# LAKE WAWASEE AND SYRACUSE LAKE DIAGNOSTIC STUDY

## From the 1995 Wawasee Area Watershed Lake Enhancement Diagnostic/Feasibility Study By Commonwealth Biomonitoring, Inc.

## I. INTRODUCTION

### A. Objectives of this Study

The Wawasee Area Watershed Lake Enhancement Diagnostic/Feasibility Study is a results oriented project. Its purpose was to diagnose ailments, prescribe the most feasible cures, and be a guide to ultimately carry out implementation of watershed nonpoint source pollution control treatments.

Our project objectives were to:

1. Examine the overall health of area lakes and streams and the conditions of their watersheds.

2. Identify existing and potential threats to the water quality of area lakes.

3. Prepare a long term management plan or preventive maintenance plan designed to be a plan of action for future activities to preserve existing lake water quality and the integrity of the watershed ecosystem.

### B. The General Condition of Most Other Indiana Lakes.

To put the information presented in this study on the Wawasee Area Watershed (WAW) into perspective we first need to briefly describe the condition of other Indiana lakes. Most lakes in Indiana are presently suffering the effects of water pollution from a variety of sources. They are becoming increasingly eutrophic.

Eutrophication is an overloading of nutrients to water a body. Often this nutrient enrichment is associated with substantial sediment loading to the water body.

Results of nutrient overloading include one or more of the following conditions: a predominance of nuisance weed growth; nuisance algae growth; poor fishing; poor water clarity; periodic foul odors; high bacteria counts; and general impaired use. Advanced cases usually result in a decrease in the suitability of the lake to support healthy gamefish populations and can even result in fish kills. In addition, the volume of water in a lake available as fishery habitat decreases due to a larger percent of the water column having sufficient dissolved oxygen content to support gamefish species.

The water column of eutrophic lakes with a maximum depth of greater than 15 feet tend to stratify by water of different temperatures, and thus densities (weight per unit volume), segregating during summer and winter periods. As water decreases in temperature to $39^0$ (f) it becomes increasingly dense. The inverse is also true, as the temperature of water increases it becomes increasingly lighter until it turns into steam vapor. Therefore, during winter and summer, colder, heavier water is

layered below warmer, lighter water. The lower layer is referred to as the hypolimnion, and the upper layer is referred to as the epilimnion. The layer of water where the temperature and density changes rapidly is called the metalimnion or more commonly, the thermocline.

Because the hypolimnion is separated from the atmosphere by the epilimnion, there is no water/air interaction to oxygenate the hypolimnion. Furthermore, since the hypolimnion is typically below the level of solar light penetration, there is no photosynthesis from algae or aquatic plants to give off dissolved oxygen to the hypolimnion as a byproduct of photosynthesis. Therefore, the hypolimnetic layer of water can go anoxic in the summer and be incapable of supporting fish populations.

The more eutrophic a body of water becomes, the more of the water column becomes anoxic. The more of the water column that becomes anoxic, the less habitat is available for the aquatic community.

Eutrophication is a natural process that is experienced by all lakes. However, the natural rate of eutrophication is very slow, on the order of the geologic time scale. Cultural eutrophication, on the other hand, is eutrophication resulting from the activities of humans, primarily how we manage the land within a watershed. The symptoms of cultural eutrophication are evident within the human time scale. Most of us are aware of lakes that were in much better condition years ago than they are today.

## C. The Condition of the WAW Lakes.

### 1. General Features and Water Quality

Lake Wawasee is the largest natural lake in Indiana with a surface area of 3,060 acres, a maximum depth of 77 feet and an average depth of 22 feet. Syracuse Lake is located adjacent to the City of Syracuse and has a surface area of 414 acres with a maximum depth of 34 feet and an average depth of 13 feet. Most of the shoreline of lakes Wawasee and Syracuse are developed. There is one public access site at each lake (see maps).

The lakes are typical in structure of natural lakes of the glaciated portions of the upper Midwest. Lakes Wawasee and Syracuse are connected by a channel between the two lakes. Both lakes are presently healthy, balanced aquatic ecosystems. The wetlands in portions of the lakes support among the most diverse aquatic plant communities in Indiana.

Neither lake develops a well defined thermocline. In Lake Wawasee dissolved oxygen concentrations are adequate for gamefish comfort down to approximately 30 feet. In Syracuse, the Dissolved oxygen content can comfortably support gamefish down the approximately 18 feet deep.

The lakes are clear with most of the nutrients tied up in aquatic vegetation (and zebra mussels) rather than in nuisance algaes. Both lakes provide good fishing for a wide variety of fish species.

The lakes of the Wawasee Area Watershed presently have among them the highest water quality of any lakes in Indiana. Most Indiana lakes have a Secchi depth reading (measure of water clarity) of from 2 to 6 feet. The Lake Wawasee Secchi depth in 1995 was as much as 15 feet. The introduction of zebra mussels may have helped to increase water clarity by filtering phytoplankton from the water column. Because the zebra mussel community and their effects are being studied by other researchers this project did not include a study of zebra mussels. Their presence may pose problems to the aquatic community yet to be manifested.

In addition to having a deep Secchi reading, water column nutrient levels, as measured in July 1995, continue to be relatively low, compared to other Indiana lakes, and sedimentation also continues to be low. Given the quality of these natural lakes, they should be considered a resource to be guarded jealously by their stewards.

The quality of the WAW is the reason the lakes' water quality continues to be so good. However, the water quality of area lakes could very easily take a turn for the worse, depending on how the watershed is managed. Although the condition of the subject lakes is good compared to other Indiana lakes, the decline of sensitive fish species such as cisco and lake sturgeon are indicators of long term reduction in the overall health of the lakes. An example of a degraded watershed would be a conversion of land use along the margins of the waterways from idle, naturally vegetated land, to developed or tilled up to channel edges.

## D. The Condition of the Wawasee Area Watershed

A watershed is the lake drainage basin, that catchment area where, if a drop of water falls within the basin it has the opportunity to flow into the lake. An often used phrase in lake and watershed management today is "a lake is a reflection of its watershed", this is very true.

The WAW is among the largest lake watersheds in Indiana at 24,000 acres. Presently it is one of the highest quality watersheds in the state, for three primary reasons:

1. the amount of water-purifying wetlands in the watershed;

2. the large number of highly erodible land (HEL) in some form of conservation tillage or idle land. In addition, there is some Conservation Reserve Program (CRP) acres in the watershed. HEL in CRP does not have the opportunity to contribute significant sediment loads due to stabilizing ground cover, and;

3. other conservation practices in place throughout the watershed.

CRP contract expiration could result in putting more acres of HEL into production. Conversion of idle land to agriculture production is the primary factor that could result in a future decrease in water quality of the WAW. The Wawasee Area Conservancy Foundation (WACF) should work with the local Soil and Water Conservation Districts (SWCD) to renew CRP contracts and to assist in recruiting more acres into the CRP program, as well as installing other treatments.

The watershed is unique in its high quality habitat and ability to support a highly diverse natural community (see endangered species section) including a very high concentration of rare species. These plants and animals can be considered "canaries in the coal mine". The ability of the watershed to support these species has diminished over time. This trend may be an indication that the watershed is losing some of its pollution absorbing and buffering capacity, as well as losing natural habitat by conversion of land uses.

## E. Watershed Nutrient and Sediment Loading

To determine a nutrient and sediment (pollutant) loading budget for Lake Wawasee and to determine which loading sources are most important, loading estimates were made based on average measured pollutant concentrations and flows from each of the WAW subwatersheds. Measurements of nutrients in local runoff and direct precipitation were not made during this study. Estimates of loadings from these sources depend on average values found in studies of other lakes. The nutrient parameters listed in the table below are phosphorus (P) and nitrogen (N). The total suspended solids (Solids) is basically the sediment and suspended particulate load of the tributaries.

When the available data were tabulated, the following results were obtained:

**Table A.R. 1**
**Annual Nutrients and Suspended Solids Loading From Tributaries***

| | Total P[1] kg/yr | Total N[2] kg/yr | Solids[3] kg/yr |
|---|---|---|---|
| Enchanted Hills Channel | 350 | 22,400 | 36,000 |
| Norris Branch | (30) | (1,300) | (1,000) |
| Launer Ditch | (130) | (14,000) | (11,300) |
| South Dillon Crk. | (180) | (16,000) | (18,400) |
| Turkey Creek | 810 | 39,200 | 46,700 |
| South Shore Ditch | 20 | 1,300 | 11,300 |
| Papakeechie Watershed | 215 | 3,600 | 4,000 |
| Bonar Lake Watershed | 75 | 500 | 1,000 |
| Local Runoff | 400 | 5,000 | 8,000 |
| Direct Precipitation | 155 | 4,000 | 1,000 |
| **TOTAL** | **2025 ** ** | **76,000** | **108,000** |

[1] Total P = Total phosphorus loading to Lake Wawasee in kilograms per year.
[2] Total N = Total nitrogen loading to Lake Wawasee in kilograms per year.
[3] Total Solids = Total suspended solids (including sediment) in kilograms per year.
* Late spring and early summer high flow and base flow sampling events.
** This is a maximum estimate. Actual loadings are lower because many of the values used to calculate loadings were set at the analytical detection limit rather than the actual value below the detection limit.

Values in parentheses are for Dillon Creek tributaries as they enter the Enchanted Hills area.

During this study, phosphorus (P) and total suspended solids (TSS) were relatively low in concentration. However, nitrate loadings were unusually high in the Enchanted Hills subwatershed. Further study should be done to identify the source of elevated nitrates.

A 1973 EPA study indicated that phosphorus was the limiting nutrient in Lake Wawasee water. Therefore, if phosphorus can be controlled, good water quality can be maintained.

From aerial observations, the most obvious problem watershed wide is transport of sediment from construction sites. Best management practices to control erosion should be installed for commercial, residential, utility, or any other kind of construction involving earth moving. An enforceable erosion control ordinance and drainage ordinance should be passed by the county. The Kosciusko County Lakes Council would be the appropriate body to lobby the county commissioners for such an ordinance.

## F. In Lake Water Quality

### 1. Eutrophication Index Sampling Results

The in-lake water quality of the following lakes were sampled after they reached summer stratification:

- Lake Wawasee
- Syracuse Lake
- Bonar Lake

The Indiana Department of Environmental Management (IDEM) uses a unique monitoring technique to determine the "trophic status" of lakes in Indiana. This technique, which has been rigorously tested and proven to produce very reliable results, uses 11 different measurements to produce an index value for any given lake. This value ranges between 0 and 75, with lower numbers indicating clear, "high quality" lakes and higher numbers indicating "problem" lakes with nuisance algae problems.

Lakes are then classified into on of three trophic classes based on the trophic index value. Class 1 lakes have the highest water quality, Class 2 lakes are moderately eutrophic, and Class 3 lakes are the most eutrophic.

Commonwealth Biomonitoring staff calculated the IDEM lake eutrophication index (EI) for Lakes Wawasee, Syracuse, and Bonar during the summer of 1995. The following results were obtained:

**Table A.R. 2**
**Eutrophication Index (E.I.) Values For Lakes Wawasee, Syracuse, and Bonar**

| Lake Name / Location | E. I. Values | Trophic Class |
|---|---|---|
| Wawasee - South Basin | 10 | I |
| Wawasee - North Basin | 12 | I |
| Syracuse Lake | 10 | I |
| Bonar Lake* | 6 | I |

### 2. Historical and 1995 Secchi Depth Comparisons

One of the most commonly used methods of measuring water quality is "Secchi disk depth." The Secchi disk depth reading is the depth at which a black and white disk lowered into the water column can no longer be seen from the surface. Measurements of Secchi disk depth have been made in Lake Wawasee fairly regularly by various government and academic researchers and by volunteers since 1974. A comparison of these measurements over time can help determine whether Lake Wawasee is becoming clearer or more turbid. Table A.R. 3 is a compilation of available Secchi disk depth data.

**Table A.R. 3**
**Secchi Depth Trends**

| | 1973-1989 | 1989-1993 | 1994-1995 |
|---|---|---|---|
| Average Secchi Depth (Feet) | 9.3 | 10.4 | 8.2 |
| Standard Deviation | 1.25 | 0.96 | 1.92 |
| Number of Samples | >12 | 25 | 15 |

By applying a statistical test to these results, we observe that the average Secchi Disk Depth during the 1989-93 period was significantly greater (5%) than the value for the previous 1973-89 period. This finding indicates that water clarity improved somewhat during 1989-93. The greatest improvement occurred during the 1990-92 period, when average Secchi Depth was as high as 11.5 feet.

During the most recent two-year period, average lake clarity has decreased once again. The Secchi Disk Depths for 1994-95 were statistically less than they were for 1989-1993 but were not significantly different (5%) from those observed during the earlier 1973-89 monitoring period. These results suggest that the clarity of Lake Wawasee has not changed very much during 20 years.

3. Kosciusko County Health Department 1995 Sampling Results

Results from in-lake sampling studies performed by the Kosciusko County Health Department (as well as Commonwealth Biomonitoring limnological profiles) and the watershed sampling results consistently indicate high water quality prevails in the lower WAW lakes. However, the Enchanted Hills Subwatershed exhibited high nitrate concentrations, and the outlet to the Enchanted Hills channels were consistently murky or turbid.

Based on the sampling results bacteria is generally not a problem in the lake, with concentrations well below Environmental Protection Agency (EPA) standards for full body contact (235 cells/100 ml). The area near the mouth of Turkey Creek had the highest concentrations of bacteria in the water column and this is consistent with sampling done in previous years. Consistent with other Indiana water bodies, Atrazine (agricultural herbicide) was detected in measurable concentrations above maximum contaminant levels for potable water. These concentrations of Atrazine are not considered unsafe for recreation. Atrazine application in the watershed should be done with care to avoid increasing the concentrations in area waters. In-lake phosphorus concentrations were consistently low wherever tested.

The source of the high nitrate concentrations in the Enchanted Hills subwatershed and the elevated levels of bacteria near the mouth of Turkey Creek should be further investigated. Also more research needs to be done on the fate of on-board wastewater from boats moored at the marinas around Lake Wawasee. Commonwealth Biomonitoring staff are available to assist in these investigations.

4. Flushing Rate

Natural lakes tend to have a relatively long flushing rate compared to reservoirs. The flushing rate of Lake Wawasee is 3.5 years as calculated by Purdue University researchers. This is a relatively long flushing rate which results in the prolonging of the residence time of pollutants in the water. Extension of the residence time of pollutants is not good for water quality. Once a lake with a slow flushing rate becomes polluted, it takes much longer for a reversal or an improvement of water quality to become apparent from lake enhancement treatments. In addition to a long flushing rate, Lake Wawasee is relatively deep with a relatively large volume. Thereby, the lake can absorb a lot of pollution before its effects are apparent. There is a delayed response between introduction of pollutants and degradation of water quality.

## G. Special Problems and Considerations

1. Boating Impacts

The lake margin wetlands function as natural purification systems for water entering the lakes. They also function as habitats for diverse species of wildlife. The wetland areas, such as Conklin Bay, Johnson Bay, and Mud Lake, are vital to the health of a self-sustaining fishery of Lakes Syracuse and Wawasee. Based on the field observations by Commonwealth Biomonitoring aquatic biologists, these areas presently function as rich fish nursery areas. These wetlands are especially rich in juvenile game fish species.

Because there are no 200 foot marker buoys in place in Johnson Bay, Conklin Bay or the Southeast corner of Syracuse Lake, people ski up to the edge of these wetlands. Commonwealth Biomonitoring staff have seen these wetland hummocks bouncing violently from wave energy.

After observing the value of the lake margin wetland areas to the overall health of the lakes system, no wake zones have been proposed in the shallower, more sensitive areas of Lakes Wawasee and Syracuse to protect the wetland resources and for public safety considerations. These areas include the southeast corner of Syracuse Lake, Mud Lake, Conklin Bay, and Johnson Bay. Portions of these areas, especially the southeast corner of Syracuse Lake, also include shallow water boating hazards that warrant reduced boat speeds.

2. Seawalls

Water waves can be either partially or totally deflected or reflected back into a lake from natural or manmade barriers. Reflection of waves implies a reflection of wave energy from the seawall back out into the lake without energy dissipation. A natural, gradually sloping shoreline or beach tends to dissipate energy rather than reflecting it back out into the lake.

Seawalls all around the perimeter of Lakes Syracuse and Wawasee are positioned at different angles. These seawalls reflect waves back into the lake from these angles. This wave reflection is why Lake Wawasee is such a rough lake with a standing chop that continues to swell long after boat traffic has passed or subsided. Water, being a relatively dense medium, is an excellent conductor of sound and vibration and where wave energy is not dissipated it continues to bounce off of seawalls around the lake.

This excessive turbulence may be a contributing factor in the disappearance of the soft stemmed water bulrushes. Further investigation is recommended to determine if wave energy is a major factor in water bulrush community survival rates.

3. Residential and Commercial Lawn Care

Local residential and commercial lawn care has the potential to affect water quality through the application of pesticides and fertilizers to area lawns. There is no specific information available on lawn care practices in the Lake Wawasee area.

It is important to maintain a relatively dense vegetative ground cover on soil to reduce the rainfall impact and reduce the erosive potential of managed lawns. Whenever possible, lawns surrounding lakes should be fertilized sparingly using fertilizer with little or no phosphorus. On lawns that need nutrient enhancement, the grass clippings from lawn mowing should be left on the lawn for recycling of the nutrients that are in the grass clippings.

4. Residential and Commercial Water Withdrawals

One caveat of water withdrawal for residential or commercial lawn use has to do with return flows. Where flows from boat or car washing or lawn chemical application is allowed to return to a lake water quality could be negatively impacted. This type of activity should be discouraged where pollutants may enter the water via overland flow or by entering a downspout, storm drain, or drain tile and flow into a lake.

According to the Indiana Department of Natural Resources (IDNR) Division of Water, there are two registered (permitted) surface water withdrawal facilities in Lake Wawasee. IDNR records for 1991-93 show that the Wawasee Golf and Country Club uses approximately 170,000 to 290,000 gallons of lake water per year for irrigation. The South Shore Golf Course uses an additional 24 to 40 million gallons per year for irrigation. Therefore, from 24,170,000 to 40,290,000 gallons per year are withdrawn from Lake Wawasee for commercial lawn irrigation from these two uses. There is no

estimate of the quantity or quality of return flows re-entering Lake Wawasee from this irrigation activity. The total volume of water permitted for irrigation withdrawal is a very small proportion of the total Lake water. However, with the long flushing rate (3.5 years) the withdrawal of water for irrigation could potentially lower the lake levels and prolong the residence time of pollutants in the lake water column.

5. Effects of Waterfowl on Water Quality

There is a possibility in some lake systems that an overabundance of waterfowl may contribute to an unacceptable level of nutrient loading from untreated "droppings". A rough calculation was made of potential nutrient loading to Lake Wawasee using an established method.

In a worst case situation waterfowl in Lake Wawasee could contribute up to 2% of all nitrogen loading and 14% of all phosphorus loading in the lake. This amount of loading is less than that from agricultural runoff, precipitation, and septic tanks. Removing all nutrient loading from waterfowl droppings would have no significant effect on the lake's "Trophic Index" of nutrient enrichment.

Since large flocks of waterfowl resting on the WAW lakes is seasonal, waterfowl concentrations in the Wawasee area are not a significant potential contributor to lake enrichment. However, feeding of waterfowl to attract a larger resident flock should be discouraged. The negative aspects of waterfowl manure nutrient loading is likely offset by the positive aesthetic value of waterfowl and their foraging on zebra mussels.

6. Management of Wetlands Around the Perimeter of the Lakes

Most of the former wetlands around the perimeter of the lakes have been filled in for residential and commercial development. This makes the remaining wetlands even more valuable.

The wetlands function as natural purification systems for water entering the lakes. They also function as habitats for diverse species of wildlife. The wetland areas, such as Conklin Bay, Johnson Bay, and Mud Lake, are vital to the health of a self-sustaining fishery. These areas presently function as very rich fish nursery areas.

These areas should be preserved around the lake for a variety of reasons, including their NPS pollution buffering, habitat value, wave energy buffering, aesthetic and intrinsic values.

## H. Watershed Problem Areas

Based on the results of watershed water quality sampling and total annual loadings of nutrients and suspended solids (nonpoint source pollutants) to Lake Wawasee from each respective subwatershed, these subwatersheds have been prioritized from highest to lowest priority.

1. Turkey Creek Subwatershed
2. Enchanted Hills Subwatershed

3. South Shore Subwatershed
4. Immediate Lakeshore Land Uses
5. On Lake Uses
6. Bonar Lake Subwatershed
7. Papakeechie Lake Subwatershed

**Table A.R. 4**
**On-Lake Use Problems**

| Location | Description of NPS Problem |
|---|---|
| On Lakes and Lakeshore Land Uses | -- Wake in wetlands areas - resuspension of nutrients and sediment<br>-- High speed operation in shallow (<5') areas, prop scarring<br>-- Lack of head pumping facilities<br>-- Lake use etiquette (pollution prevention)<br>-- Advertise public rest room facilities (discourage "going in lakes")<br>-- Seawall wave reflection, habitat replacement<br>-- Construction and lawn care activities must stabilize soils with minimum of phosphorus fertilizer inputs. |

## I. Evaluation of the Operation of the Dams of Syracuse Lake Dam

1. Discussion of General Conditions of Dam Structures and Apparatus

The structure of the Syracuse Lake Dam at Crosson Park is in excellent condition. The existing dam was constructed in 1963 with funds donated by Eli Lilly (along with an operations and maintenance fund established at the same time). The structure is very well maintained and Indiana Department of Natural Resources (IDNR) dam inspection reports indicate that there is presently no problem with the dam, nor has there been, since construction of the existing dam.

a. Syracuse Lake Dam Operations

The Town of Syracuse dam operation staff have tried various strategies to maintain the lake level as stable as possible, including reactionary versus anticipatory strategies to maintain a stable lake level. The anticipatory strategy was tried but has been abandoned for the reactionary management strategy.

The water must be released from the Syracuse Dam at a controlled rate to prevent causing damage (erosion) to the channel downstream of the Lake and to protect property below the Lake. A minimum amount of flow must be maintained by the dam operator to maintain a stream ecosystem in Turkey Creek below the Syracuse Dam.

The urbanization of portions of the WAW, which has included replacement of wetland and natural pervious soils with impervious rooftops and pavement, has altered the rate of water flow to the lakes and has resulted in the operation of the dam requiring more operator attention to maintain the legal level. Operators of the dam must try to compensate for ever decreasing peak runoff “times of concentration” and the increasing volumes of peak runoff to the lakes system.