The photic zone in Lake Oscawana can be estimated by using the Secchi disk depth record (shown in **Figure 3**). Secchi disk depth has been shown to estimate the maximum depth of aquatic plant colonization in lakes (Canfield et. al., 1985[2]). For Lake Oscawana, the average Secchi disk depth (average of available data between 1987 and 2009) is 10 feet suggesting that the maximum depth that plants can grow will be about 10 feet. However, Secchi depths up to 13 feet occur commonly enough that plant growth may extend to depths of 13 - 14 feet, or slightly deeper. The maximum Secchi disk depth reading was 16.5 feet (occurring on three dates; July 8, 1984, June 30, 2000, and June

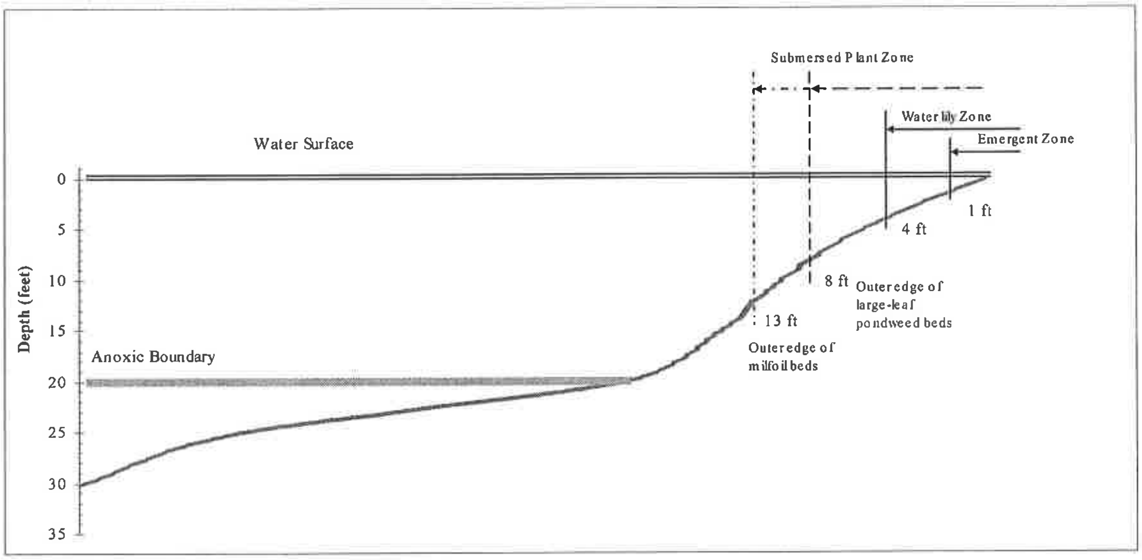
1 Wetzel, Robert G. 2001. Limnology. Academic Press.

2 Canfield D.E., K.A. Langeland, S.R. Linda, and W.T. Haller. 1985. Relations Between Water Transparence and Maximum Depth of Macrophyte Colonization in Lakes. J. Aquat. Plant Manage. 23:25-28.

30, 2004) indicating that vascular aquatic plants might occur to depths of 16 feet, but are not expected to grow deeper than that.

The surface area of the lake between the shore and 14 feet of water depth is 108 acres. This is probably a good estimate of the size of the littoral zone of Lake Oscawana.

**Figure 14 - Schematic Representation of Littoral Habitat Zones in Lake Oscawana**




The floating leaved plants were found in the sheltered coves in water depths that generally did not exceed about 3 feet. The largest bed of these plants was in the outlet cove where they cover about 6 acres. There were also beds of floating leaved plants in north end coves and in scattered coves on the east and west sides of the lake. In a few of these isolated coves and in the outlet cove floating mud islands were observed.

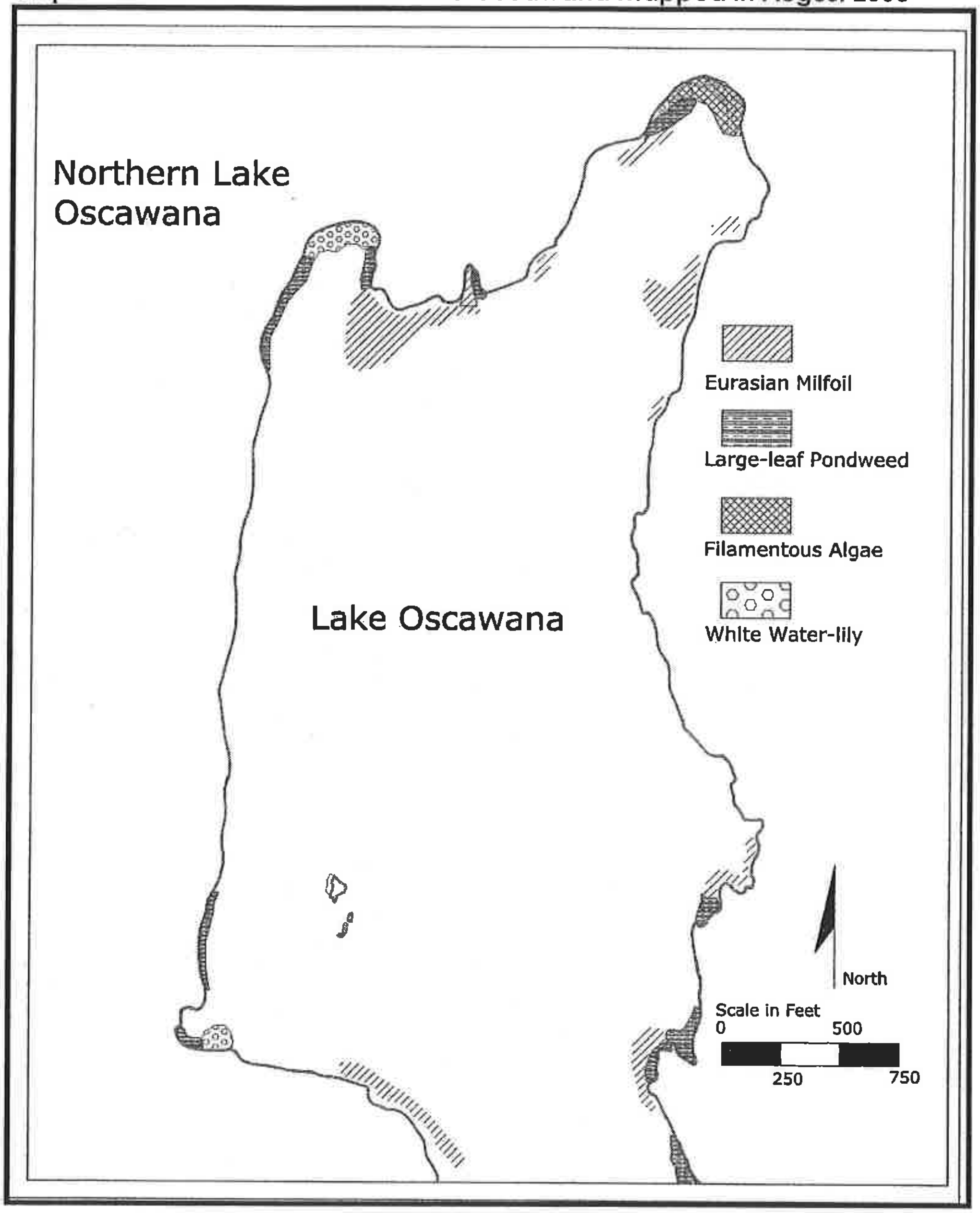
The submersed plants were found in most all areas around the shore of the lake in the depth range between the shoreline and about 13 feet of water depth. The three dominant species were found in different depth ranges with Eurasian water milfoil occupying the deepest water between about 6 feet and around 13 feet. This outer depth cut-off was not precise, milfoil was found in water as deep as 13 feet routinely, and several sites had water depths of 14 – 16 feet with no plants. Several stretches of shoreline milfoil occurred only as a narrow band due to steep shoreline. There were approximately 22 beds of milfoil around the lake totaling about 13 acres of coverage. Although the eastern bay, (Abele Cove) is full of milfoil but is harvested regularly. This area is about 18 acres in size so adding this to the 13 identified beds would bring the total milfoil coverage to 30 acres.

Large-leaf pondweed was found between about 3 and 8 feet of water depth. Large-leaf pondweed grows to the surface producing both small, oval, shaped floating leaves and a small erect flowering stalk. Large-leaf pondweed was found in about 24 beds totaling about 7 acres. The eastern bay, also has a dense covering of large-leaf pondweed but is regularly harvested. On the date of the survey in 2009, Eurasian Milfoil and large-leaf pondweed was visible from the surface because no harvesting had taken place as yet. The total area of large-leaf pondweed in the lake is probably closer to 26 acres. Generally mixed in with large leaf pondweed was Robbins Pondweed, although there this species was common it was not found growing singly enough to warrant a separate map code. The floating leaved plants occurred in about 20 beds covering about 8 acres, with the largest in the outlet cove covering about 3 acres. Together these three species cover about 64 acres out of the total area between 0 and 13 feet of 108 acres.

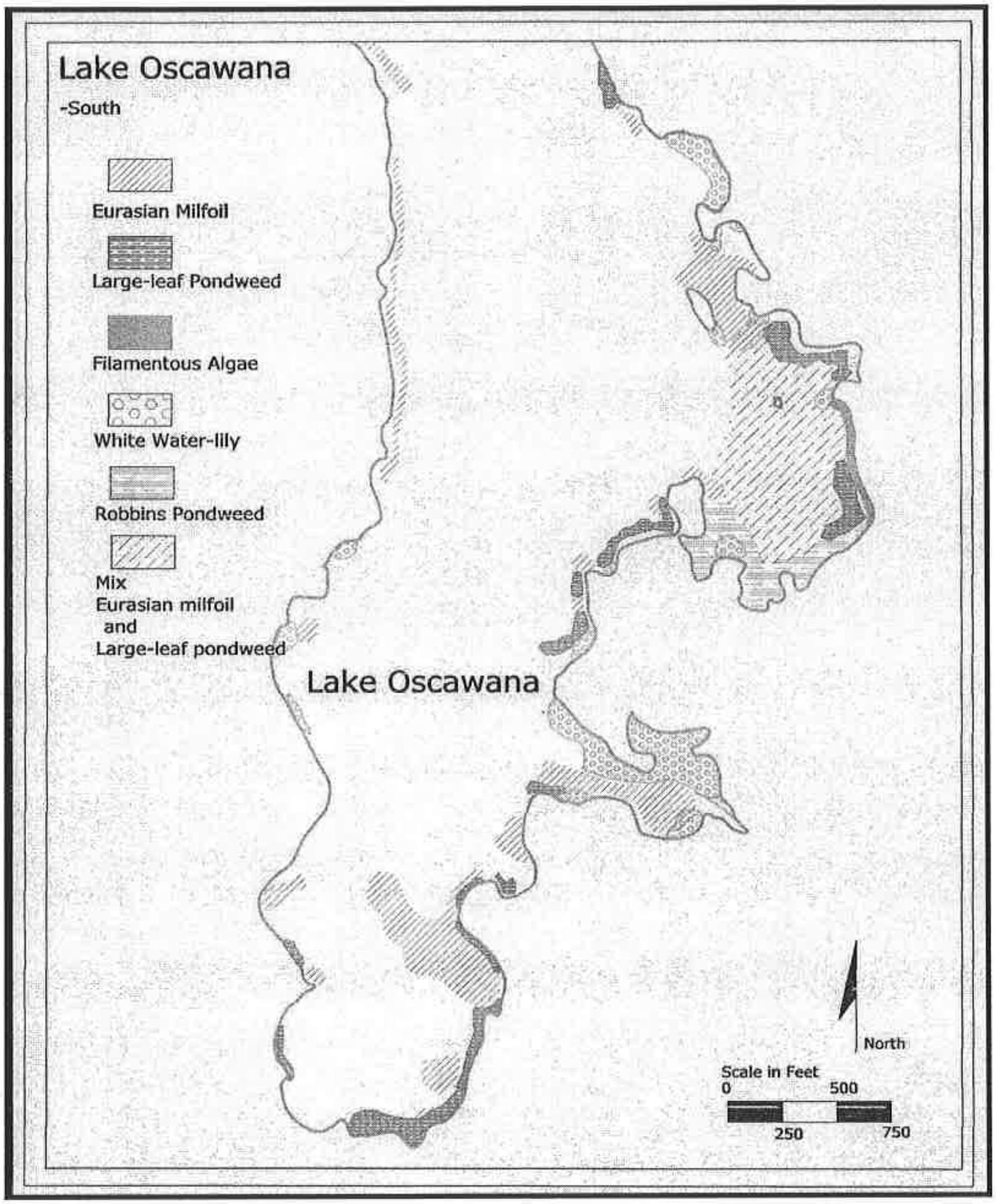
The other submersed species listed on **Table 6** were found only rarely in the lake. The principal site where all of the species were found was the northwest corner cove. In that area tape-grass was very abundant as was arrow-head, a small leafy plant that grows on the bottom. Coontail was seen rarely mixed in with denser growing large-leaf pondweed beds. The northeast cove contained a very dense mat of filamentous algae that coated all of the submersed plants and formed a thick blanket over the bottom that floated to the surface in many places. There was also a thick blanket of filamentous algae along the inside shore of bay on the eastern side of the lake.

Floating islands were observed in several locations. These were composed of buoyant rhizomes of while water-lily. The most abundant floating islands were in the outlet cove where at least three large clumps of buoyant rhizome mats were seen. A large percentage of the remaining cove area had 100% cover of white water-lily. Rhizome mats were also observed in the small cove associated with the inlet from the Lost River Swamp, and in the northeastern cove. The appearance of white water-lily mats suggests that the sediments in these areas consist largely of organic materials. The mats have the potential to accelerate the colonization of the water by wetland plants.

**Map 1 - Aquatic Plant Beds in Northern Lake Oscawana mapped in August 2008**



**Map 2 - Aquatic Plant Beds in Southern Lake Oscawana mapped in August 2008, with details for Abele Cove added in August 2009**



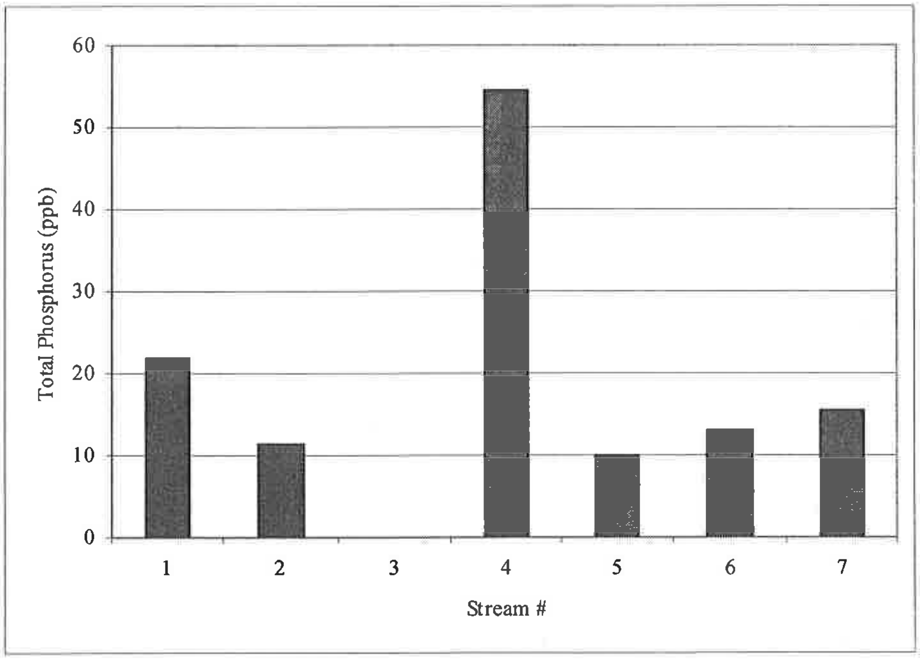
# 2010 STREAM MONITORING RESULTS

The seven regularly monitored inlets to Lake Oscawana were visited 7 times during the 2010 season to collect water samples and record the temperature and oxygen of the water. However, due to a lack of adequate shoulder for safe parking, stream #3 was not visited for sample collection in 2010.

## Total Phosphorus

Similar to prior seasons, stream #4 had high total phosphorus levels during the 2010 season (**Figure 15**). Concentrations were about half what was seen last year. The average concentration was 55 ppb in 2010 and 110 ppb in 2009, with a maximum concentration of 73 in 2010 and 304 ppb in 2010. Stream #1 had an average of 22 ppb in 2010 and 35 ppb in 2009. Other streams had average phosphorus of less than 20 ppb. Although Stream #4 had highest phosphorus concentration the water flow is the lowest of any of the other inlets monitored as part of the program.

**Figure 15 -Average Phosphorus Concentration At Each of the Seven Streams in 2010**




## Nitrate

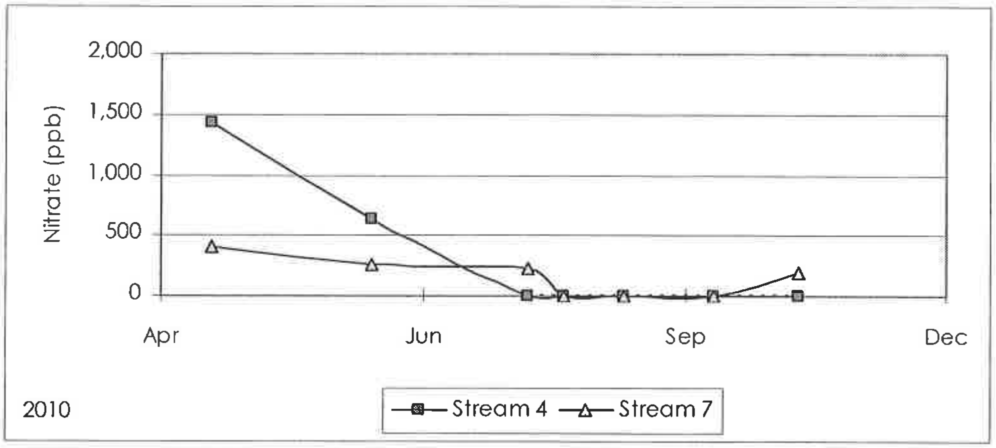
The nitrate concentration was highest in streams #4, and #7 (**Table 6**). The nitrate concentration trends for streams #2, #3, #4, and #7 during the 2009 season is shown in **Figure 16.** The zeros on the chart were when the streams were dry and no sample was collected.

**Table 7 - Average Seasonal Nitrate (ppb) Concentrations at Inlet Streams 2, 3, 4, & 7**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|
| #2 | 37 | 127 | 148 | 57 | 137 | 107 | 37 | 157 |
| #3 | 646 | 801 | 678 | 674 | 960 | 410 | 315 | - |
| #4 | 1,173 | 1,498 | 1,690 | 1,375 | 1,340 | 725 | 830 | 1,030 |
| #7 | 454 | 448 | 322 | 313 | 262 | 237 | 302 | 268 |

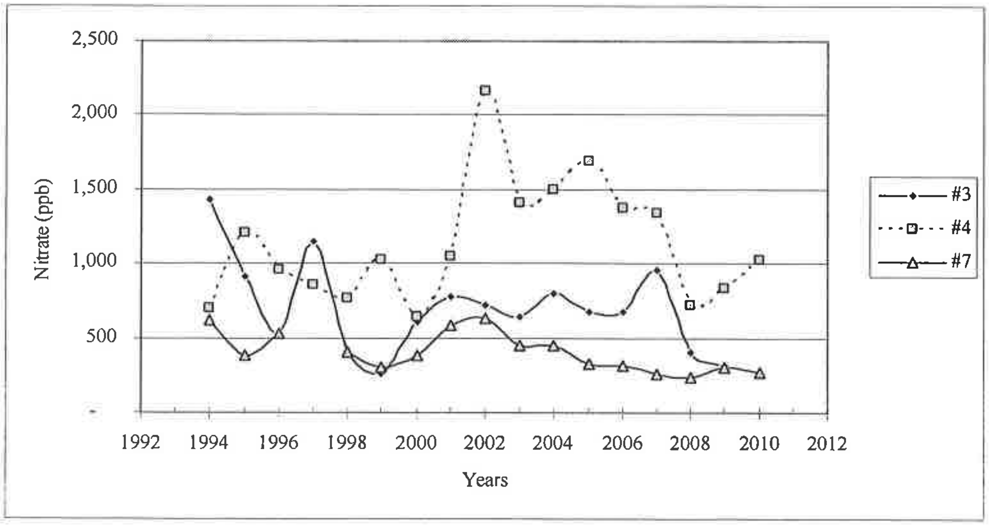
| | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|
| #2 | 90 | 53 | 54 | 128 | 87 | 70 | 53 | 95 | 119 |
| #3 | 1,428 | 916 | 961 | 1,153 | 407 | 257 | 612 | 780 | 725 |
| #4 | 876 | 1,207 | 946 | 858 | 770 | 1,023 | 640 | 1,052 | 2,160 |
| #7 | 533 | 388 | 533 | 391 | 407 | 305 | 381 | 587 | 626 |

**Figure 16 - 2010 Seasonal Trends In Nitrate Concentration At Streams #4, and #7**




The long-term trend in nitrate concentration in streams #3, #4 and #7 is shown in **Figure 17**. The chart gives the seasonal average concentration beginning in 1994. The trend shows that Stream #4 has had the highest nitrate.

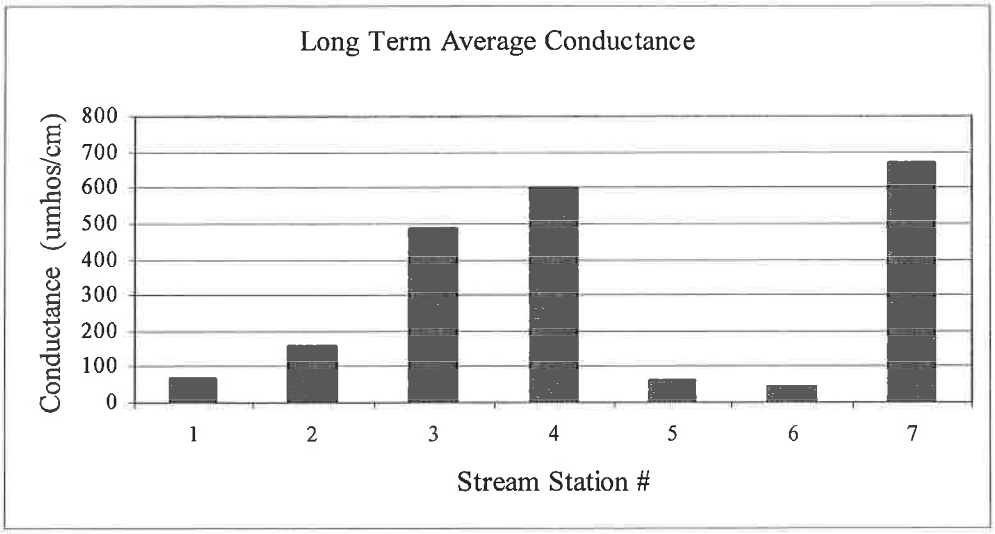
**Figure 17 - Long Term Trend in Average Nitrate Concentration from Three Streams**



## Conductivity

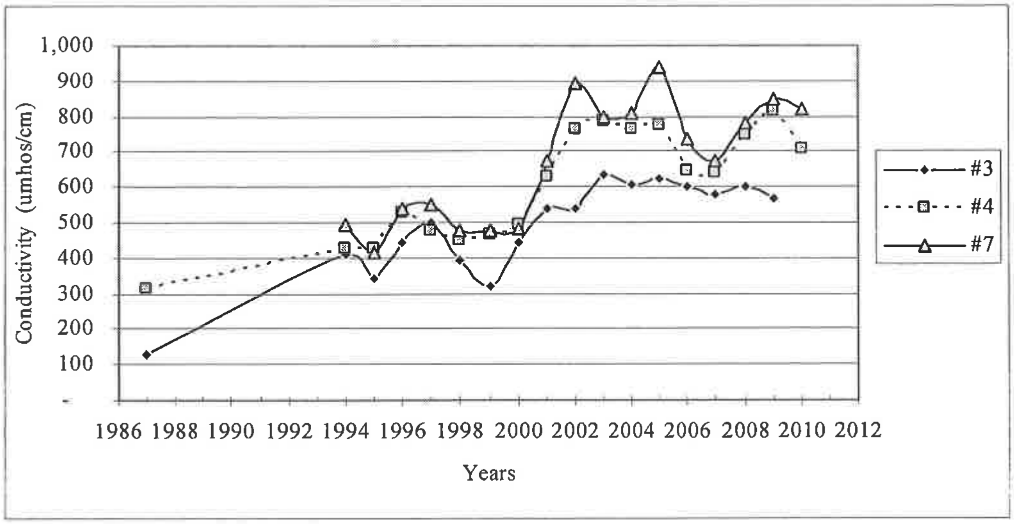
The long-term average conductivity (conductance) in stream waters is shown in **Figure 18.** Streams #3, #4, and #7 have consistently had the highest values, several times higher than the remaining streams. The streams with the low values, #1, #2, #5, and #6 had conductance levels consistent with undeveloped landscapes. The streams with the high values suggest septic system leach field water influence.

**Figure 18 - Average Conductance Values from All Streams**




The long-term trend in annual average conductivity from the three high values streams #3, #4, and #7, is shown in **Figure 19.** Streams #4 and #6 show increasing conductance, while stream #7 appears to have stabilized.

**Figure 19 - Long Term Trend in Average Conductivity from Three Streams**



## Bacterial Indicators

The results of indicator bacteria sampling at streams #3, #4, and #7 are shown in **Figures 20 and 21**. The charts show seasonality to the numbers of both total coliform and fecal coliform bacteria with initially low values in early spring and high levels in summer and lowest numbers in the fall. Both streams showed peak numbers in July, sampling probably followed a thunderstorm on that day. Both stream had very low fecal numbers in the fall of 2010.

**Figure 20 - Total Coliform (colonies/100mL) Results From Streams #4, and #7 During 2010**

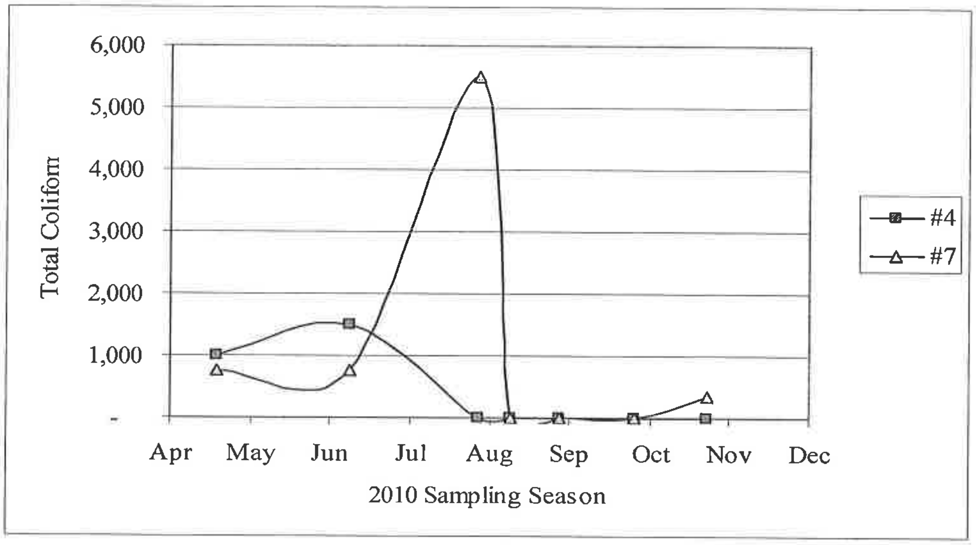
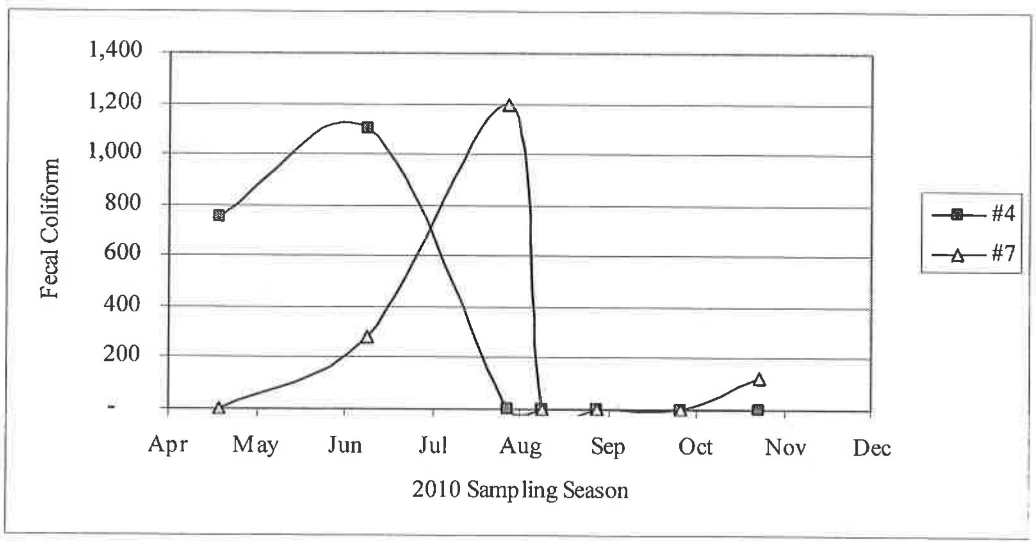
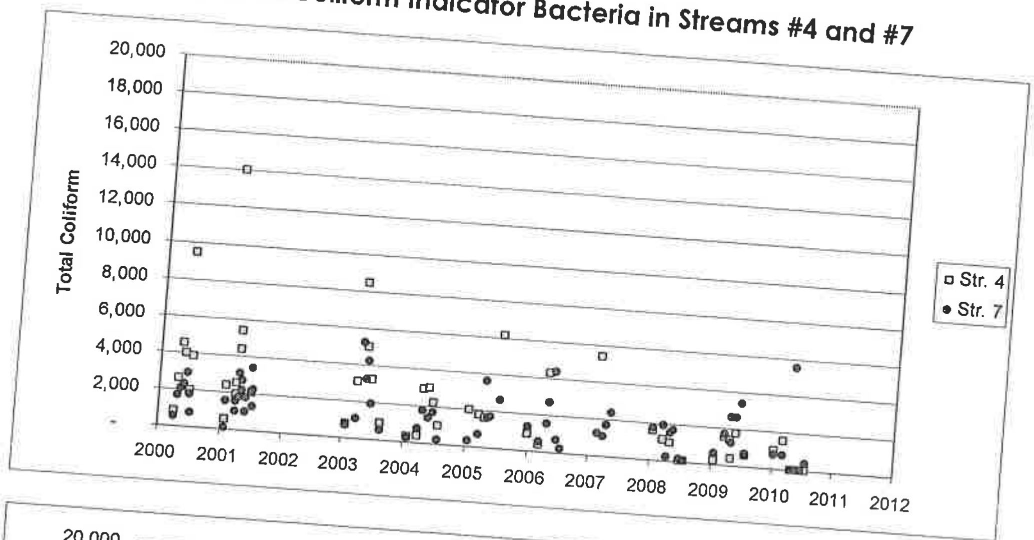


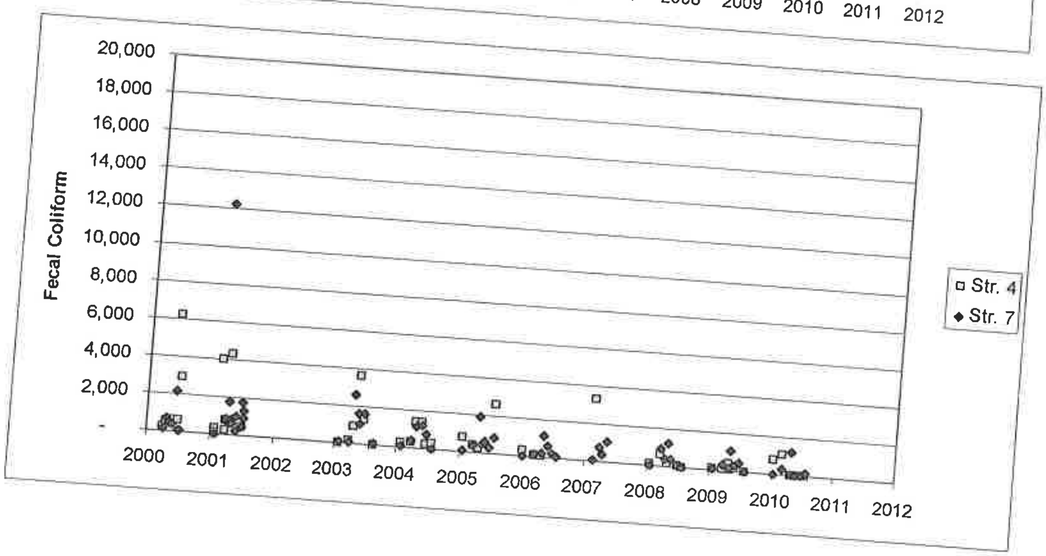

**Figure 21 - Fecal Coliform (colonies/100mL) Results From Streams #4, and #7 During 2010**



The long-term trend in bacterial indicator numbers at Streams #4 and #7 are shown in **Figure 22**. The charts suggest a decreasing trend in indicator bacteria at both sites.

**Figure 22 - Total and Fecal Coliform Indicator Bacteria in Streams #4 and #7**



# CONCLUSIONS AND RECOMMENDATIONS

## 2010 Monitoring Conclusions

The water clarity was good to very good during the entire season in 2010. The lowest clarity occurred in April when the Secchi disk depth was 2.9 meters. The average Secchi disk depth for the 2010 was the best of any season on record at 3.67 meters.

Phosphorus concentration in the epilimnion (1 and 4 meter samples) ranged between 5 and 16 ppb, with an average of 11 ppb during 2010. These were the best values since 2002.

The spring phosphorus concentration in 2010 was 14 ppb, equal to the long-term average spring value. The best, lowest, spring phosphorus concentration was 9 ppb observed in 1999.

The maximum phosphorus at Station 1 was 120 ppb. The maximum phosphorus values from stations 2 and 3 were also lower in 2010 suggesting that overall internal loading at the lake was low again in 2010.

The anoxic boundary remained below 6 meters for the entire season, reached a maximum ascent depth of 6.67 meters below the surface on June 10th, at Station 1. After that date, the anoxic boundary remained between 6.7 and 7 meters.

The zooplankton community showed no large bodied individuals during 2010. Bosmina was the only cladoceria in the samples. Rotifers reached very high numbers in 2010 almost 90 organisms/L, this happened before in 2006 when Rotifer numbers reached close to 60 organisms/L. Diatoms were very abundant in spring and early summer staying dominant although at lesser numbers throughout the summer. Green and blue-green algae occurred but did not become dominant during the summer. Diatoms become very numerous in late summer and fall.

Inlet streams #4 and #7 again showed high levels of nitrate. Initially indicator bacteria were high, spring and early summer during the 2010 season but decreased to very low in late summer. There is an apparent trend of decreasing levels at stream #4 and #7.

## Suggestions for Future Action

There were several interesting results from the 2010 monitoring that need to be verified during the monitoring conducted in 2011.

1) Water clarity was very good in 2010. There was no late summer decline in clarity as has been seen in prior years.
2) Phosphorus concentrations were very low in the bottom waters in 2010. The phosphorus concentration in the bottom water continues to be much lower than recent trends indicate it should be. A mechanism for this lower concentration should be considered with testing conducted in 2011 to determine why these concentrations are so much lower than during prior years.
3) Phosphorus concentrations in the surface water were lower in 2010.

   The phosphorus was not sporadically high during the 2010 season suggesting 2009 results were aberrant. It is possible that low phosphorus is linked to rainfall with lower levels occurring during dry years.
4) Low bacteria levels in streams #4 and #7.

   Indicator bacteria levels at streams 4 and 7 were again low in late summer of 2010. The long-term trend shows that bacteria levels are declining at these stations.
5) Lower nitrate values in the inlet streams.

   Nitrate levels at streams 4, and 7 declined in 2010 but are still high.
6) Zooplankton samples were devoid of large bodied cladocerns in 2010. Prior years had shown a possible recovery in large daphnia that was not evident during 2010 with samples devoid of large-bodied size classes in 2010.
7) Storm drain mapping around Lake Oscawana has been completed. Approximately 38% of the drainage basin of Lake Oscawana is not included by the regular stream sampling. Most of this area is land adjacent to the lake that drains via storm water outfalls. Each of the identified discharge points should be sampled to determine nutrient levels and water volumes during storm events.
8) Aquatic plants were not surveyed in 2010; the last whole lake survey was conducted in 2008. Aquatic plants should be surveyed in 2011. Analysis of weed harvesting operations should be conducted to determine effectiveness of this method of weed control.

# APPENDIX 1.

## 2010 Water Column Temperature and Dissolved Oxygen Values for Stations 1, 2, and 3:

Station 1

**Temperature °C**

**Station 1**

| Depth meters | 19-Apr-10 | 10-Jun-10 | 30-Jul-10 | 11-Aug-10 | 30-Aug-10 | 28-Sep-10 | 26-Oct |
|---|---|---|---|---|---|---|---|
| 0 | 12.9 | 21.7 | 27.5 | 27.4 | 24.9 | 21.0 | 16.1 |
| 1 | 12.8 | 21.8 | 27.6 | 27.6 | 24.7 | 21.1 | 15.1 |
| 2 | 12.8 | 21.8 | 27.5 | 27.6 | 24.4 | 21.0 | 14.8 |
| 3 | 12.8 | 21.8 | 27.3 | 27.5 | 24.2 | 21.0 | 14.5 |
| 4 | 12.8 | 19.9 | 27.3 | 27.2 | 24.0 | 20.8 | 14.3 |
| 5 | 12.7 | 16.9 | 25.6 | 27.0 | 23.5 | 20.6 | 14.2 |
| 6 | 10.2 | 15.0 | 20.7 | 22.8 | 23.2 | 20.3 | 14.1 |
| 7 | 9.5 | 14.0 | 17.3 | 17.7 | 19.6 | 20.0 | 14.0 |
| 8 | 9.2 | 13.6 | 14.8 | 15.5 | 16.6 | 19.9 | 13.9 |
| 9 | 9.1 | 13.2 | 13.8 | 14.2 | 15.2 | 19.1 | 13.8 |
| 10 | 9.0 | 12.7 | 12.7 | | 14.0 | 14.7 | 13.5 |
| 11 | | 12.6 | | | | 13.4 | 13.4 |

**Dissolved Oxygen (mg/L)**

**Station 1**

| Depth in meters | 19-Apr-10 | 10-Jun-10 | 30-Jul-10 | 11-Aug-10 | 30-Aug-10 | 28-Sep-10 | 26-Oct |
|---|---|---|---|---|---|---|---|
| 0 | 12.4 | 10.0 | 9.7 | 9.9 | 10.3 | 7.9 | 9.4 |
| 1 | 12.5 | 10.0 | 9.8 | 10.0 | 10.5 | 7.9 | 9.5 |
| 2 | 12.5 | 10.0 | 9.7 | 10.0 | 10.5 | 7.8 | 9.4 |
| 3 | 12.4 | 10.0 | 9.6 | 10.0 | 10.4 | 7.7 | 9.1 |
| 4 | 12.4 | 10.7 | 9.7 | 9.8 | 10.2 | 6.5 | 8.8 |
| 5 | 12.3 | 7.3 | 8.6 | 9.1 | 10.1 | 4.9 | 8.6 |
| 6 | 9.0 | 1.8 | 2.6 | 3.1 | 9.0 | 2.6 | 8.5 |
| 7 | 7.5 | 0.6 | 0.8 | 0.4 | 0.4 | 0.8 | 8.3 |
| 8 | 6.5 | 0.4 | 0.3 | 0.3 | 0.3 | 0.3 | 8.0 |
| 9 | 6.1 | 0.4 | 0.3 | 0.2 | 0.3 | 0.3 | 7.7 |
| 10 | 4.6 | 0.4 | 0.2 | 0.0 | 0.3 | 0.3 | 7.4 |
| 11 | | 0.4 | 0.0 | 0.0 | | 0.2 | 6.8 |

## Dissolved Oxygen Percent Saturation (%)

### Station 1

| Depth in meters | 19-Apr-10 | 10-Jun-10 | 30-Jul-10 | 11-Aug-10 | 30-Aug-10 | 28-Sep-10 | 26-Oct-10 |
|---|---|---|---|---|---|---|---|
| 0 | 117 | 114 | 123 | 125 | 124 | 89 | 95 |
| 1 | 118 | 114 | 124 | 127 | 126 | 89 | 94 |
| 2 | 118 | 114 | 123 | 127 | 126 | 87 | 93 |
| 3 | 117 | 114 | 121 | 127 | 124 | 86 | 89 |
| 4 | 117 | 117 | 122 | 123 | 121 | 73 | 86 |
| 5 | 116 | 75 | 105 | 114 | 119 | 55 | 84 |
| 6 | 80 | 18 | 29 | 36 | 105 | 29 | 83 |
| 7 | 66 | 6 | 8 | 4 | 4 | 9 | 81 |
| 8 | 56 | 4 | 3 | 3 | 3 | 3 | 77 |
| 9 | 53 | 4 | 3 | 2 | 3 | 3 | 74 |
| 10 | 40 | 4 | 2 | 0 | 3 | 3 | 71 |
| 11 | | 4 | 0 | 0 | | 2 | 65 |

## Relative Thermal Resistance to Mixing

### Station 1

| Depth in meters | 19-Apr-10 | 10-Jun-10 | 30-Jul-10 | 11-Aug-10 | 30-Aug-10 | 28-Sep-10 | 26-Oct-10 |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | |
| 1 | 1 | -3 | -3 | -7 | 6 | -3 | 19 |
| 2 | 0 | 0 | 3 | 0 | 9 | 3 | 6 |
| 3 | 0 | 0 | 7 | 3 | 6 | 0 | 5 |
| 4 | 0 | 50 | 0 | 10 | 6 | 5 | 4 |
| 5 | 1 | 70 | 57 | 7 | 15 | 5 | 2 |
| 6 | 33 | 38 | 144 | 132 | 9 | 8 | 2 |
| 7 | 7 | 18 | 82 | 131 | 98 | 8 | 2 |
| 8 | 3 | 7 | 50 | 46 | 69 | 2 | 2 |
| 9 | 1 | 7 | 18 | 24 | 28 | 20 | 2 |
| 10 | 1 | 8 | 18 | | 22 | 93 | 5 |
| 11 | | 1 | | | 20 | 22 | 2 |

Colors for RTRM help show magnitudes of stratification strength. Each interval of 30 RTRM units is given a darker color.

Station 2

| Temperature °C | | | | | |
|---|---|---|---|---|---|
| Station 2 | | | | | |
| Depth in meters | 10-Jun-10 | 30-Jul-10 | 11-Aug-10 | 30-Aug-10 | 28-Sep-10 |
| 0 | 22.0 | 27.7 | 27.6 | 24.4 | |
| 1 | 22.1 | 27.7 | 27.5 | 24.4 | |
| 2 | 22.1 | 27.4 | 27.4 | 24.3 | |
| 3 | 21.9 | 27.2 | 27.3 | 24.0 | |
| 4 | 21.6 | 27.0 | 27.2 | 23.7 | |
| 5 | 17.4 | 24.1 | 25.7 | 23.2 | |
| 6 | 15.3 | 19.4 | 20.6 | 22.5 | |
| 7 | 14.1 | 16.6 | 17.4 | 19.5 | |
| 7.5 | 13.4 | 15.3 | 15.6 | 17.3 | |

| Dissolved Oxygen (mg/L) | | | | | |
|---|---|---|---|---|---|
| Station 2 | | | | | |
| Depth in meters | 10-Jun-10 | 30-Jul-10 | 11-Aug-10 | 30-Aug-10 | 28-Sep-10 |
| 0 | 10.0 | 9.9 | 10.0 | 10.4 | |
| 1 | 10.0 | 9.9 | 10.0 | 10.5 | |
| 2 | 10.0 | 9.8 | 10.0 | 10.4 | |
| 3 | 9.8 | 9.7 | 10.0 | 10.4 | |
| 4 | 9.7 | 9.4 | 9.8 | 10.4 | |
| 5 | 8.5 | 7.1 | 8.7 | 9.8 | |
| 6 | 3.4 | 1.6 | 0.7 | 4.8 | |
| 7 | 0.7 | 0.4 | 0.3 | 0.4 | |
| 7.5 | 0.4 | 0.3 | 0.2 | 0.3 | |

| Dissolved Oxygen Percent Saturation (%) | | | | | |
|---|---|---|---|---|---|
| Station 2 | | | | | |
| Depth in meters | 10-Jun-10 | 30-Jul-10 | 11-Aug-10 | 30-Aug-10 | 28-Sep-10 |
| 0 | 114 | 126 | 127 | 124 | |
| 1 | 115 | 126 | 127 | 126 | |
| 2 | 115 | 124 | 126 | 124 | |
| 3 | 112 | 122 | 126 | 124 | |
| 4 | 110 | 118 | 123 | 123 | |
| 5 | 89 | 84 | 107 | 115 | |
| 6 | 34 | 17 | 8 | 55 | |
| 7 | 7 | 4 | 3 | 4 | |
| 7.5 | 4 | 3 | 2 | 3 | |

| Relative Thermal Resistance to Mixing | | | | | |
|---|---|---|---|---|---|
| Station 2 | | | | | |
| Depth in meters | 10-Jun-10 | 30-Jul-10 | 11-Aug-10 | 30-Aug-10 | 28-Sep-10 |
| 0 | | | | | |
| 1 | -3 | 0 | 3 | 0 | |
| 2 | 0 | 10 | 3 | 3 | |
| 3 | 6 | 7 | 3 | 9 | |
| 4 | 8 | 7 | 3 | 9 | |
| 5 | 104 | 94 | 50 | 15 | |
| 6 | 43 | 130 | 150 | 20 | |
| 7 | 22 | 64 | 77 | 80 | |
| 7.5 | 12 | 26 | 37 | 51 | |

Station 3

| Temperature °C | | | | | |
|---|---|---|---|---|---|
| Station 3 | | | | | |
| Depth meters | 10-Jun-10 | 30-Jul-10 | 11-Aug-10 | 30-Aug-10 | 28-Sep-10 |
| 0 | 21.8 | 26.8 | 27.8 | 24.9 | 21.1 |
| 1 | 21.8 | 27.4 | 27.7 | 24.8 | 21.1 |
| 2 | 21.8 | 27.3 | 27.6 | 24.5 | 21.0 |
| 3 | 21.9 | 27.2 | 27.4 | 24.4 | 20.9 |
| 4 | 20.3 | 27.2 | 27.3 | 23.8 | 20.8 |
| 5 | 17.0 | 26.7 | 26.8 | 23.5 | 20.6 |
| 6 | 14.9 | 20.3 | 24.7 | 23.2 | 20.2 |
| 7 | 14.1 | 16.9 | 19.2 | 21.9 | 20.2 |
| 8 | 13.4 | 16.1 | | | 20.0 |

| Dissolved Oxygen (mg/L) | | | | | |
|---|---|---|---|---|---|
| Station 3 | | | | | |
| Depth meters | 10-Jun-10 | 30-Jul-10 | 11-Aug-10 | 30-Aug-10 | 28-Sep-10 |
| 0 | 10.1 | 9.9 | 9.9 | 10.3 | 7.9 |
| 1 | 10.0 | 9.9 | 9.9 | 10.5 | 7.6 |
| 2 | 9.6 | 9.8 | 9.9 | 10.7 | 7.4 |
| 3 | 9.6 | 9.8 | 10.0 | 10.7 | 6.6 |
| 4 | 10.3 | 9.5 | 9.9 | 9.9 | 6.2 |
| 5 | 7.6 | 8.7 | 9.6 | 9.5 | 4.8 |
| 6 | 1.2 | 1.7 | 6.5 | 8.3 | 2.4 |
| 7 | 0.5 | 0.4 | 0.4 | 1.0 | 1.7 |
| 8 | 0.3 | 0.3 | 0.0 | | 1.0 |

## Dissolved Oxygen Percent Saturation (%)

### Station 3

| Depth meters | 10-Jun-10 | 30-Jul-10 | 11-Aug-10 | 30-Aug-10 | 28-Sep-10 |
|---|---|---|---|---|---|
| 0 | 115 | 124 | 126 | 124 | 89 |
| 1 | 114 | 125 | 126 | 127 | 85 |
| 2 | 109 | 124 | 126 | 128 | 83 |
| 3 | 110 | 123 | 126 | 128 | 74 |
| 4 | 114 | 120 | 125 | 117 | 69 |
| 5 | 79 | 109 | 120 | 112 | 53 |
| 6 | 12 | 19 | 78 | 97 | 27 |
| 7 | 5 | 4 | 4 | 11 | 19 |
| 8 | 3 | 3 | 0 | | 11 |

## Relative Thermal Resistance to Mixing

### Station 3

| Depth meters | 10-Jun-10 | 30-Jul-10 | 11-Aug-10 | 30-Aug-10 | 28-Sep-10 |
|---|---|---|---|---|---|
| 0 | | | | | |
| 1 | 0 | -21 | | 3 | 0 |
| 2 | 0 | 3 | 3 | 9 | 3 |
| 3 | -3 | 3 | 3 | 3 | 3 |
| 4 | 43 | 0 | 7 | 18 | 3 |
| 5 | 78 | 17 | 3 | 9 | 5 |
| 6 | 42 | 191 | 17 | 9 | 10 |
| 7 | 14 | 80 | 68 | 37 | 0 |
| 8 | 12 | 17 | 154 | | 5 |

# APPENDIX 2.

## Lake Water Quality Data:

Station 1

**Lake Oscawana Water Chemistry Data 2010**

**Total Phosphorus as P (ppb)**

| Depth | 19-Apr | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep | 26-Oct |
|---|---|---|---|---|---|---|---|
| 1 m | 14 | 10 | 11 | 9 | 8 | 13 | 12 |
| 4 m | 12 | 16 | 5 | 9 | 11 | 14 | 13 |
| 6 m | 13 | 18 | 12 | 17 | 15 | 17 | 13 |
| 9 m | 16 | 24 | 84 | 79 | 120 | 68 | 18 |
| *mean* | 14 | 17 | 28 | 29 | 39 | 28 | 14 |

**Ammonia as N (ppb)**

| Depth | 19-Apr | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep | 26-Oct |
|---|---|---|---|---|---|---|---|
| 1 m | < 10 | | < 10 | < 10 | < 10 | 25 | 26 |
| 4 m | < 10 | | < 10 | < 10 | < 10 | 35 | 32 |
| 6 m | < 10 | | 11 | 16 | < 10 | 64 | 26 |
| 9 m | < 10 | | 385 | 875 | 1,210 | 800 | 19 |

**Total Nitrogen as N (ppb)**

| Depth | 19-Apr | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep | 26-Oct |
|---|---|---|---|---|---|---|---|
| 1 m | | 229 | 262 | 254 | 445 | 368 | 326 |
| 4 m | | 276 | 289 | 275 | 468 | 343 | 314 |
| 6 m | | 241 | 287 | 362 | 524 | 278 | 298 |
| 9 m | | 296 | 668 | LE | LE | 810 | 263 |

**Total Iron (mg/L)**

| Depth | 19-Apr | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep | 26-Oct |
|---|---|---|---|---|---|---|---|
| 1 m | < 0.02 | 0.10 | 0.04 | 0.02 | < 0.02 | 0.08 | 0.06 |
| 4 m | < 0.02 | 0.09 | 0.04 | 0.43 | 0.06 | 0.08 | 0.10 |
| 6 m | < 0.02 | 0.18 | 0.15 | 0.14 | 0.11 | 0.15 | 0.07 |
| 9 m | < 0.02 | 1.10 | 5.90 | 5.30 | 6.10 | 0.90 | 0.10 |

Station 2

**Total Phosphorus as P (ppb)**

| Depth | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep |
|---|---|---|---|---|---|
| 1 | 10 | 5 | 11 | 10 | NC |
| 7.5 | 24 | 48 | 56 | 32 | NC |
| Mean | 17 | 27 | 34 | 21 | |

**Total Iron (mg/L)**

| Depth | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep |
|---|---|---|---|---|---|
| 1 | 0.06 | 0.06 | 0.04 | 0.014 | NC |
| 7.5 | 0.23 | 0.39 | 0.37 | 0.16 | NC |

Station 3

| Total Phosphorus as P (ppb) | | | | | |
|---|---|---|---|---|---|
| Depth | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep |
| 1 | 11 | 7 | 9 | 11 | 9 |
| 7.5 | 21 | 40 | 48 | 21 | 17 |
| Mean | 16 | 24 | 29 | 16 | 13 |

| Total Iron (mg/L) | | | | | |
|---|---|---|---|---|---|
| Depth | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep |
| 1 | 0.07 | 0.04 | 0.036 | 0.16 | 0.07 |
| 7.5 | 0.41 | 0.94 | 0.63 | 0.029 | 0.22 |

## Stream Water Quality Data:

Total Phosphorus (ppb)

| Stream # | 19-Apr | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep | 26-Oct |
|---|---|---|---|---|---|---|---|
| 1 | 42 | 20 | Dry | Dry | Dry | Dry | 4 |
| 2 | 10 | 19 | 9 | 9 | 10 | 27 | 10 |
| 3 | NC | NC | NC | NC | NC | NC | NC |
| 4 | 36 | 73 | Dry | Dry | Dry | Dry | Dry |
| 5 | 8 | 16 | Dry | Dry | Dry | Dry | 6 |
| 6 | 13 | Dry | Dry | Dry | Dry | Dry | Dry |
| 7 | 10 | 21 | 18 | Dry | Dry | Dry | 13 |

Nitrate / Nitrite Nitrogen (ppb)

| Stream # | 19-Apr | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep | 26-Oct |
|---|---|---|---|---|---|---|---|
| 1 | < 10 | < 10 | Dry | Dry | Dry | Dry | < 10 |
| 2 | < 10 | < 10 | 168 | 192 | 111 | < 10 | <10 |
| 3 | NC | NC | NC | NC | NC | NC | NC |
| 4 | 1,430 | 630 | Dry | Dry | Dry | Dry | Dry |
| 5 | 18 | 46 | Dry | Dry | Dry | Dry | < 10 |
| 6 | < 10 | Dry | Dry | Dry | Dry | Dry | Dry |
| 7 | 400 | 255 | 225 | Dry | Dry | Dry | 192 |

Alkalinity (mg/L)

| Stream # | 19-Apr | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep | 26-Oct |
|---|---|---|---|---|---|---|---|
| 1 | 12 | 20 | Dry | Dry | Dry | Dry | 8 |
| 2 | 14 | 26 | 40 | 36 | 36 | 30 | 18 |
| 3 | NC | NC | NC | NC | NC | NC | NC |
| 4 | 22 | 118 | Dry | Dry | Dry | Dry | Dry |
| 5 | 8 | 18 | Dry | Dry | Dry | Dry | 8 |
| 6 | 4 | Dry | Dry | Dry | Dry | Dry | Dry |
| 7 | 50 | 64 | 72 | Dry | Dry | Dry | 68 |

Conductivity (µmhos/cm)

| Stream # | 19-Apr | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep | 26-Oct |
|---|---|---|---|---|---|---|---|
| 1 | 83 | 64 | Dry | Dry | Dry | Dry | 75 |
| 2 | 166 | 195 | 320 | 312 | 335 | 336 | 217 |
| 3 | NC | NC | NC | NC | NC | NC | NC |
| 4 | 730 | 683 | Dry | Dry | Dry | Dry | Dry |
| 5 | 62 | 79 | Dry | Dry | Dry | Dry | 54 |
| 6 | 41 | Dry | Dry | Dry | Dry | Dry | Dry |
| 7 | 753 | 755 | 880 | Dry | Dry | Dry | 883 |

Turbidity (NTU)

| Stream # | 19-Apr | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep | 26-Oct |
|---|---|---|---|---|---|---|---|
| 1 | 1.4 | 1.2 | Dry | Dry | Dry | Dry | 0.4 |
| 2 | 2.0 | 1.8 | 1.4 | 1.0 | 0.6 | 1 | 0.6 |
| 3 | NC | NC | NC | NC | NC | NC | NC |
| 4 | 2.3 | 0.9 | Dry | Dry | Dry | Dry | Dry |
| 5 | 0.8 | 8.7 | Dry | Dry | Dry | Dry | 0.5 |
| 6 | 0.9 | Dry | Dry | Dry | Dry | Dry | Dry |
| 7 | 0.6 | 1.8 | 2.4 | Dry | Dry | Dry | 0.9 |

pH (Units)

| Stream # | 19-Apr | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep | 26-Oct |
|---|---|---|---|---|---|---|---|
| 1 | 6.9 | 6.9 | Dry | Dry | Dry | Dry | 8.4 |
| 2 | 6.9 | 7.2 | 7.5 | 7.4 | 7.5 | 7.3 | 6.9 |
| 3 | NC | NC | NC | NC | NC | NC | NC |
| 4 | 7.3 | 7.6 | Dry | Dry | Dry | Dry | Dry |
| 5 | 7.3 | 7.3 | Dry | Dry | Dry | Dry | 6.8 |
| 6 | 6.7 | Dry | Dry | Dry | Dry | Dry | Dry |
| 7 | 7.2 | 7.2 | 7.3 | Dry | Dry | Dry | 7.2 |

Total Coliform / 100 mL

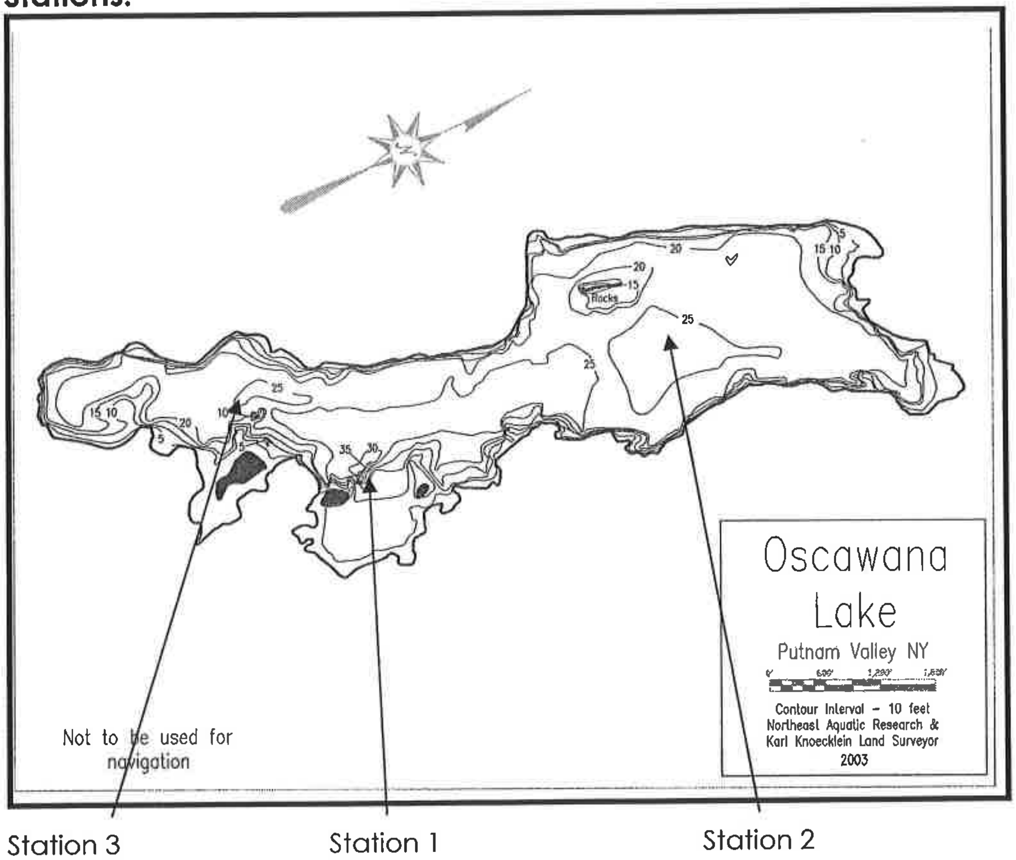
| Stream # | 19-Apr | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep | 26-Oct |
|---|---|---|---|---|---|---|---|
| 3 | | | | | | | |
| 4 | 1000 | 1,500 | Dry | Dry | Dry | Dry | Dry |
| 7 | 750 | 750 | 5,500 | Dry | Dry | Dry | 350 |

Fecal Coliform / 100 mL

| Stream # | 19-Apr | 10-Jun | 30-Jul | 11-Aug | 30-Aug | 28-Sep | 26-Oct |
|---|---|---|---|---|---|---|---|
| 3 | | | | | | | |
| 4 | 750 | 1,100 | Dry | Dry | Dry | Dry | Dry |
| 7 | < 20 | 280 | 1,200 | Dry | Dry | Dry | 125 |

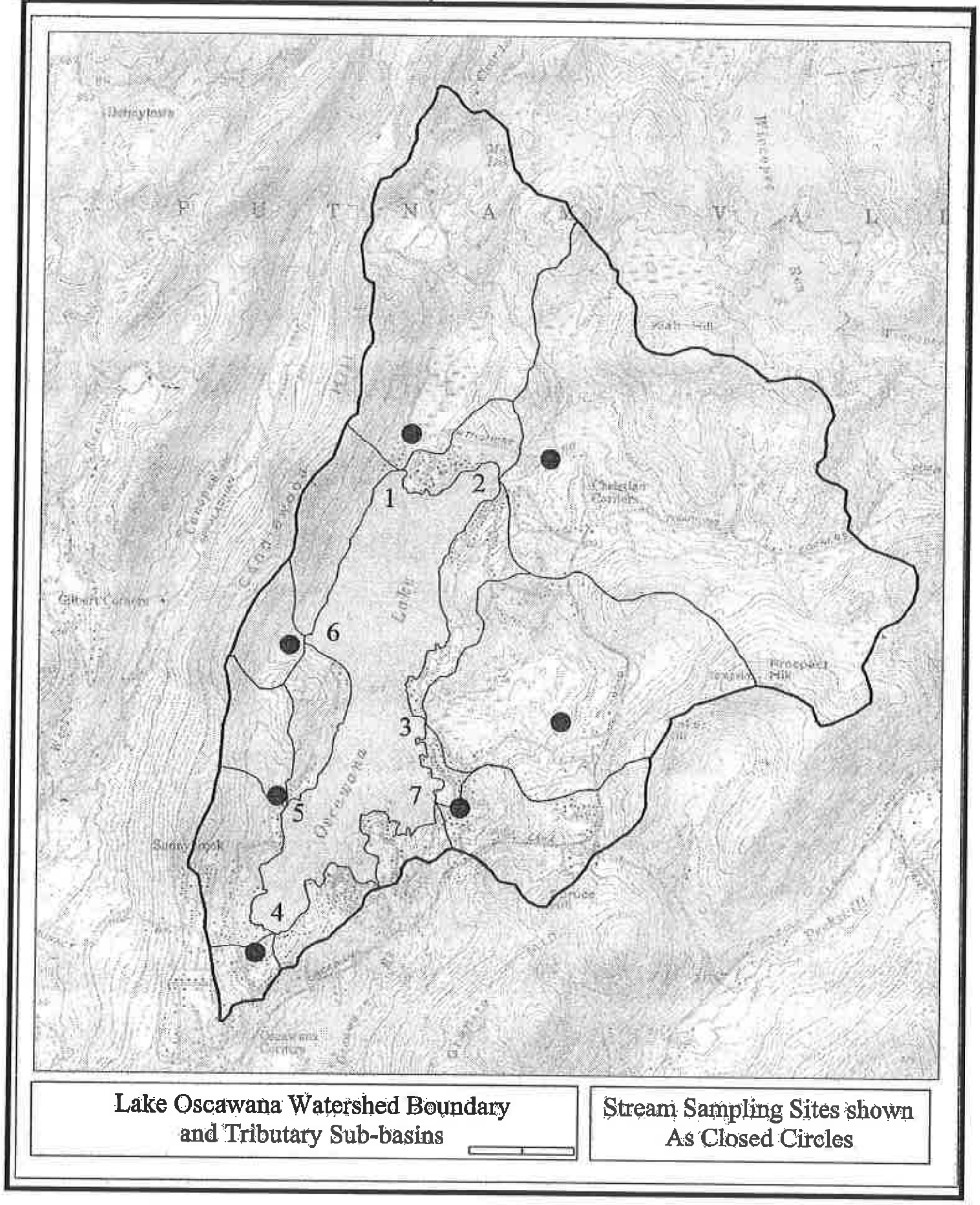
# APPENDIX 3

**Bathymetric Map of Lake Oscawana Showing the In-Lake Sampling Stations.**



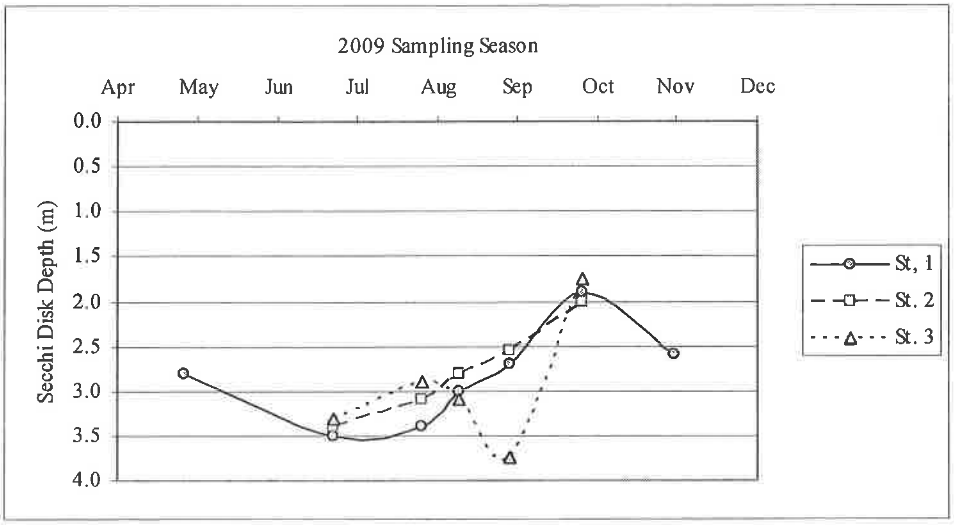
# APPENDIX 4

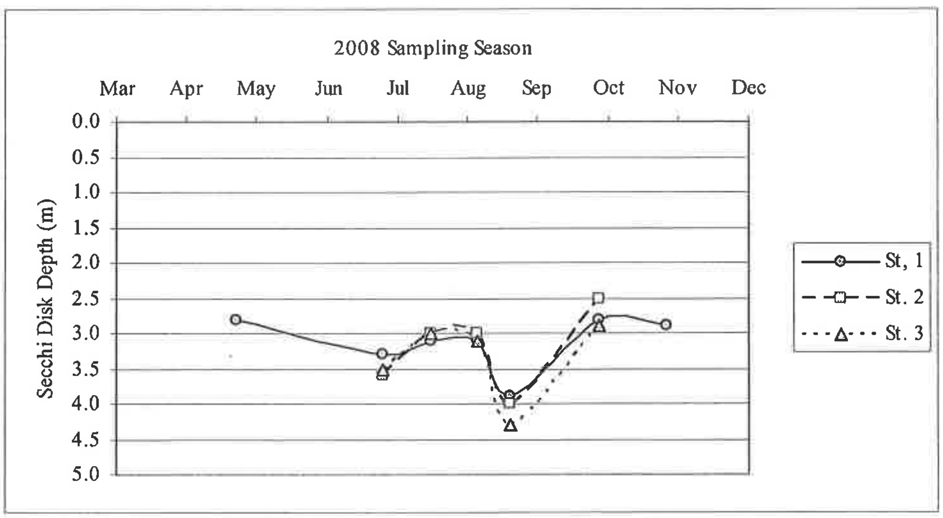
**Lake Oscawana Drainage Basin Sampling Stations:** The map shows the drainage boundaries of each of the major sub-basins in the watershed.

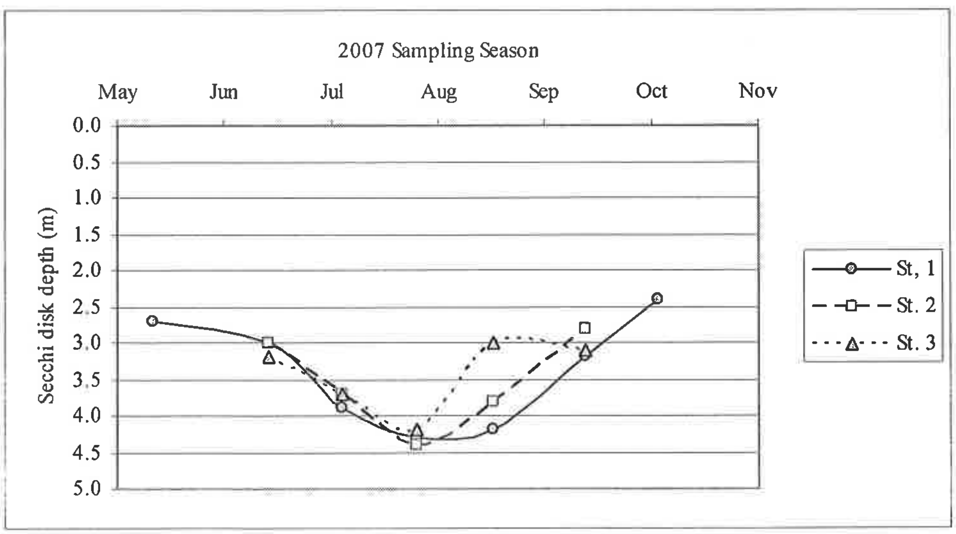


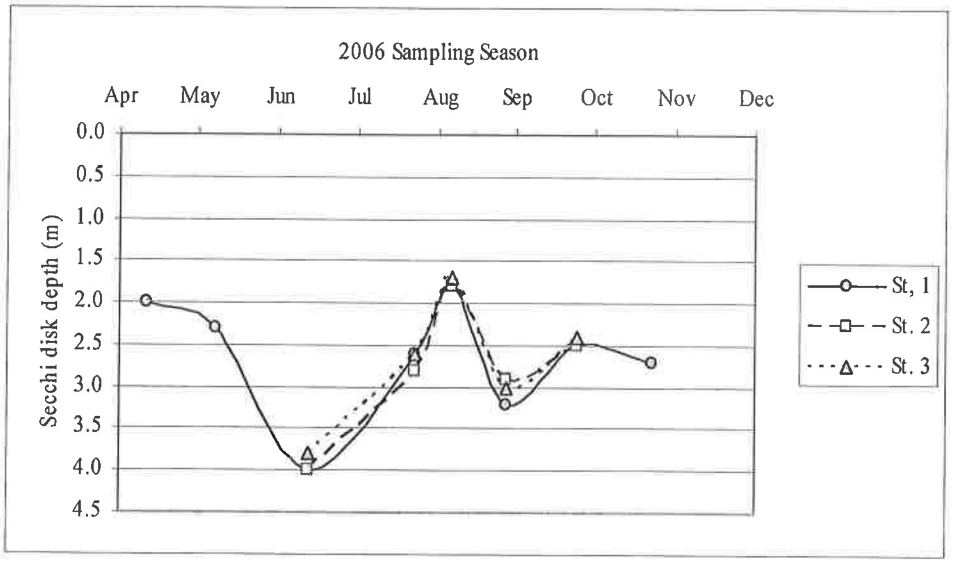
# APPENDIX 5

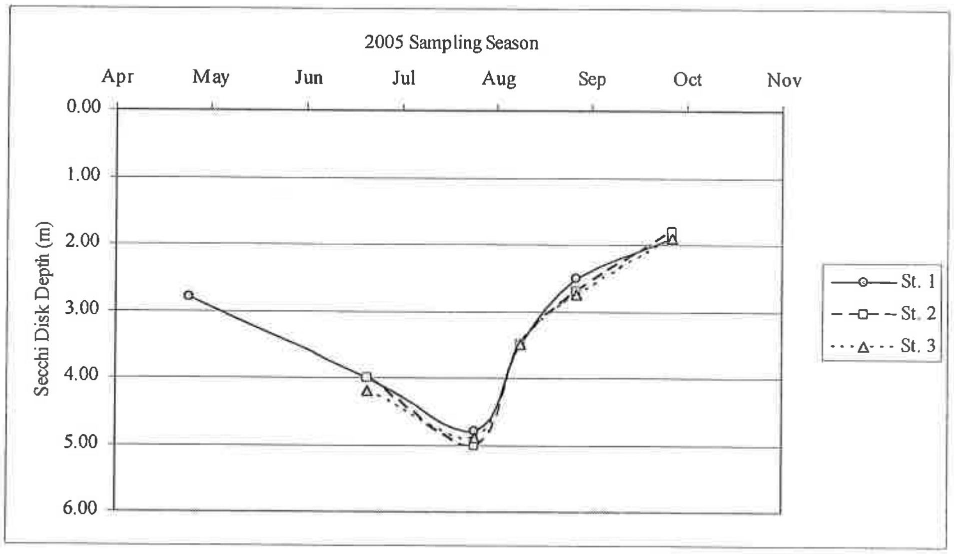
## Seasonal Tends in Secchi Disk, 2005 – 2009




2006 Sampling Season
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
Secchi disk depth (m)
St, 1
St. 2
St. 3


2005 Sampling Season
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
0.00
1.00
2.00
3.00
4.00
5.00
6.00
Secchi Disk Depth (m)
St. 1
St. 2
St. 3

# APPENDIX 6

## Total Phosphorus Sampling Results 2005 – 2008

Station 1

**2009**

| Depth | 27-Apr | 24-Jun | 28-Jul | 11-Aug | 31-Aug | 28-Sep | 3-Nov |
|---|---|---|---|---|---|---|---|
| 1 m | 11 | 12 | 13 | 16 | 15 | 15 | 19 |
| 4 m | 13 | 15 | 17 | 27 | 15 | 16 | 19 |
| 6 m | 18 | 15 | 82 | 43 | 32 | 15 | 16 |
| 9 m | 14 | 30 | 131 | 170 | 252 | 298 | 15 |
| mean = | 14 | 18 | 61 | 64 | 79 | 86 | 17 |

**2008**

| Depth | 23-Apr | 26-Jun | 18-Jul | 7-Aug | 22-Aug | 30-Sep | 30-Oct |
|---|---|---|---|---|---|---|---|
| 1 m | 17 | 15 | 31 | 27 | 7 | 30 | 15 |
| 4 m | 10 | 13 | 13 | 27 | 11 | 17 | 22 |
| 6 m | 13 | 19 | 21 | 15 | 21 | 16 | 24 |
| 9 m | 15 | 58 | 76 | 227 | 176 | 151 | 17 |
| mean = | 14 | 26 | 35 | 74 | 54 | 54 | 20 |

Colored cells unusually high values – possible outliers

**2007**

| Depth | 23-May | 26-Jun | 17-Jul | 8-Aug | 30-Aug | 26-Sep | 16-Oct |
|---|---|---|---|---|---|---|---|
| 1 m | 14 | 19 | 10 | 13 | 10 | 10 | 15 |
| 4 m | 14 | 22 | 14 | 14 | 11 | 14 | 17 |
| 6 m | 19 | 31 | 48 | 40 | 36 | 25 | 19 |
| 9 m | 27 | 69 | 158 | 263 | 380 | 635 | 14 |
| mean = | 19 | 35 | 58 | 83 | 109 | 171 | 16 |

**2006**

| Depth | 12-Apr | 14-Jun | 27-Jul | 9-Aug | 30-Aug | 27-Sep | 26-Oct |
|---|---|---|---|---|---|---|---|
| 1 m | 13 | 10 | 10 | 12 | 13 | 14 | 13 |
| 4 m | 13 | 14 | 19 | 13 | 17 | 17 | 15 |
| 6 m | 12 | 18 | 26 | 49 | 146 | 19 | 13 |
| 9 m | 14 | 34 | 277 | 500 | 735 | 354 | 19 |
| mean = | 13 | 19 | 83 | 144 | 228 | 101 | 15 |

**2005**

| Depth | 25-Apr | 23-Jun | 27-Jul | 11-Aug | 29-Aug | 28-Sep | 20-Oct |
|---|---|---|---|---|---|---|---|
| 1 m | 16 | 9 | 12 | 13 | 18 | 23 | 15 |
| 4 m | 12 | 13 | 26 | 13 | 15 | 14 | |
| 6 m | 15 | 12 | 60 | 20 | 52 | 15 | |
| 9 m | 15 | 24 | 133 | 311 | 291 | 386 | |
| **mean =** | 15 | 15 | 58 | 89 | 94 | 110 | |

**2004**

| Depth | 29-Apr | 30-Jun | 27-Jul | 30-Aug | 20-Sep | 27-Oct |
|---|---|---|---|---|---|---|
| 1 m | 13 | 8 | 15 | 15 | 26 | 13 |
| 4 m | 10 | 11 | 15 | 19 | 21 | 14 |
| 6 m | 12 | 23 | 13 | 32 | 19 | 10 |
| 9 m | 14 | 54 | 99 | 370 | 73 | 13 |
| **mean =** | 12 | 24 | 36 | 109 | 35 | 13 |

2003

| Depth | 30-Apr | 27-Jun | 23-Jul | 13-Aug | 27-Aug | 24-Sep | 19-Nov |
|---|---|---|---|---|---|---|---|
| 1 m | 14 | 9 | 8 | 11 | 13 | 16 | 16 |
| 4 m | 18 | 15 | 17 | 34 | 14 | 13 | 18 |
| 6 m | 43 | 24 | 20 | 21 | 58 | 13 | 17 |
| 9 m | 25 | 50 | 236 | 197 | 495 | 430 | 16 |
| **Mean =** | 25 | 25 | 70 | 66 | 143 | 118 | 17 |

# APPENDIX 7

## Total Phosphorus Sampling Results 2005 - 2009

Station 2 and 3

**2009**

| Station 2 (TP ppb) | | | | | |
|---|---|---|---|---|---|
| Depth | 24-Jun | 28-Jul | 11-Aug | 31-Aug | 28-Sep |
| 1 | 12 | 14 | 15 | 19 | 19 |
| 7.5 | 26 | 9 | 57 | 40 | 42 |
| **Station 3 (TP ppb)** | | | | | |
| Depth | 24-Jun | 28-Jul | 11-Aug | 31-Aug | 28-Sep |
| 1 | 12 | 10 | 10 | 13 | 31 |
| 7.5 | 26 | 57 | 41 | 58 | 44 |

**2008**

| Station 2 (TP ppb) | | | | | |
|---|---|---|---|---|---|
| Depth | 26-Jun | 18-Jul | 7-Aug | 22-Aug | 30-Sep |
| 1 | 10 | 11 | 10 | 9 | 21 |
| 7.5 | 21 | 51 | 52 | 73 | 15 |
| **Station 3 (TP ppb)** | | | | | |
| Depth | 26-Jun | 18-Jul | 7-Aug | 22-Aug | 30-Sep |
| 1 | 16 | 9 | 10 | 10 | 67 |
| 7.5 | 42 | 56 | 107 | 81 | 28 |

**2007**

| Station 2 (TP ppb) | | | | | |
|---|---|---|---|---|---|
| Depth | 26-Jun | 17-Jul | 8-Aug | 30-Aug | 26-Sep |
| 1 | 12 | 10 | 10 | 12 | 13 |
| 7.5 | 40 | 76 | 98 | 70 | 44 |
| **Station 3 (TP ppb)** | | | | | |
| Depth | 26-Jun | 17-Jul | 8-Aug | 30-Aug | 26-Sep |
| 1 | 13 | 5 | 10 | 10 | 10 |
| 7.5 | 55 | 72 | 107 | 118 | 59 |

**2006**

| Station 2 (TP ppb) | | | | | |
|---|---|---|---|---|---|
| Depth | 14-Jun | 27-Jul | 9-Aug | 30-Aug | 27-Sep |
| 1 | 6 | 6 | 13 | 12 | 14 |
| 7.5 | 50 | 194 | 112 | 460 | 92 |
| **Station 3 (TP ppb)** | | | | | |
| Depth | 14-Jun | 27-Jul | 9-Aug | 30-Aug | 27-Sep |
| 1 | 8 | 9 | 13 | 13 | 14 |
| 7.5 | 23 | 98 | 221 | 193 | 63 |

**2005**

| Station 2 (TP ppb) | | | | | |
|---|---|---|---|---|---|
| Depth | 23-Jun | 27-Jul | 11-Aug | 29-Aug | 28-Sep |
| 1 | 10 | 12 | 8 | 15 | 24 |
| 7.5 | 42 | 96 | 89 | 58 | 62 |

**Station 3 (TP ppb)**

| Depth | 6 23 | 7 27 | 8-11 | 8-29 | 9-28 |
|---|---|---|---|---|---|
| 1 | 17 | 13 | 4 | 17 | 12 |
| 7.5 | 18 | 58 | 82 | 79 | 12 |

**2004**

| Station 2 (TP ppb) | | | |
|---|---|---|---|
| Depth | 7-27 | 8-30 | 9-20 |
| 1 | 10 | 13 | 21 |
| 7 | 36 | 166 | 83 |

| Station 3 (TP ppb) | | | |
|---|---|---|---|
| Depth | 7-27 | 8-30 | 9-20 |
| 1 | 12 | 12 | 21 |
| 7 | 61 | 143 | 19 |

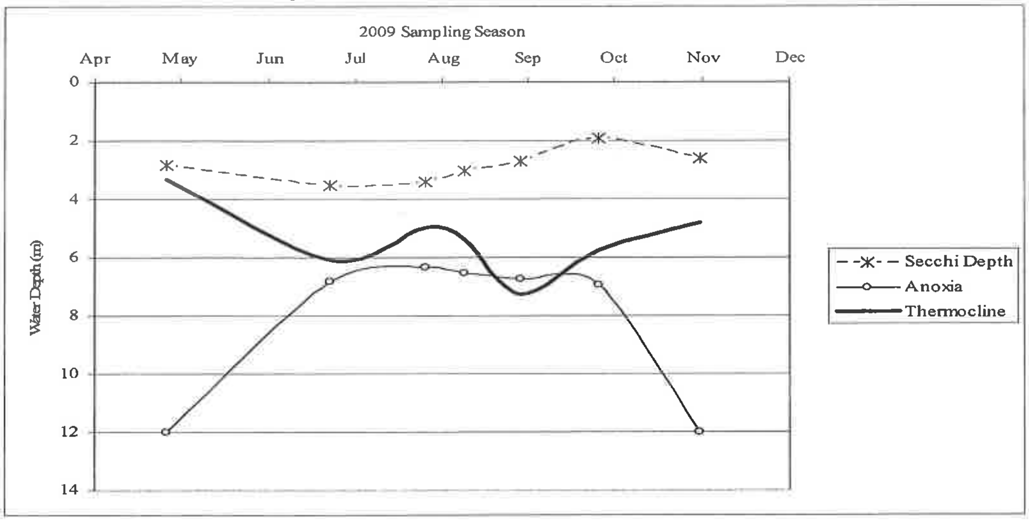
**2003**

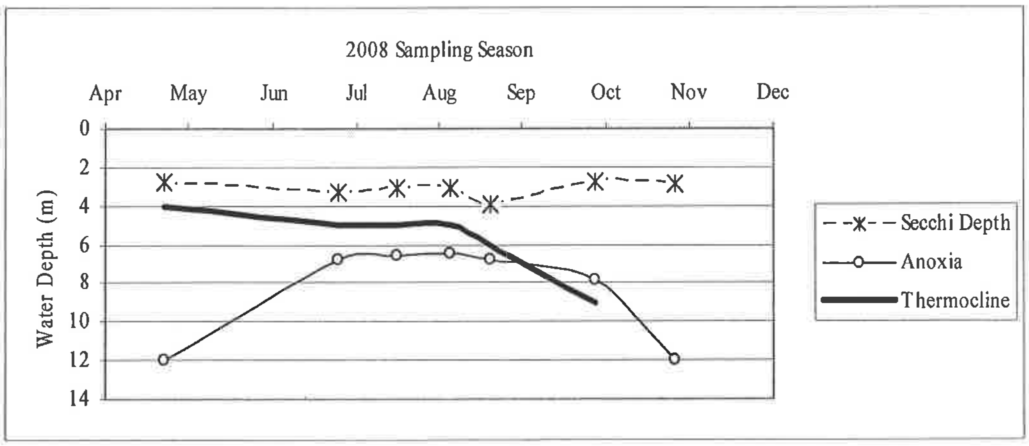
| Station 2 (TP ppb) | | | |
|---|---|---|---|
| Depth | 8-13 | 8-27 | 9-24 |
| 1 | 11 | 10 | 12 |
| 7 | 47 | 230 | 49 |

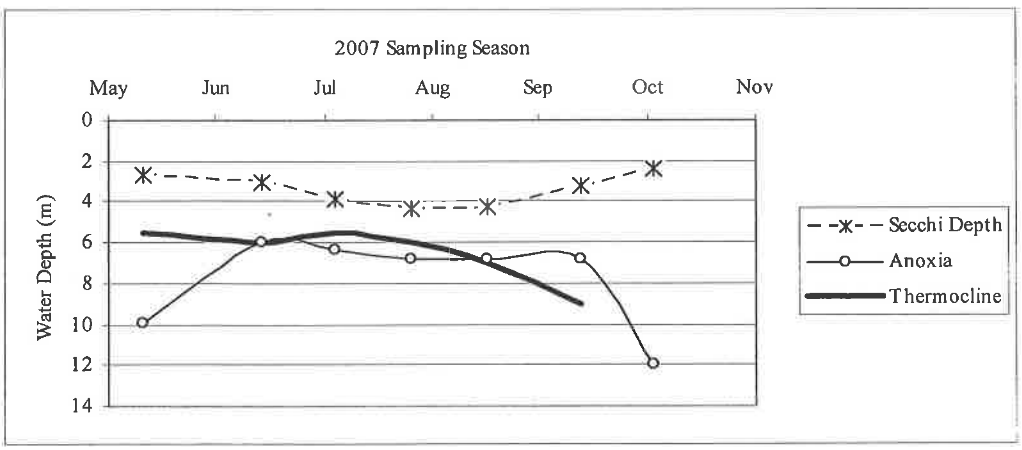
| Station 3 (TP ppb) | | | |
|---|---|---|---|
| Depth | 8-13 | 8-27 | 9-24 |
| 1 | ~ | 10 | 17 |
| 7 | ~ | 213 | 201 |

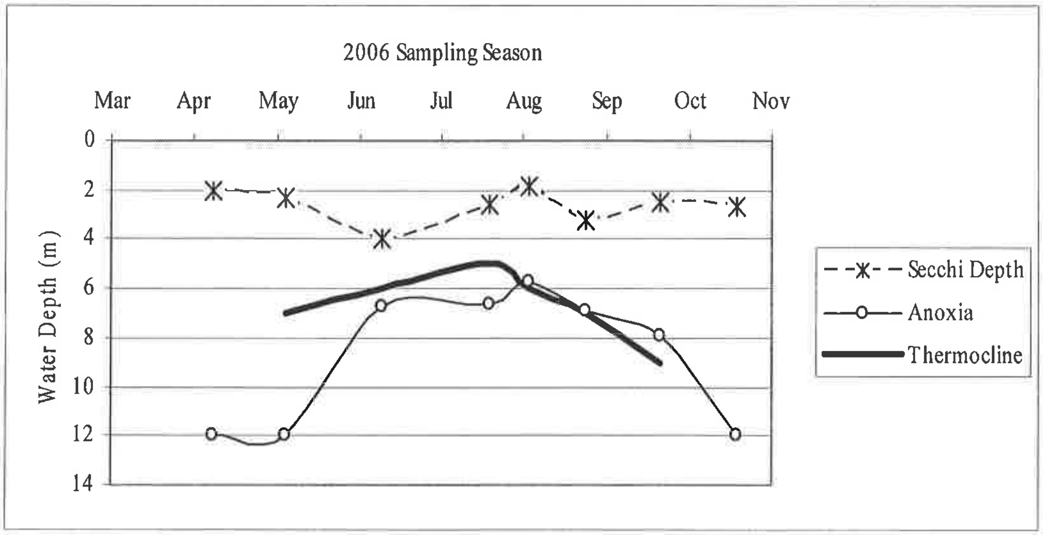
# APPENDIX 8

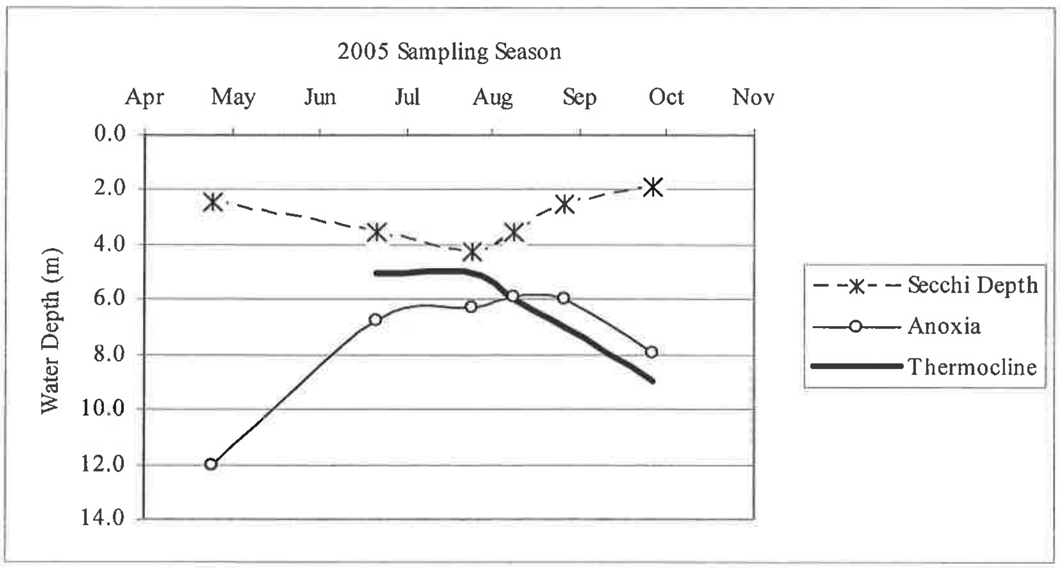
## Thermocline/Clarity/Anoxia Trends at Station 1 for 2005 – 2009



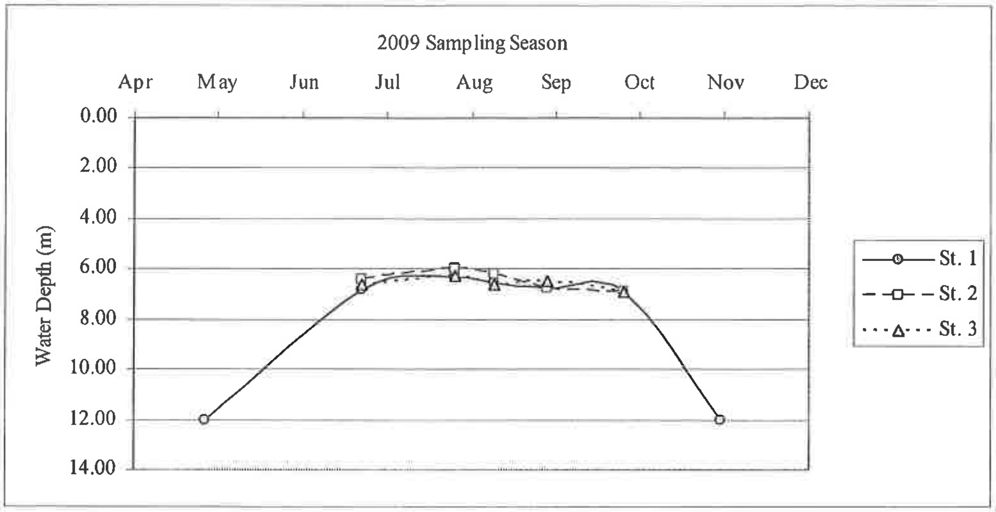



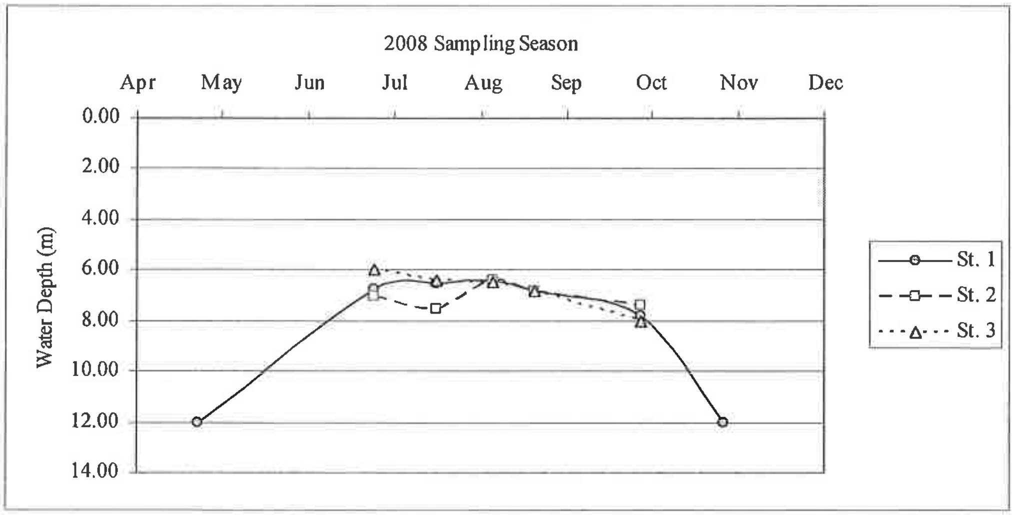

2006 Sampling Season
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
0
2
4
6
8
10
12
14
Water Depth (m)
Secchi Depth
Anoxia
Thermocline

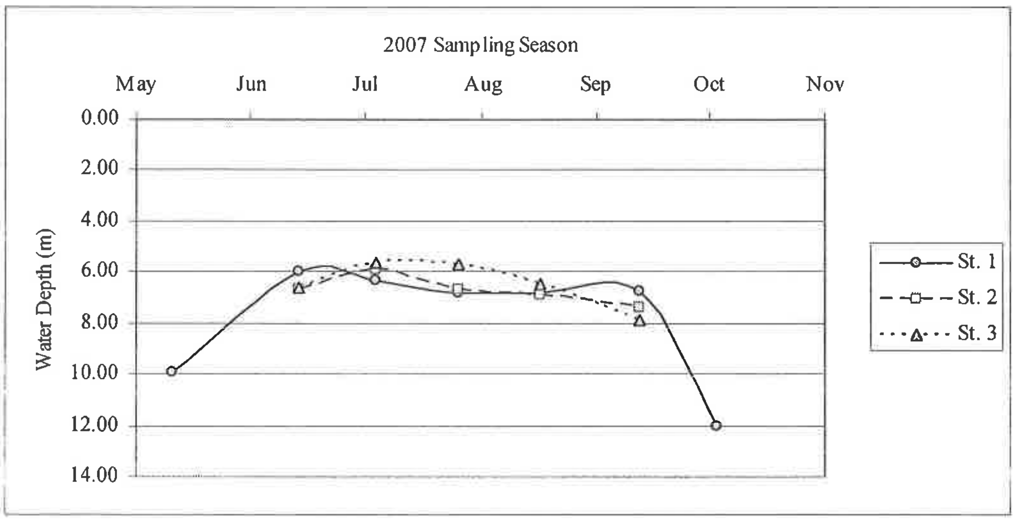

2005 Sampling Season
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
Water Depth (m)
Secchi Depth
Anoxia
Thermocline

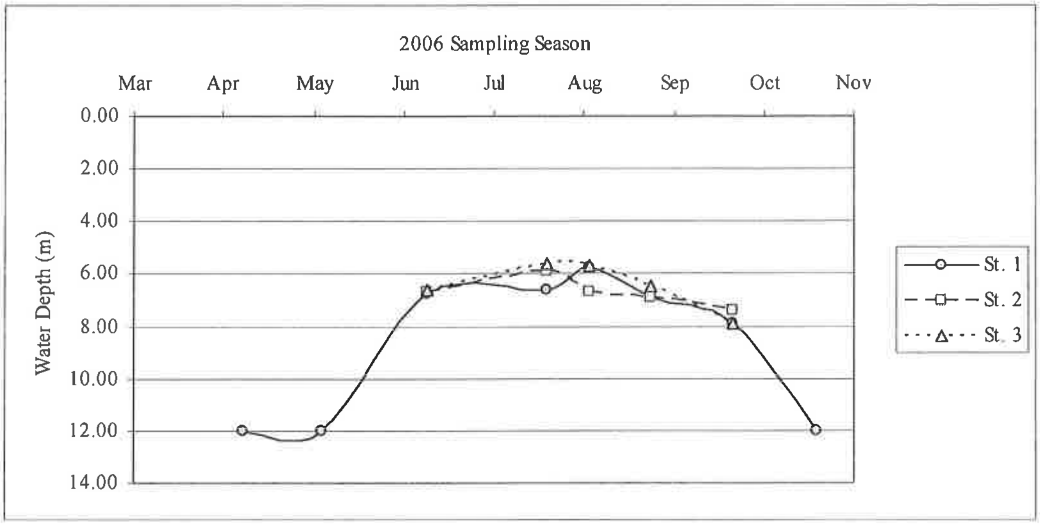
# APPENDIX 9

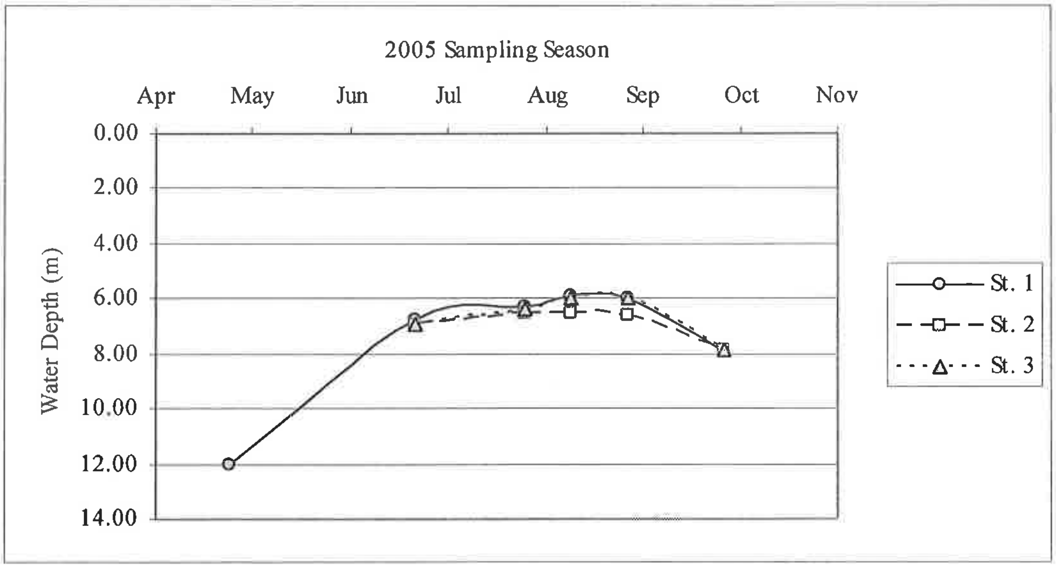
## Anoxia Boundary Trends At Each Lake Station for 2005 – 2009




2006 Sampling Season
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Water Depth (m)
St. 1
St. 2
St. 3


2005 Sampling Season
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Water Depth (m)
St. 1
St. 2
St. 3

# APPENDIX 10

## Aquatic Plant Survey Results

**2003**

| Common Name | Scientific Name | Relative Abundance |
|---|---|---|
| Large-leaf Pondweed | *Potamogeton amplifolius* | Abundant |
| Eurasian Milfoil | *Myriophyllum spicatum* | Abundant |
| White Water-lily | *Nymphaea odorata* | Abundant |
| Robbins Pondweed | *Potamogeton robbinsii* | Abundant |
| Yellow Water-lily | *Nuphar variegata* | Common |
| Coontail | *Ceratophyllum demersum* | Uncommon |
| Water Naiad | *Najas flexilis* | Rare |
| Water Weed | *Elodia canadensis* | Rare |
| Watershield | *Brasenia schreberi* | Uncommon |
| Tape grass | *Vallisneria americana* | Rare |
| Arrow-head | *Sagittaria cristata* | Rare |
| Filamentous Algae | *Spirogyra, Mougeotia* | Common |

**1998**

| Common Name | Scientific Name | Relative Abundance |
|---|---|---|
| Large-leaf Pondweed | *Potamogeton amplifolius* | Abundant |
| Eurasian Milfoil | *Myriophyllum spicatum* | Abundant |
| White Water-lily | *Nymphaea odorata* | Abundant |
| Robbin's Pondweed | *Potamogeton robbinsii* | Common |
| Coontail | *Ceratophyllum demersum* | Uncommon |
| Watershield | *Brasenia schreberi* | Uncommon |
| Tape grass | *Vallisneria americana* | Rare |
| Arrow-head | *Sagittaria cristata* | Rare |